Residential Exposure to Indoor and Outdoor Volatile Organic Compounds

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Introduction

Since the Clean Air Act of 1970, the USEPA has regulated outdoor air pollution to maintain a safe and healthy environment. However, because people spend 90% of their time inside, the concern has shifted from outdoor to indoor air pollution [1].

Volatile organic compounds (VOCs) are gases released from various sources found indoors and outdoors. Ten particular VOCs of concern were chosen for this study because they are known to cause depression of the central nervous system, respiratory irritation and various other adverse health effects [2].

The University of Washington's Center for Clean Air Research (CCAR) is currently conducting Project 5 of MESA Air: Effects of Long-Term Exposure to Traffic-Derived Particles and Gases on Subclinical Measures of Cardiovascular Disease in a Multi-Ethnic Cohort, data from their findings were used to complete this project.

Common Sources of VOC Exposure

Chemical	Indoor Sources	Outdoor Sources
Pentane	refrigerators, construction and packaging materials, aerosols	gasoline combustion, car care products
Isoprene	paints, coatings, synthetic rubbers, adhesives	gasoline and biomass combustion, cigarette smoke, pesticides
n-Nonane	paints, dry cleaning	jet fuel, petroleum, kerosene
n-Decane	paints, wood stains, dry cleaning	gasoline, jet fuel
n-Undecane	adhesives, latex	diesel fuel
n-Dodecane	synthetic rubbers	jet fuel, diesel fuel, gasoline
Benzene	plastics, foams, resins, lubricants, detergents, dyes, paints, synthetic fibers	crude oil, gasoline, biomass combustion, cigarette smoke, pesticides
Toluene	paints, foams, adhesives, synthetic fragrances and rubber, cleaning agents	fuel additive, jet fuel, kerosene
m-Xylene	paint thinners, aerosols, synthetic fibers	gasoline, pesticides, fiberglass
o-Xylene	wood stains, varnishes, lacquers, liquid inks	gasoline, automobile paints, pesticides

Methods

The CCAR Project 5 air samples were collected over 14 days from 46 participants in the winter using 3M 3520 organic vapor monitors (OVMs). Indoor sampling units were placed in the main room of the house. Outdoor sampling units were assembled in the participant's backyard. After two weeks, the OVMs were evaluated using gas chromatography to calculate a time weighted average of contaminants in parts per billion (ppb) or parts per trillion (ppt).

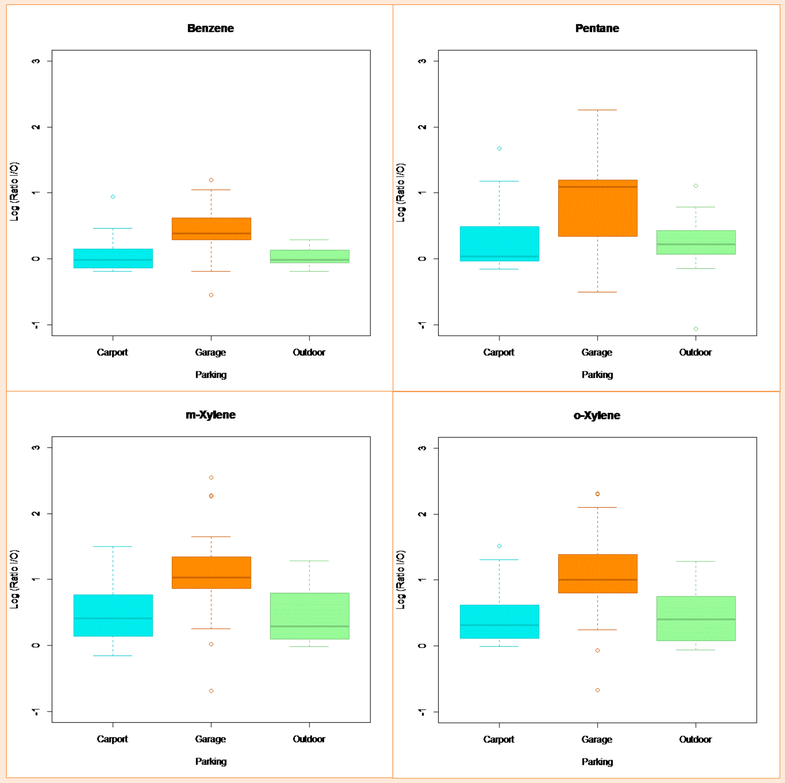
A: A 3M organic vapor monitor (OVM) with a quarter for scale
B: An indoor sampling station
C: An outdoor sampling station

