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Quantifying volatile organic compounds and their sources in residences in Ahmedabad and Gandhinagar, India, and in suburban Shanghai, China

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1. Introduction

Volatile organic compounds (VOCs) are often measured at higher concentrations inside than outside, with concentrations influenced by:

- Outdoor sources (vehicles, industry, solvents)
- Indoor sources (personal care products, food, construction materials, furniture)
- Human behaviors (opening windows, doors).

People in urban environments spend the majority of their time indoors and many VOCs are associated with adverse effects on health but these pollutants and their sources remain poorly characterized indoors. With a growing middle class in India and China, an increasing number of people are living in newer homes where VOCs may be prevalent.

2. Methods

	China (suburban Shanghai)	India (Ahmedabad/Gandhinagar)
Sample description	• Spring 2017 - 20 homes	• Summer 2019 - 20 homes • Winter 2020 - 19 homes
Additional context	• Families asked to keep doors, windows closed • Air filtration: TRUE filtration; Pre-filter, HEPA, Activated carbon; SHAM filtration	• Doors, windows often open • High temperatures: 28-45°C in summer, ~7-30°C in winter • Sampling + questionnaires (household characteristics, activities during sampling) • No homes with air filtration
Sampling	• 90-minute integrated using Tenax and DNPH cartridges • Early morning • Twice per home, ~1 month apart (once each during sham and true filtration)	• Early morning (all) • Afternoon/evening (subset)
Analysis	• Source identification via non-negative matrix factorization (variable reduction) • Identification and quantification of hazardous compounds • Indoor/outdoor comparisons • Filtration effects	• AM/PM comparisons

3. Results and Discussion

In China and in India in the morning during the summer, total VOC concentrations (TVOC) were higher indoors than outdoors. Concentrations indoors in India tended to be lower than in China. In both locations, the individual compounds detected and their concentrations varied substantially between homes. These differences may relate to the products and materials used in the home, local pollution near the home infiltrating the home, and the time of day that sampling occurred. Many compounds were only detected indoors pointing to indoor sources, while others (toluene, acetaldehyde, formaldehyde) were nearly ubiquitous regardless of sampling location and time.

