Title
Spatially and temporally resolved measurements of volatile organic compounds in a residence

ISBN
9788379472604

Authors
Liu, Y
Misztal, PK
Xiong, J
et al.

Publication Date
2017

Peer reviewed

Healthy Buildings 2017 Europe
July 2-5, 2017, Lublin, Poland

Paper ID to be filled in by Organizers ISBN: 978-83-7947-232-1

Spatially and temporally resolved measurements of volatile organic compounds in a residence

Yingjun Liu[1,*], Pawel K Misztal[1], Jianyin Xiong[1], Yilin Tian[2], Caleb Arata[3], William W Nazaroff[2], and Allen H Goldstein[1, 2]

[1] Department of Environmental Science, Policy, and Management, University of California, Berkeley, CA, United States;
[2] Department of Civil and Environmental Engineering, University of California, Berkeley, CA, United States;
[3] Department of Chemistry, University of California, Berkeley, CA, United States.

[*]*Corresponding email: yingjun.liu@berkeley.edu*

Keywords: indoor VOCs, indoor VOC sources, time-resolved VOC measurements, residential environment

1 Introduction

The average American spends 70% of their time in a residence (Klepeis et al., 2001). One major concern regarding residential indoor air quality is elevated concentrations of volatile organic compounds (VOCs) emitted from indoor sources (Weschler, 2009). A wide variety of VOCs have been measured in residential environments through time-integrated off-line methods (e.g., Zhu et al., 2013). Conversely, temporally resolved data are rare. As a result, we are lacking deep insight regarding the sources of VOCs in residential environments and their dynamic behavior influencing indoor concentrations and exposures. The current study carries out spatially and temporally resolved measurements of VOCs, combined with extensive auxiliary data acquisition, to understand the composition, dynamics, and sources of VOCs in a residence.

2 Materials/Methods

A single-family house in the San Francisco Bay Area, USA, was selected for the study. The house was built in the 1930s of conventional wood-frame construction. Two field campaigns are being undertaken, one in the summer (non-heating, completed) and a second during the winter (heating, ongoing) seasons. Both campaigns include vacant and occupied periods. Preliminary data from the summer campaign (Aug–Oct, 2016) are presented here.

A proton-transfer-reaction time-of-flight mass spectrometer (PTR-ToF-MS; Jordan et al., 2009) was used for temporally and spatially resolved measurements of VOC composition, switching between 6 different inlet locations (outdoor, kitchen, bedroom area, basement, crawl space, and attic) at 5-minute intervals. Other trace gases, such as CO_2 and O_3, were measured simultaneously. Three deuterated tracers were continuously released at constant rates from different locations in the house, to determine air-exchange and interzonal transport rates. An extensive set of metadata were collected, including the utilization of more than 50 wireless sensors to monitor time-resolved room occupancy, appliance use, door/window open status, temperature, and humidity.

3 Results and Discussion

Altogether, more than 600 mass peaks, corresponding to at least 400 VOC species, were

detected throughout the campaign. For 75% of observed ions, the mean signals in the living space (kitchen and landing) were more than double the outdoor levels. For 50 ions, levels in the living space were at least 10 times higher than outdoors. As indicated by tracer gases, air from the crawl space is transported upward into the living space and the attic. Conversely, and somewhat surprisingly, transport from the attic to the living space was not detectable (< 1%). The crawl space air composition was very similar to that outdoors; consequently, VOC emissions into the subspaces and their transport to the living space appears to be a minor indoor source for this house. A key conclusion is that VOCs observed in the living space are mainly emitted from sources in the living space itself. These emissions must originate from a combination of the building structure surrounding that space, the indoor contents, the occupants, and their activities.

The time series of most VOCs observed in the living space was characterized by clear episodic short-term enhancements on top of consistently elevated baseline levels. The enhancements generally occurred during human occupancy, and were associated with activities such as cooking and personal care product use. Except for a few species closely tied to human activities (e.g., ethanol and cyclic siloxanes), the contribution of the episodic enhancements represented a relatively small contribution to the overall time-integrated signal of the VOCs. Instead, the high background level for the majority of observed ions is a more general, and, to some extent, unexpected feature of the time series.

As a further step, indoor VOC source strengths are being quantified and detailed source apportionment is being assessed. This goal is being pursued by combining the VOC data with time-resolved measurements of air-exchange rates, interzonal transport rates, and house operational parameters (e.g., room occupancy, temperature/humidity, and appliance use).

4 Conclusions

More than 300 VOC ions were more abundant indoors than outdoors, with the levels of at least 50 being a full order of magnitude higher. Spatially resolved measurements demonstrate that VOCs present in the living space are mainly emitted from sources in the living space itself and from the building envelope materials that surround that space. Temporally resolved measurements indicate that the VOCs in the living space are dominantly from the building and its contents, with episodic short-term emissions occurring due to human activities such as cooking.

5 Acknowledgement

This work is supported by the Chemistry of the Indoor Environments program of the Alfred P. Sloan Foundation. Y. Liu acknowledges support from the Microbiology of the Built Environment Postdoctoral Fellowship of the Alfred P. Sloan Foundation.

6 References

Jordan, A., Haidacher, S., Hanel, G., Hartungen, E., Märk, L., Seehauser, H., Schottkowsky, R., Sulzer, P. and Märk, T.D., 2009. A high resolution and high sensitivity proton-transfer-reaction time-of-flight mass spectrometer (PTR-TOF-MS). *International Journal of Mass Spectrometry*, 286(2–3), 122–128.

Klepeis, N.E., Nelson, W.C., Ott, W.R., Robinson, J.P., Tsang, A.M., Switzer, P., Behar, J.V., Hern, S.C. and Engelmann, W.H., 2001. The National Human Activity Pattern Survey (NHAPS): a resource for assessing exposure to environmental pollutants. *Journal of Exposure Science and Environmental Epidemiology*, *11*(3), 231.

Weschler, C.J., 2009. Changes in indoor pollutants since the 1950s. *Atmospheric Environment*, 43(1), 153–169.

Zhu, J., Wong, S.L. & Cakmak, S., 2013. Nationally representative levels of selected volatile organic compounds in Canadian residential indoor air: population-based survey. *Environmental Science & Technology*, 47(23), 13276–13283.