Questioning the appropriateness of sieving for processing indoor settled dust samples

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- **Microscopy, carbon, and PAH analysis suggest inconsistent particle separation by sieving**
- **Presence of fibers in indoor dust interferes with sieve separation**
- **Separation of indoor dust by sieving can introduce bias in exposure estimates and size fraction profiles**

Motivation

- Sieving of dust is used frequently to find the distribution of chemicals in dust according to particle size, particularly to identify the fraction of the dust that is inhaled or adheres to the skin.
  - Studies investigating distributions of chemicals in dust fractions typically find inconsistent or highly variable distributions by size (Al-Omran and Harrad, 2016).
- What if sieving distorts the final result of the dust analysis due to fibers that do not pass into the correct fraction or occur in multiple fractions?
- Fibres may carry a unique chemical profile, and it is important to understand the impact of sieving on observed chemical distributions, and whether it can bias our view of human exposure to chemicals via dust.

Study design

Composite dust samples from indoor microenvironments

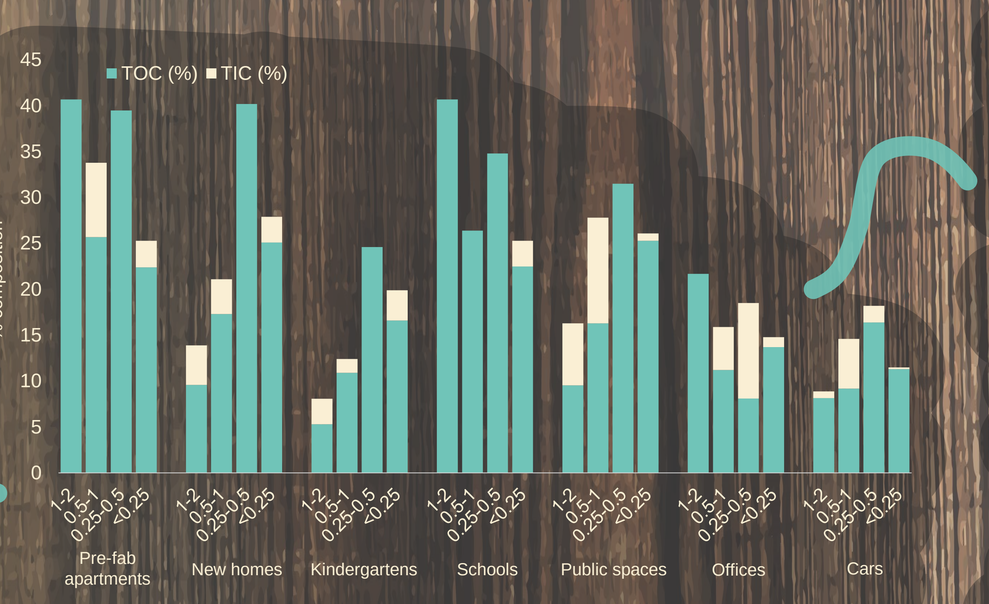
- Pre-fabricated apartments
- New houses
- Kindergartens
- Schools
- Public spaces
- Offices
- Cars