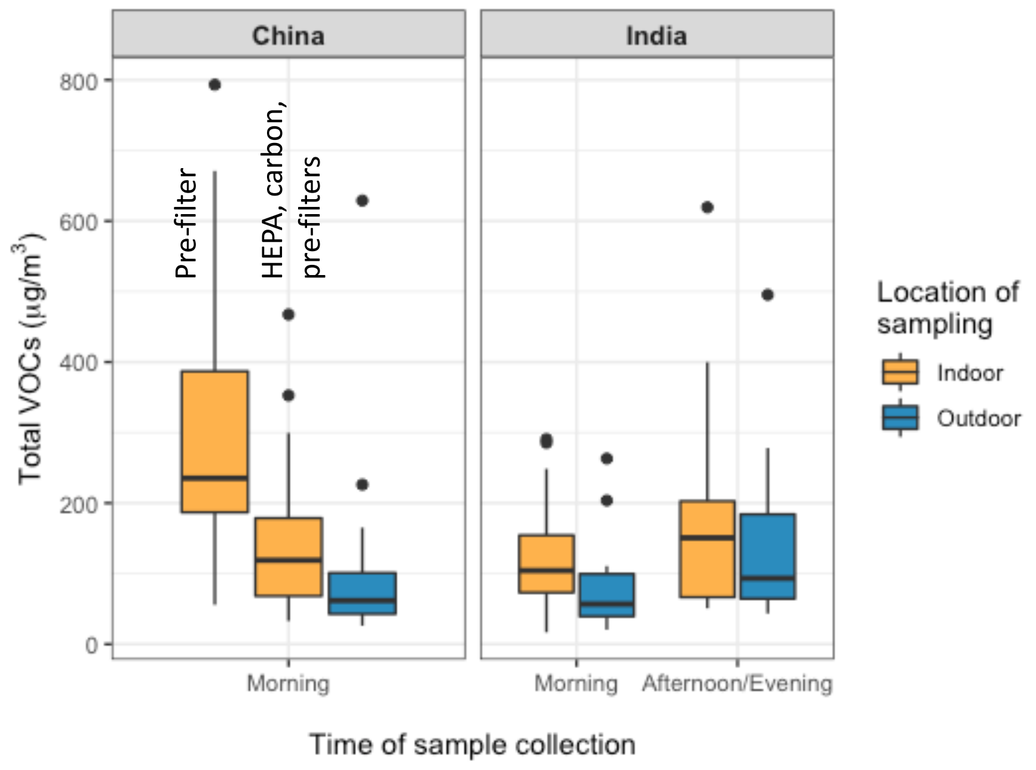

Figure 1: Total VOC concentrations at homes in Shanghai and Ahmedabad/Gandhinagar (summer only).

There were distinct indoor (e.g., cooking-related, personal care product) and outdoor (e.g., solvents, traffic) sources common to both sites. A hexane source and a wood-related source were identified in China and plastics-related and siloxane sources were identified in India. In China, air filtration was associated with lower TVOC, contributions from solvents and consumer products, and of numerous individual compounds – some hazardous. Seasonal differences were apparent in India, with higher concentrations in winter.

4. Conclusions

Substantial variation exists for VOCs, with concentrations often higher indoors than outdoors. Many hazardous compounds are prevalent indoors, and indoor sources of VOCs abound. To reduce exposures to these compounds, we must first quantify temporal, seasonal, and indoor/outdoor relationships of these compounds, and identify sources of the compounds. Exposures in these indoor environments are likely to become increasingly important with the burgeoning middle class and continued growth and development in India and China.

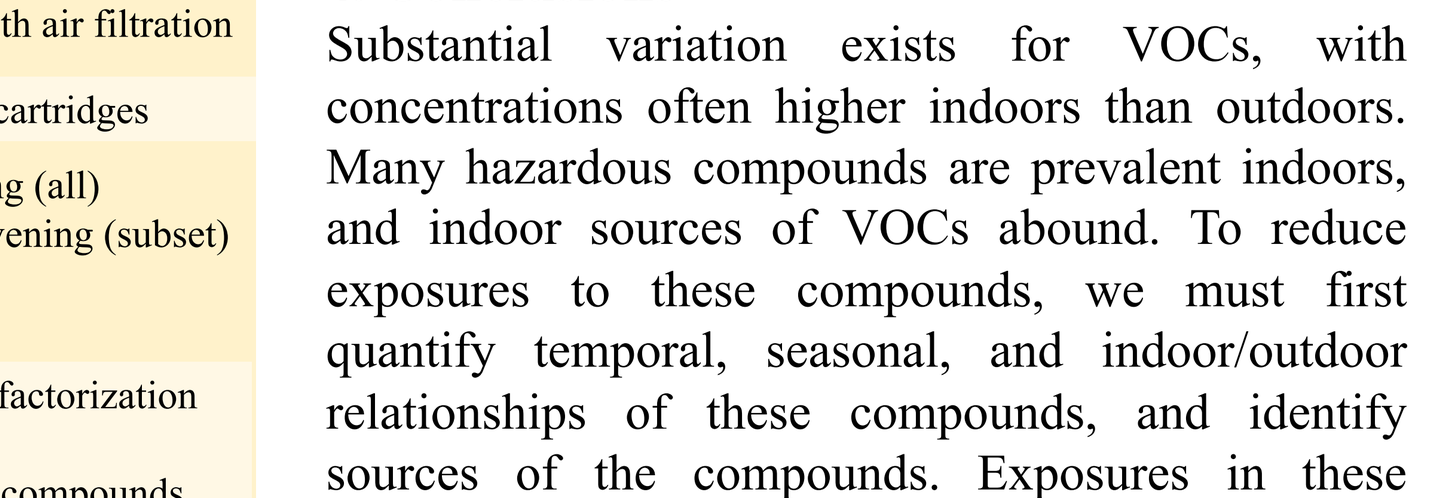

Figure 2: Overlap of compounds measured by group. Dots indicate that the bar applies to that sampling group (e.g., 36 compounds were measured indoors in January during both AM and PM sampling, but these 36 compounds were not measured in any of the other groups).

Acknowledgements

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