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Use of portable particle counters for the assessment of residential exposure to indoor-generated particles

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Contribution of indoor sources of particles to personal exposure has not been fully assessed nor understood. Ambient and non-ambient origin of particles present in indoor environments with their site specificity and intermittent nature do not make the assessment easy. In the past large and noisy instruments requiring operator attendance prevented measurements in indoor environments on large scale. Data available on indoor particle number concentrations originate from measurements conducted in a few residences. So far three published studies addressed indoor source contribution to residential exposure, the amount of residences covered range between 1 to 7 (Bhangar et al., 2011; Mullen et. al., 2011, Wallace and Ott, 2011)

The aim of this study was to evaluate the suitability of portable particle counters for the assessment of the indoor sources contribution to residential particle exposure.

Measurements were conducted in 56 residences in Copenhagen for about 45h during weekdays of the 2011/2012 winter season. Three NanoTracers (Philips Aerasense) were used for particle number concentration measurements in the size range between 10 and 300 nm. Participants filled in a detailed activity logbook for identification of time spent at home, identification of indoor sources and subsequent estimation of the contribution of indoor sources to residential particle exposure. The instruments were purchased directly before the commencement of the measurements thus were manufacturer's calibrated. Their performance in measuring particle concentration was assesed against a Scanning Mobility Particle Sizer (SMPS 3934, TSI Inc.) at the end of the measurement period in a chamber experiments conducted in the Aerosol Laboratory at Lund University. Particles from three typical indoor sources (candle, cigarette smoke, incense) were used for comparisons.

Results from the chamber experiments showed that for the tested indoor sources 1-hour average NanoTracer-to-SMPS number concentration ratios were between 0.73 and 1.03 for the three instruments, indicating that the NanoTracers tend to underestimate the number concentrations. The obtained results can be compared to results of Asbach et al. (2012) who reported Nanotracers' accuracy of ± 30% for measuring number concentrations of sodium chloride, di-ethyl-hexyl-sebacate and soot particles. On two occasions in our chamber experiments one Nanotracer showed 43% lower concentration during incense burning while another showed 53% higher concentrations during cigarette smoke, compared to SMPS. There was no trend suggesting that any of the instruments would measure different results in a consistent manner. Thus, no correction factor was applied to the measured data.

Based on the time resolved particle number concentrations and the detailed activity logbooks, indoor sources were identified and their contribution to the daily residential exposure was estimated. On average, indoor sources accounted for 65% of the daily residential exposure. When the contribution from candle burning, the dominant indoor particle source, was excluded, the indoor sources accounted for 50%. These values are comparable to the results from 7 California residences (Bhangar et al., 2011) where indoor sources accounted on average for 59% of the residential exposure.

Even if the accuracy of the NanoTracers is ± 30%, their small size, battery and silent operation make them an interesting alternative for measurements in indoor environments, where minimal disturbance for the occupants is crucial. They allow conducting time resolved particle number measurements in a relatively large study population, that can give a unique insight into important part of personal exposure i.e. residential exposure. Results from the measurements in 56 Danish residences proved that these instruments can be used for estimation of residential exposure to indoor-generated particles. The results point out that contribution of indoor sources can be significant and should be considered in the health effects assessments. However the use of these portable instruments requires regular comparisons of their performance against other particle counters as well as their cross-comparisons (if several are used).

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