Sieve sizes

- <0.25 mm
- 0.25-0.5 mm
- 0.5-1 mm
- 1-2 mm

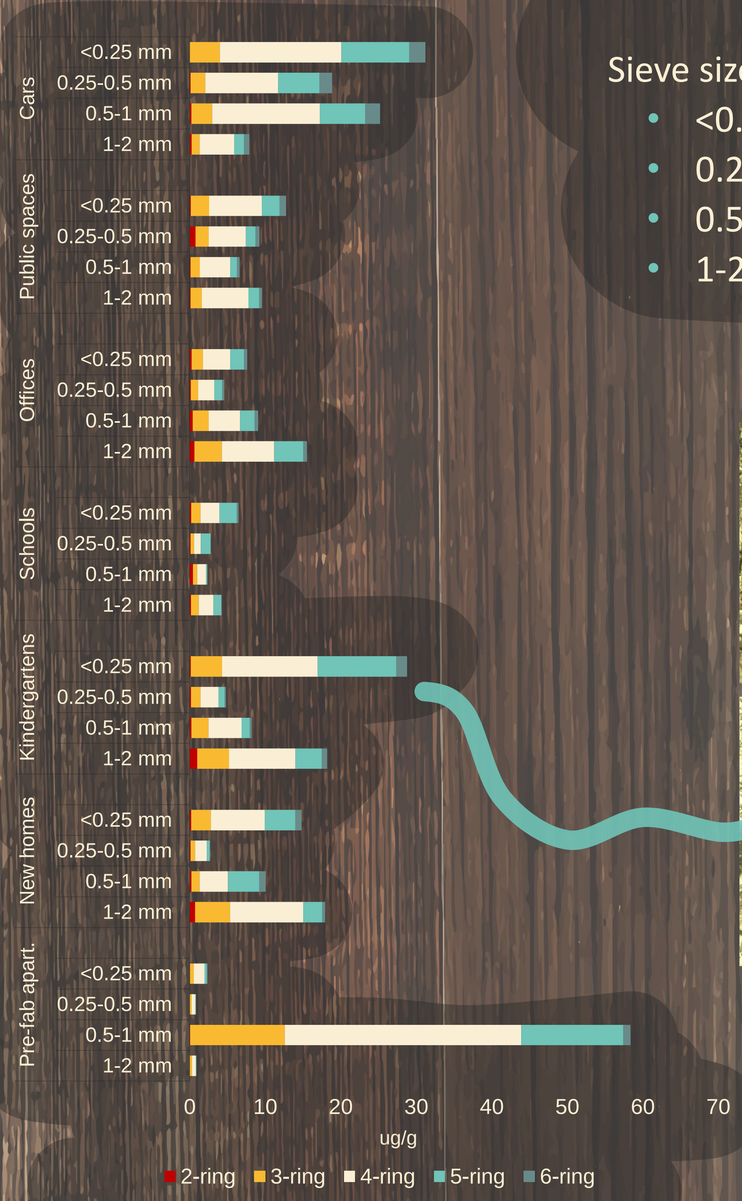
Analytes/methods

- Polycyclic aromatic hydrocarbons (PAHs)
- Organic and inorganic carbon (TOC, TIC)
- Optical microscopy



Carbon in individual dust size fractions in %

- Total carbon is highly variable, with notably lower levels in cars, public spaces, and kindergartens
  - TOC - in 31% of samples all carbon was in organic form
- TIC - very low, many cases below detection limit, all cases under <12%
  - Highest TIC - bulk dust from public spaces (4.5%) and cars (2.3%), attributed to outdoor material



ΣPAHs in ug/g TOC in indoor dust according to particle size fraction

Irregular distribution across dust size fractions - consistent with other studies (Cao et al., 2019; Liu et al., 2018)

Optical microscopy images of kindergarten dust size fractions

- visible absence of fibres in <0.25 mm fraction
- presence of fibers in all other fractions
  - 1-2 mm fraction - agglomerates of fibres, which also have fine dust

Discussion and Recommendations

- Irregular distributions of carbon content and PAH content across size fractions
  - PAH distributions did not follow the conventional understanding of partitioning to size fractions with greater surface area and/or carbon content.
- Chemical data combined with microscopy suggest that unclear separation of fibres and fine particles adhering to fibres may be contributing to this.
  - Caution should be used in interpreting chemical distributions in indoor dust amongst size fractions separated by sieving.
- Size segregated fractions with high fibre content may bias estimates of human exposure.
- Alternatives to dry sieving are not ideal: wet sieving risks "washing out" chemicals and techniques using air separation require more specialized equipment.
  - To avoid such bias, it is important to consider when such sieving is truly necessary, and when bulk dust could be appropriate (perhaps with only manual removal of large debris). This dust would retain the fibre content that may be important for exposure, and these fibers, due to their different origin, may have a very different chemical content than other dust particles.

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