Mahdavi A, Siegel JA. 2020. Quantitative Filter Forensics: Size Distribution and Particulate Matter Concentrations in Residential Buildings. *Indoor Air,* **31**(4): 1050-1060.
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Abstract

Quantitative filter forensics (QFF) is a promising technique to measure indoor air prolonged particle size distribution and the concentration of particle-bound contaminants. This technique is established based on the combination of filter forensic, i.e., the analysis of dust collected in the heating, ventilation, and air-conditioning (HVAC) filters, and HVAC effective filtration volumes (the product of HVAC flow rate, runtime, and filter efficiency). We applied QFF in 21 residences in Toronto, Canada, and 6 residences in Central Texas, U.S., to estimate the total suspended particle (TSP) size distribution and/or concentrations. Using extraction and laser diffraction, we found that approximately 90% of the volumetric distributions were >10 µm and the volume median diameter (VMD) ranged from ~ 25 to 75 µm. The total suspended particle (TSP) concentrations in Toronto residences ranged from 2.9 to 823.7 µg/m3 (median = 89.8 µg/m3) with a moderate correlation with the content of TSP on the filters (g) and with the TSP effective filtration volume (m^3) showing the importance of both filter forensics and HVAC metadata parameters to QFF concentration estimates. No strong correlation was found between PM_{10} or $PM_{2.5}$ and hourly airborne particle number concentrations measured by low-cost sensors suggesting an evaluation of QFF is warranted, particularly for the exploration of smaller particles.

Main findings

1. Particles larger than 10 µm form a substantial fraction of indoor airborne particles that may be underestimated by real-time samplers due to the short airborne lifetime of these particles as well as the low real-time sampling efficiency for these particles.
2. Filter dust is less biased in terms of particle size than settled dust. The higher settled dust VMD suggests less prevalence of smaller particles in settled dust as of low gravitational settling relative to larger particles.
3. The correlation between TSP concentration and the content of TSP on filters was stronger for the refined case of high effective filtration volumes (the top quartile), indicating QFF can be estimated by filter forensics when filtration volumes are higher to avoid difficult HVAC metadata measurements.
4. The fraction of particles < 10 µm and < 2.5 µm in filter dust measured by laser diffraction didn't correlate with filter efficiencies in these ranges, suggesting these particles are either lost in the extraction, masked by larger particles during the diffraction, or agglomerated to larger particles. This necessitates the evaluation of QFF, particularly for smaller particles.

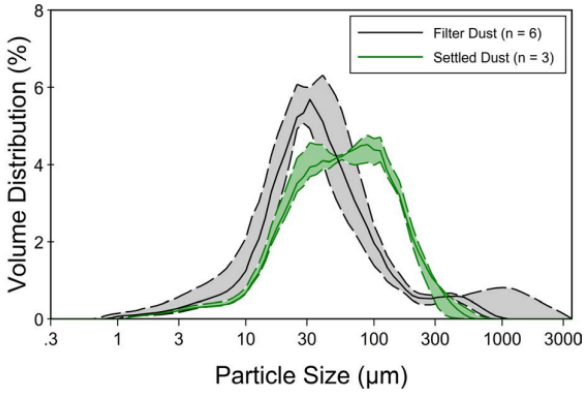

Figure 1B Size distribution of filter and settled dust in Central Texas residences (n represents the # of samples).

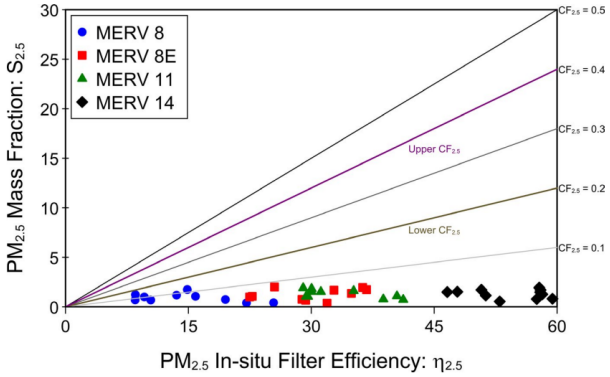

Figure 5 Measured (markers) and calculated (lines) $PM_{2.5}$-to-TSP concentration ratios ($CF_{2.5}$) with upper/lower $CF_{2.5}$ from the literature and airborne sampling in Toronto Site #1.

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