EVALUATION OF FUGITIVE METHANE MEASUREMENT TECHNIQUES FOR LARGE DIFFUSE SOURCES

Jane Barnett[1], Damon Roddis[1], Russ Francis[1], Tom Mifsud[1] and Jarred Inzinger[1]

[1]Zephyr Environmental Pty Ltd, 300 Barangaroo Avenue, Barangaroo, NSW, 2000, Australia

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1. Introduction

The reduction of methane emissions has become a key focus for government and regulators. This extended abstract summarises multiple techniques that have been trialled to find a method to estimate methane emissions from large diffuse sources, that is both practical and feasible. These methods range from satellite imaging, down through the atmosphere using aircraft and drone survey, and finally using on-the-ground measurements such as flux chambers, open-path technology, and static research-grade instrumentation.

Coal mines and landfills are recognised sources of fugitive methane, a greenhouse gas with a global warming potential far exceeding that of carbon dioxide. Emissions from coal mines occur across large, spatially distributed areas and at variable rates. Landfills similarly generate diffuse methane emissions from the decomposition of buried waste. Quantifying these fugitive emissions with the accuracy, and spatial and temporal coverage, required for greenhouse gas inventory reporting remains a significant technical challenge.

2. Methodology

Table 1 summarises the six different techniques that have been trialled during this program of research.

Table 1. Fugitive methane measurement techniques trialled

No.	Technique
1	Flux chamber survey (Picarro G2201-i CRDS)
2	Flux survey (LI-COR LI-7810 + Smart Chamber)
3	Mobile monitoring (vehicle-mounted Picarro)
4	Drone survey, upwind-downwind (aircore)
5	Drone survey, point sensor (ABB HoverGuard)
6	Drone survey, path sensor (Pergam Laser Falcon Plus)

In addition, a co-location study was also completed to compare different lower cost instruments with the Picarro G2201-i cavity ring-down spectrometer (CRDS), considered state-of-the-art and the most accurate for high-concentration sources. However, it is highly labour intensive and difficult to use in the field and the study tested smaller, more portable equipment, using the Picarro as a benchmark. The other instruments tested were the Aeroqual AQS1, the ABB MicroGuard, Aeris, Axetris and LI-COR.

3. Results and discussion

3.1. Flux chamber surveys

Picarro flux chamber surveys remained the most accurate technique for high-concentration sources. The LI-COR system offered much greater portability and spatial coverage at a landfill. However, it is only stable to concentrations up to 200 ppm, and measurements at both landfills and coal mines can be significantly higher than this.

3.2. Mobile monitoring

Mobile monitoring identified plumes 3 – 4 km wide with methane plume enhancements of up to 5 ppm above background. This was useful in identifying a shift in drone survey design from a whole-of-site exercise to a more targeted survey of a smaller area.

3.3. Aircore drone surveys

Aircore-mounted drone surveys proved the concept of drone-based surveying. However, they were too time-consuming in set-up and analysis to progress further.

3.4. Realtime drone surveys

Real-time sensor drone surveys (ABB HoverGuard; Pergam Laser Falcon Plus) performed well at the landfill, identifying discrete hotspots and plume structures, and are considered more viable than aircore-based surveys.

3.5. Co-location study

All instruments compared relatively well with the Picarro. Some basic statistics are noted in Table 1 and indicate that the Aeroqual and the Axetris perform slightly better.

Table 1. Basic statistics for five instruments against the Picarro

Metric	r	R^2	RMSE	IOA
Ideal value	***1***	***1***	***0***	***1***
ABB	0.97	0.93	3.1	0.90
Aeris	0.91	0.83	8.3	0.86
Axetris	0.98	0.95	4.5	0.91
Licor	0.97	0.93	5.0	0.91
Aeroqual	0.99	0.99	1.8	0.87

Figure 1 shows a series of quantile-quantile plots for each instrument, and each shows reasonable performance. There is some divergence at higher concentrations for all instruments.