Results

VOC	Indoor Median	Indoor IQR	Outdoor Median	Outdoor IQR	Median I:O Ratio
Pentane (ppb)	38.9	17.9-136.6	14.6	12.7-18.1	2.0
Isoprene (ppt)	14.8	4.9-55.9	5.0	5.0-5.1	2.9
n-Nonane (ppt)	87.1	34.6-227.2	8.9	4.5-13.4	7.8
n-Decane (ppt)	100.1	59.7-270.2	3.4	3.4-5.4	27.4
n-Undecane (ppt)	194.0	140.4-392.2	5.7	5.6-5.7	35.8
n-Dodecane (ppt)	65.5	32.2-171.3	16.5	16.4-16.7	3.9
Benzene (ppt)	266.2	185.6-438.5	194.5	190.9-230.0	1.4
Toluene (ppb)	1.2	0.6-2.6	0.2	0.2-0.3	5.4
m-Xylene (ppt)	330.3	106.8-887.0	71.9	55.3-95.2	3.7
o-Xylene (ppt)	142.4	56.7-382.2	36.2	27.1-46.5	3.4

- We evaluated the associations between the indoor to outdoor concentration ratios with gas-powered appliances and the parking locations of participants
- We investigated models to predict a relationship based on multiple factors—no other home characteristics significantly improved predictions over parking preference alone
- All samples were well within OSHA PEL standards

Homes with Attached Garages Have Higher Ratios of VOC Exposure



These four VOCs were chosen because they showed significant evidence of a relationship in comparison to the other VOCs studied.

Weak evidence showed parking preference was associated with an increased ratio of indoor to outdoor concentrations with values:

- Pentane: p = 0.050 R^2 =0.13
- Benzene: p = 0.014 R^2 =0.18
- m-Xylene p = 0.044 R^2 =0.13
- o-Xylene: p = 0.024 R^2 =0.16

Parking explains 13-18% of the variability observed in the ratios.

Discussion

The relationship between increased indoor VOC concentrations in homes and the presence of attached garages can probably be attributed to residual exhaust fumes as well as the storage of hazardous chemicals inside an attached garage. All ten chemicals are found in natural gas, common gasoline, diesel and/or jet fuels [4]. Combustion and rogue vapors of fuels release harmful VOCs that contribute to the concentrations found in ambient air outside and within the home.

Benzene, toluene and xylenes are listed amongst EPA's hazardous air pollutants and are known human carcinogens, limiting daily exposure is of utmost concern [1,5].

A few ways to reduce daily exposures to these harmful chemicals are:

- park cars outside whenever possible and keep door from garage into the home closed
- store all chemicals (cleaning supplies, paints, pesticides) in a shed or outdoor structure away from daily activities
- install a garage ventilation fan to remove harmful pollutants and circulate the air in a garage with outdoor air instead of the home

This project was limited to a single trial in Winston-Salem, North Carolina; however, the CCAR plans to perform multiple trials in cities across the country to better understand these exposure scenarios.

References

[1] USEPA (U.S. Environmental Protection Agency). 1989. Report to Congress on indoor air quality: Volume 2. EPA/400/1-89/001C. Washington, DC.
[2] ATSDR (Agency for Toxic Substances and Disease Registry). Center for Disease Control and Prevention 2013.
[3]OSHA (Occupational Safety & Health Administration) 2013. DSTEM (Directorate of Technical Support and Emergency Management).
[4] NLM (National Library of Medicine). National Institutes of Health: Health and Human Services. Hazardous Substances Data Bank 2011.
[5] IARC (International Agency for Research on Cancer) 2013. Agents Classified by the IARC Monographs, Volumes 1-107.

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