Evaluating Low-Cost Sensors for Measurement of Total Volatile Organic Compounds (TVOC) in a Laboratory Chamber

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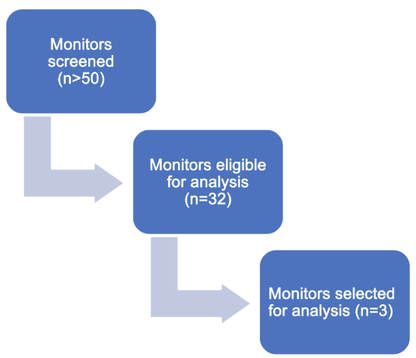
Background

- Volatile Organic Compounds (VOCs) are only routinely monitored at National Air Toxics Trends stations of which there are only 27 stations in the U.S., (compared to over 1000 for $PM_{2.5}$).[1]
- The Environmental Protection Agency does not have federally enforceable standards to regulate household products.[2]
- The term ”total VOC” (TVOC) refers to the total concentration of VOCs in given volume of air.[3]
- Low-cost VOC sensors may provide accessible, real-time monitoring of VOCs in various environments.

Objectives

- Evaluate the **accuracy and precision** of consumer-grade monitors for different TVOC sensors in a laboratory chamber.
- Determine **sensor response** across certain daily-use products among differing environmental conditions.

Methods

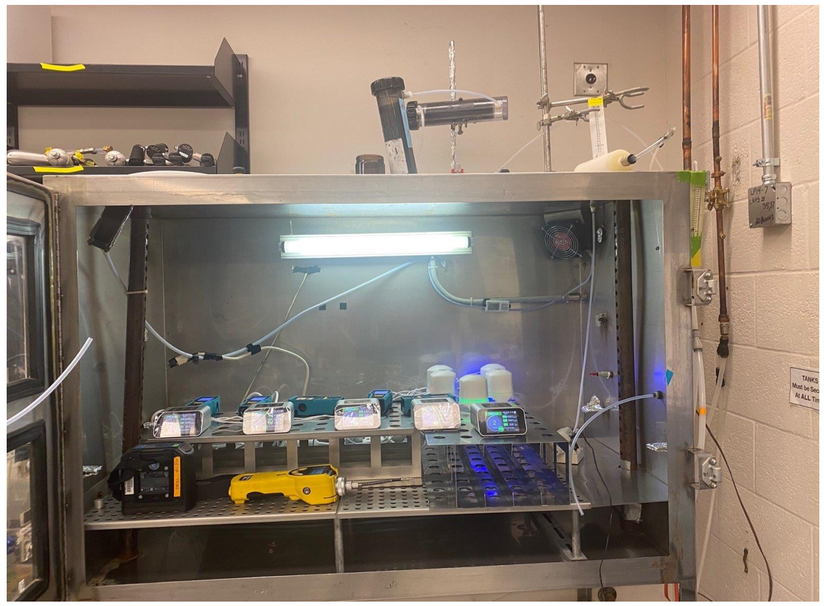


- Cost considerations
  - <$300 for low-cost
  - Accessibility
- Sensor type considerations
  - Electrochemical
  - Metal oxide semiconductor
  - Photoionization detector
- Calibration, resolution, and output considerations
  - Detection range
  - Calibration timing and maintenance
  - Data logging
  - Charging capacity or battery

Ambient air, conditioned with activated carbon

- 1-jet Collison nebulizer with different solutions
- Diluted ethanol and acetone
- Differing flow rates between 0-1 LPM
- Differing temperature and relative humidity conditions

Laboratory Chamber Set-Up



- 3 metal-oxide sensors (BLATN BR-Smart, BRWISSEN BR-A18, and Purple Air Zen)
- Reference instrument (RAE Systems MiniRAE 3000+)
- Testing with 0.1% acetone, 0.5% ethanol