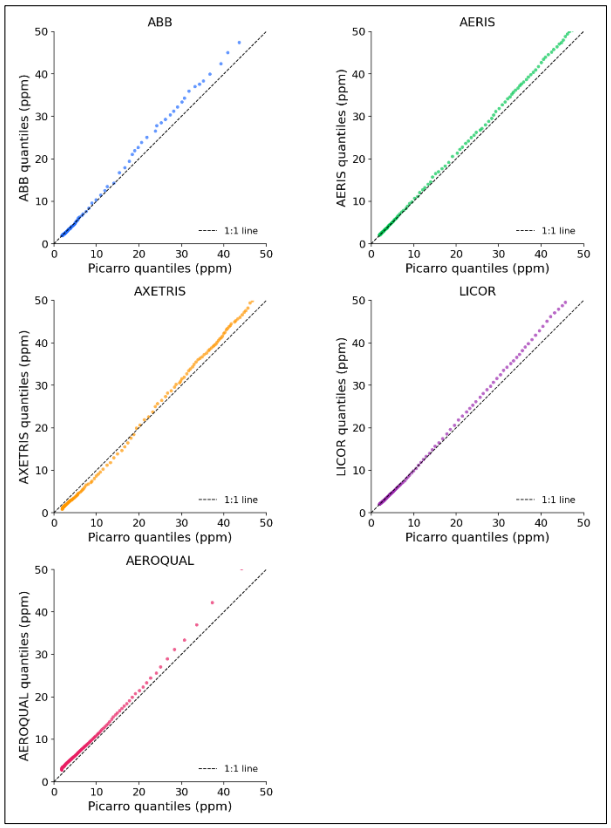


Figure 1. Q-Q plots for each of the five instruments tested against the Picarro

The Taylor diagram in Figure 2 is useful as it summarises three different measures of how well a dataset matches a reference in a single plot:

- Correlation – how well the data matches the Picarro (angular position on curved outer axis)
- Standard deviation – how well the data matches variability and peaks and troughs proportionally, even if there is a constant offset (in this case the standard deviation is normalised to the Picarro)
- Centred RMS difference – remaining error once correlation and variability are accounted for.

The Aeroqual unit performs best for this analysis, with its location on the plot (red cross) closest to the Picarro (black star). It shows the highest correlation and the lowest centred RMS difference.

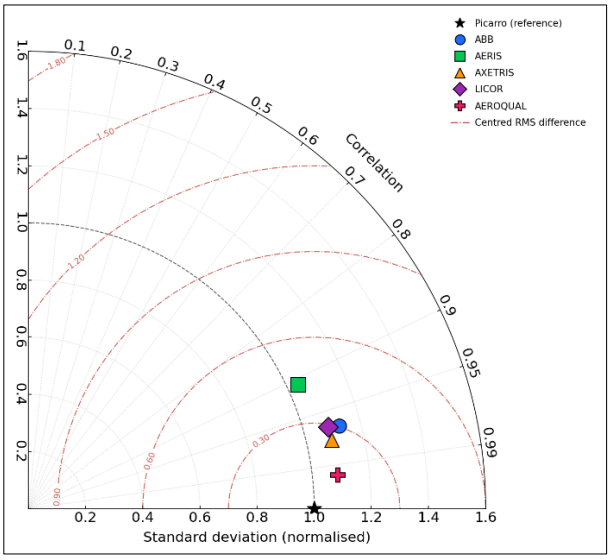


Figure 2. Taylor diagram showing the five instruments tested against the Picarro

4. Key findings and conclusions

No single technique met all requirements for a site-wide, inventory-grade fugitive methane monitoring program. Flux chamber surveys remain the most accurate option for high-concentration point sources and are being taken forward for further testing. Point-measurement drone surveys have been narrowed to the ABB MicroGuard and Axetris. Path-measurement drone surveys will progress with the Pergam Laser Falcon Plus, and several lower-cost static sensors (Aeroqual AQS1, Axetris) are being evaluated as continuous measurement alternatives. Aircore-mounted drone techniques are not recommended for further use due to their time-intensive set-up and analysis.

Overall, a complementary suite of technologies is required to characterise fugitive methane across the range of source types, spatial scales and temporal variability. These findings have informed the selection of three candidate techniques (flux measurement, point-measurement drone survey and path-measurement drone survey) for controlled-release testing of a periodic emissions measurement methodology, and further development of static/open-path techniques for a continuous emissions measurement methodology.

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