

Evaluation of Consumer Photometers for Measuring Environmental and Occupational Aerosols

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Background

- Photometers are direct-reading instruments that provide real-time aerosol mass concentrations inferred from scattered light by an assembly of particles.
- The high-cost of photometers (>\$5,000) can make them outside the budget for many industrial hygiene programs.
- Recently, many consumer photometers (<\$300) have become available, marketed for in-home use.

Objective

- Evaluate the performance of consumer low-cost sensors for environmental and occupational aerosols.

Methods

Measurement Devices

- Three Consumer Photometers (Table 1)
- Traditional Field Photometer
 - pDR-1500 (\$6,000) operated with an inlet cyclone (cut-off diameter of 2.5 μm) and a 37-mm glass microfiber filter
- Reference Instruments
 - Aerodynamic Particle Sizer (APS; \$45,000)
 - Scanning Mobility Particle Sizer (SMPS; \$65,000)
- Gravimetric filter used to correct reference instrument mass measurements only

Test Aerosols

- Salt Particles, 0.9% solution (non-absorbing fine particles)
- Welding Fume (absorbing fine particles)
- Arizona Road Dust (ARD; coarse particles)

Selected Environmental and Occupational Settings

- Environmental: up to 300 $\mu\text{g}/\text{m}^3$.
- Occupational: Maximum allowable concentration (up to 8,500 $\mu\text{g}/\text{m}^3$) based on the aerosol generation methods used and experimental setup.

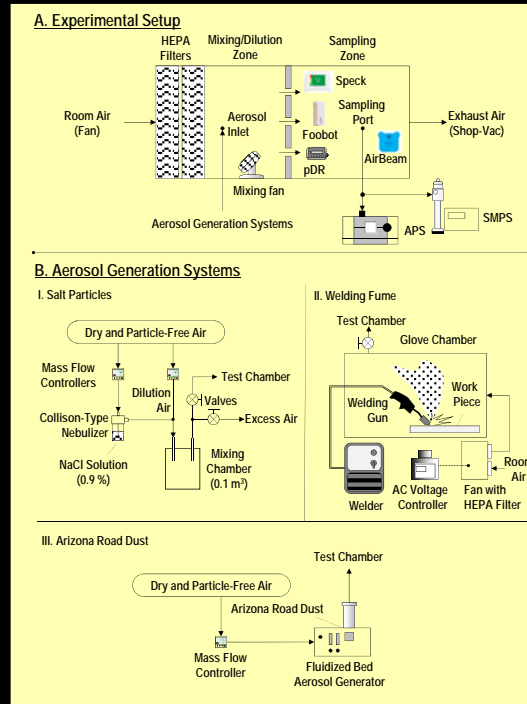
Performance Metrics

- Precision (Coefficient of variation-CV)
- Slope and Intercept
- Correlation
- Bias

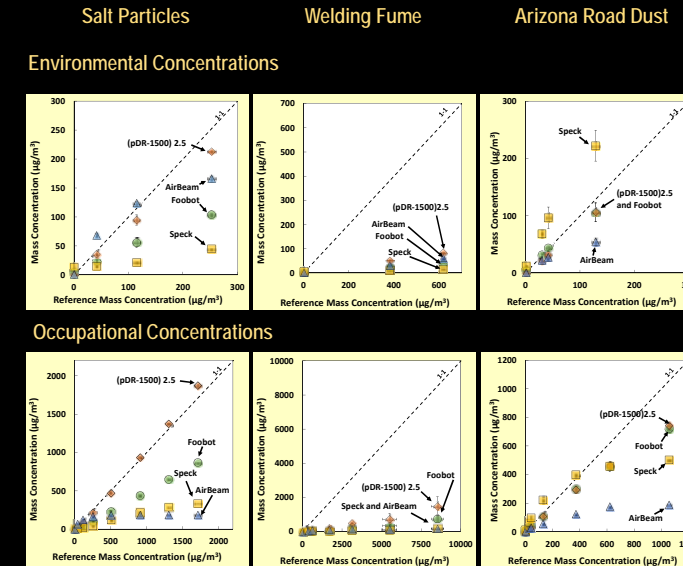
Table 1: Selected Consumer Photometers

Consumer Photometer	Manufacturer	Price	Maximum Concentration
Foobot	Airoxlab	\$200	1600 $\mu\text{g}/\text{m}^3$
Speck	Carnegie Mellon University	\$200	640 $\mu\text{g}/\text{m}^3$
AirBeam	HabitatMap	\$250	300 $\mu\text{g}/\text{m}^3$

Experimental Setup



Results



- Foobot exhibited the best performance of consumer photometers, approaching that of the pDR-1500.
- Mass concentration of Foobot linear and highly correlated with reference instruments. Speck and AirBeam non-linear.
- As expected, type of aerosol had a large impact on all photometer responses.
 - Robust response observed for salt and ARD.
 - Poor response for welding fume, which is brown in color and dominated by sub-300 nm particles.
- All consumer photometers had high bias values compared to reference instruments.

Conclusions

- Foobot (\$200) responds similarly to the traditional field photometer, pDR-1500 (\$6,000).
- Aerosol size and composition dramatically impacts the response of all photometer devices.

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