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Mahdavi A, Dingle J, Chan AWH, Siegel JA. 2021. HVAC filtration of particles and trace metals: Airborne measurements and the evaluation of quantitative filter forensics. *Environmental Pollution*, **271**, 116388. DOI: 10.1016/j.envpol.2020.116388

Abstract

The purpose of this article is to evaluate quantitative filter forensics (QFF) for prolonged indoor airborne particle and trace metal concentrations. QFF is established based on the combination of filter forensic, i.e., the analysis of dust collected in a heating, ventilation, and air-conditioning (HVAC) filter, and HVAC effective filtration volumes (the product of HVAC flow rate, runtime, and filter efficiency). The evaluation was performed by comparing the QFF results with those obtained from an alternative airborne sampling. Both QFF and airborne samplings were performed in a house equipped with a central HVAC system over six weeks to measure the integrated particle size distribution and the concentration of total suspended particles (TSP), PM_{10}, $PM_{2.5}$, PM_1, and 12 trace metals. The results indicated the concentration of TSP and over half of the tested trace metals, including Pb, Cd, Ni, V, Sb, K, and Sr, estimated by QFF was within a factor of two relative to airborne sampling results. PM_{10}, $PM_{2.5}$, and PM_1 concentrations were significantly underestimated by QFF potentially due to the limitations of size distribution analysis by a laser diffraction particle sizer (LDPS) in the detection of particles < 1 µm. Overall, while QFF was promising for TSP and some trace metals, size distribution analysis improvements and understanding other limitations such as runtime could extend the application of QFF for airborne sampling.

Main findings

1. Although less effective for the air-cleaning of particulate matter (PM) and trace metals due to uncorrelated airborne concentrations and HVAC runtime, HVAC filters remain effective for air sampling of particles and QFF estimations.
2. QFF is a promising technique to measure TSP concentration and trace metals in the TSP range. The QFF results were mostly consistent with those of integrated airborne sampling for TSP and over half of the tested trace metals. This suggests the application of QFF may expand to a broader spectrum of particle-bound contaminants in the TSP range with promise.
3. The lack of correspondence between QFF and airborne sampling for PM_{10}, $PM_{2.5}$, and PM_1 suggests the underrepresentation of particles < 10 µm with the current QFF size distribution techniques including dust extraction and laser diffraction analysis. This underrepresentation could be explained by either particle loss during the extraction process, agglomeration of small particles to larger particles, or masking of smaller particles by larger particles during the diffraction. In either case, particle separation and size distribution analysis improvements would help overcome QFF limitations.

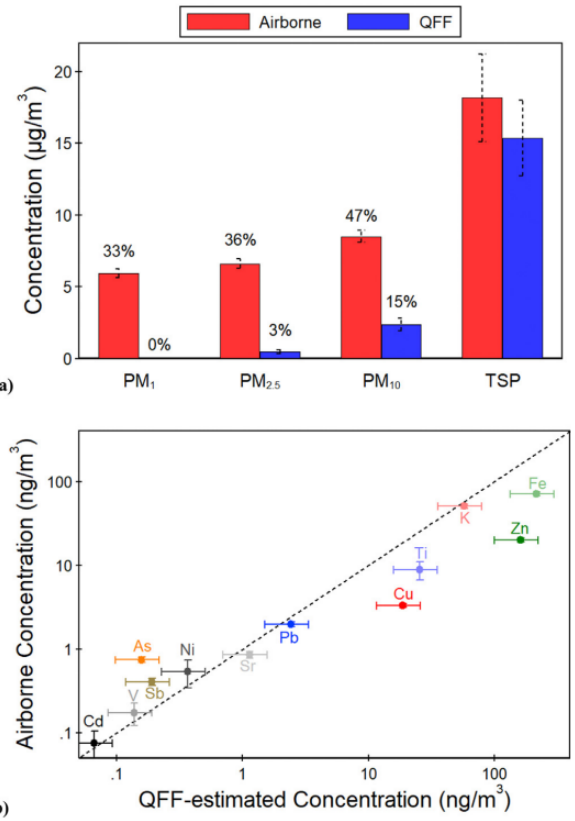

Figure 3 QFF evaluation of a) PM_1, $PM_{2.5}$, PM_{10}, and TSP, and b) trace metals.

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