Results

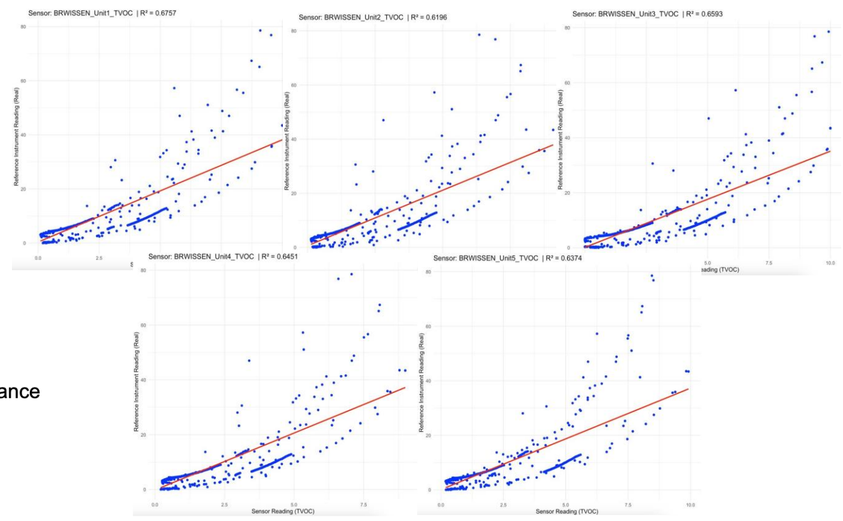


Figure 1. BRWISSEN Sensors Agreement with Reference (R^2: 0.6-0.7)

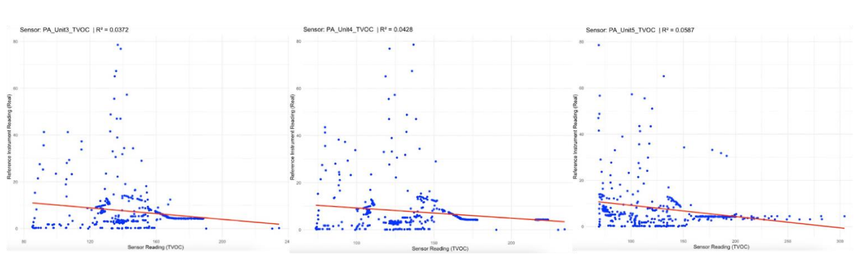


Figure 2. Purple-Air Sensors Agreement with Reference (R^2: 0.0-0.1)

Results

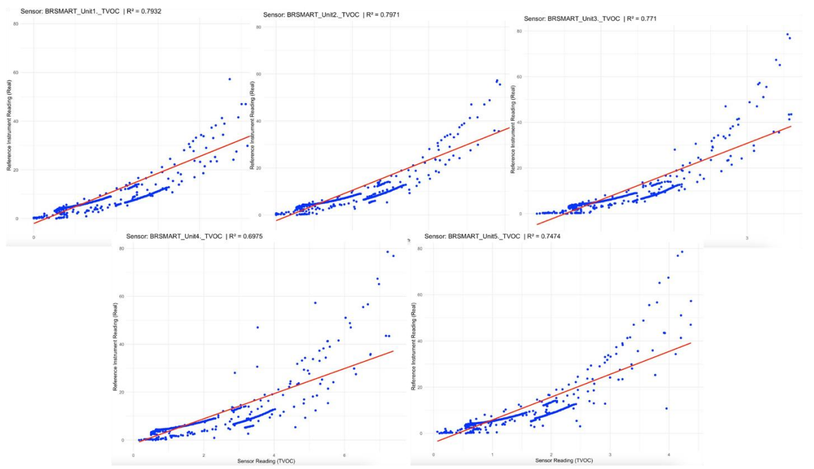


Figure 3. BRSMART Sensors Agreement with Reference (R^2: 0.7-0.8)

Conclusions

• Two monitors (BR-Smart and BRWISSEN BR-A18) rely on sensors periodically exposed to fresh air to calibrate a zero-VOC baseline reading.

• PurpleAir’s sensor does not indicate when the sensor's internal heater has reached the necessary temperature to read out a value; the values may be inaccurate.

Next Steps

• Continue testing sensor response with other single gases before moving on to the personal care and housing products (e.g., fragrances, hair spray, lotion, deodorant, all-purpose cleaners, disinfectants)

• Evaluate biases due to relative humidity and temperature

References

[1]Air Toxics Ambient Monitoring (2024). In EPA.gov. Retrieved January 8, 2025, from https://www.epa.gov/amtic/air-toxics-ambient-monitoring.

[2]Does EPA regulate volatile organic compounds (VOCs) in household products? (2024). In EPA.gov. Retrieved January 8, 2025, from https://www.epa.gov/indoor-air-quality-iaq/does-epa-regulate-volatile-organic-compounds-vocs-household-products

[3]Jia C, Cao K, Valaulikar R, Fu X, Sorin AB. Variability of Total Volatile Organic Compounds (TVOC) in the Indoor Air of Retail Stores. *Int J Environ Res Public Health*. 2019;16(23):4622. Published 2019 Nov 21. doi:10.3390/ijerph16234622

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