Comparing Personal Air Pollution Monitors for Measuring Exposure in Polluted North Denver Neighbourhoods

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SUMMARY
Personal $PM_{2.5}$ sensors (Atmotube Pro) were validated by comparison with reference monitors during colocation deployments and by testing in a chamber and apartment using representative indoor emission sources (cooking, dust, candle burning). Preliminary results from colocation deployments suggest correlations between personal sensors tend to range widely at the 1-min level and are moderately correlated with a reference monitor at the hourly average level. Personal $PM_{2.5}$ sensors will be deployed to 50 participants for month-long periods four times over the next two years as part of an environmental justice research study in North Denver communities, and sensor performance will continue to be evaluated.

KEYWORDS
Environmental Justice, Personal Exposure, $PM_{2.5}$, Low-Cost Sensors, Citizen Science

1 INTRODUCTION
The neighbourhoods of Globeville, Elyria-Swansea, and Cole (GESC) in North Denver experience elevated concentrations of ambient particulate matter and noxious odours from traffic and industrial emissions (Eltarkawe and Miller 2019; Considine et al. 2021). Large-scale construction activities currently underway compound existing poor living conditions in GESC. A two-year study is underway measuring the impact of construction activities on community members' well-being, air pollutant exposure, and ability to move around the community. During this study, 50 participants will wear a personal air quality sensor (Atmotube Pro) for a one-month period twice per year for two years. Presented are the results of sensor validation testing, including colocation with reference monitors in summer 2021.

2 MATERIALS/METHODS
Validation testing was conducted with two types of commercial-grade personal exposure sensors (Atmotube Pro, N=32-55; Flow 2, N=12), stationary sensors (QuantAQ, N=5; Dylos, N=5), and research-grade instruments (GRIMM EDM 180, TSI OPS 3330) across a range of deployment types. Colocation data sets are the focus for the present analysis (Table 1). Swansea-I70 is a monitoring site operated by the Denver Department of Public Health and Environment at Swansea Elementary School by Interstate 70 (I70), and Globeville-I25 is a US Environmental Protection Agency regulatory site located next to Interstate 25 (I25).

Table 1. Personal $PM_{2.5}$ Sensor Validation Testing Summary

Test Type	Dates	Sensors
Swansea-I70	6/10/2021 – 6/14/2021	Atmotube Pro, Flow 2, GRIMM, OPS
Globeville-I25	7/12/2021 – 7/18/2021	Atmotube Pro, Flow 2, GRIMM, OPS, QuantAQ, Dylos

3 RESULTS AND DISCUSSION

Figures 1a and 1b depict the time series during the two colocation deployments for the Atmotube Pro personal exposure monitor and GRIMM reference monitors. As preliminary analysis, correlation coefficients were calculated for 1-min raw data and hourly averages collected during the Globeville-I25 and Swansea-I70 testing.

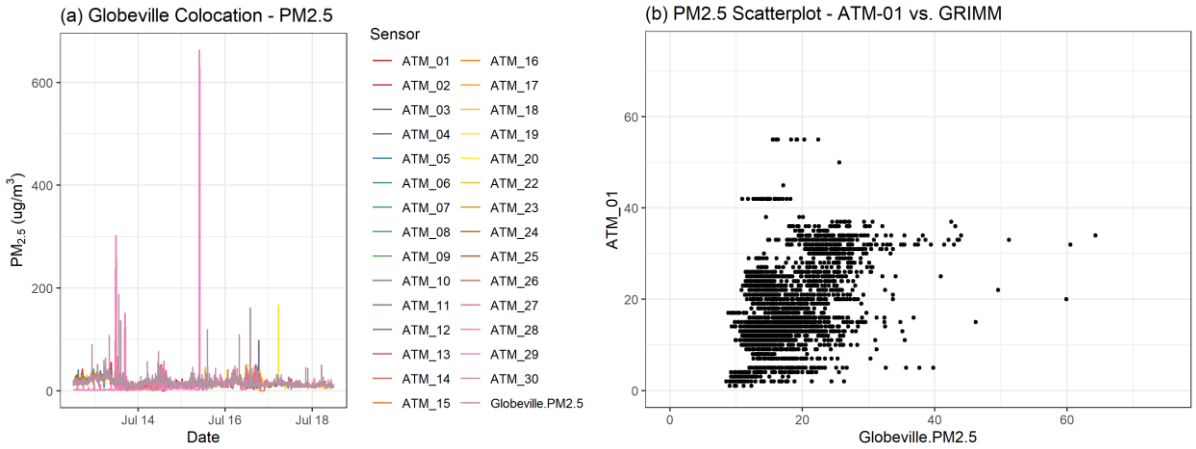

Figure 1. (a) Time series (1 min) of $PM_{2.5}$ concentrations from Globville-I70 colocation testing and (b) scatterplot (1 min) between ATM-01 and the Globeville reference monitor.

Correlations overall were lower during the Swansea deployment than for Globeville, likely due to improvements made to the instrument shelter for the Globeville deployment. For the Globeville data, correlations between Atmotubes and reference instruments were generally low for raw 1-min data, ranging from 0.2 to 0.5, while correlations between Atmotubes ranged from highly correlated (>0.9) to poorly or anti-correlated (<0.1). Correlations between Atmotubes and reference instruments for hourly-averaged data ranged from 0.2 to 0.7 and averaged (±SD) 0.6±0.2. A more detailed analysis of these data, including comparisons with other deployed sensors and for chamber and apartment deployments, as well as a more complete statistical analysis of bivariate comparisons, is forthcoming.

4 CONCLUSIONS

Personal exposure sensors tested here perform comparably to other low-cost $PM_{2.5}$ monitors. Sensor performance will continue to be evaluated twice per year between deployments with participants to observe potential long-term changes in data quality. Calibrating personal $PM_{2.5}$ sensors poses a challenge due to the variety of aerosol types encountered during a day, compared to stationary ambient or indoor monitors, and future work aims to understand the impact of this variability on data quality.

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5 REFERENCES

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