Indoor air quality assessments: Volatile Organic Compounds

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Outline

Introduction

- What are VOCs
- Sources
- Health effects

Sampling and Interpretation

- Sampling methods
- Reference values
- Interpretation

Management

- Ways to reduce exposures

Introduction

What are VOCs?

- Large group of carbon-based chemicals with similar chemical properties:
  - Have high vapor pressures at room temperature
- Differ in specific chemical properties, sources, health effects, control strategies

Examples

- Acetaldehyde
- Acetone
- Acrylonitrile
- Benzene
- Bromodichloromethane
- Carbon disulfide
- Chloroform
- Chloromethane
- Cyclohexane
- Dibromomethane
- Dicholorethane
- Ethanol
- Ethyl Acetate
- Ethylbenzene
- Ethylene gylcol
- Formaldehyde
- Hexane
- Methylene chloride
- Perchloroethylene
- Tetrachlorethene
- Tricholoroethene
- Toluene
- Xylene….

Sources

- Building materials (Paints, paint strippers, wood preservatives, solvents)
- Industrial processes
- Traffic emissions
- Soil
- Home and personal care products (cleansers, disinfectants, cosmetics, air fresheners, gasoline)

Concentrations are generally higher indoors vs. outdoors

Health Effects

Acute

- Eye, nose, throat irritation
- Nausea
- Loss of coordination

Chronic

- Kidney damage
- Liver damage
- Central nervous system effects
- Cancer

Vulnerable populations: those with pre-existing disease, such as asthma; the elderly; those sensitive to chemicals

Specific health effects vary by compound, and by dose & duration of exposure

Sources and health effects of specific VOCs

Appendix 4: Sources of VOC in Indoor Environments

Table A4-1 VOCs that may be emitted from building materials and their potential sources (California Department of Health Services 1996)

Chemical Name	Potential Sources
Acetic acid	Solvent for resins, caulks, sealants, glazing compounds, volatile oils
Acetone (2-Propanone)	Lacquer solvent
1-Amyl alcohol (Amyl alcohol; Pentyl alcohol; 1-Pentanol)	Solvent in organic synthesis
Benzaldehyde	Fiberboard, particleboard
Benzene	Adhesives, spot cleaners, alkyd paints, paint removers, particleboard, furniture waxes
2-Butanone (Methyl ethyl ketone)	Floor/wall coverings, fiberboard, caulking compounds, particleboard
n-Butyl acetate (Butyl acetate)	Floor lacquers
Butyl acrylate (Butyl-2-propenoate)	Used in manufacture of polymers and resins for textile and leather finishes
n-Butyl alcohol (1-Butanol)	Edge sealings, molding tapes, jointing compounds, cement flagstones, linoleum floor coverings, floor lacquers, industrial cleaners, paint removers
n-Butylbenzene	Solvent
Camphene	Occurs in many essential oils
Chlorobenzene	Solvent for paint, used in manufacture of phenol
Cyclohexane	Solvent for lacquers and resins, paint and varnish removers
Cyclohexanone	Solvent for many resins and waxes
Dibutylphthalate (Di-n-butyl phthalate)	Plasticizer
Diethylamine	Used in resins, dyes, and in manufacture of rubber
Dimethyl acetamide (N,N-Dimethyl acetamide)	Solvent for organic reactions
Dioxane (p-Dioxane; 1,4-Dioxane)	Solvent for many oils, waxes, dyes, cellulose acetate

Table A5-6 Toxic concentrations and endpoints for six VOC species, as identified by the California Department of Health Services (1996)

Substance	Concentration (ppm)	Health Effect	Comments and References
Benzene	7.8; 61	Olfactory threshold	(Devos *et al* 1990; AIHA 1989, respectively)
	0.24	Discomfort / mild effect	Transient changes in immune function tests may occur above this concentration (OEHHA 1995)
	1.0	Disability or serious effect	Developing fetus may be harmed above this concentration (OEHHA 1995)
	3,000	Immediately dangerous to life and health (IDLH)	NIOSH (1994)
Formaldehyde	0.87	Olfactory threshold	(Devos *et al* 1990)
	0.14	Discomfort / mild effect	Eye irritation (OEHHA 1995)
	10	Disability or serious effect	Tearing eyes (OEHHA 1995)
	20	IDLH	NIOSH (1994)
Methylene chloride	28	Olfactory threshold	(Devos *et al* 1990)
	24	Discomfort / mild effect	Subtle central nervous system impairment (OEHHA 1995)
	No threshold	Disability or serious effect	OEHHA (1995)
	2300	IDLH	NIOSH (1994)
Styrene	0.14 ; 0.14	Olfactory threshold	(Devos *et al* 1990; AIHA 1989)
	5.1	Discomfort / mild effect	OEHHA (1995)
	No threshold	Disability or serious effect	OEHHA (1995)

Taken from Ayers et al. (2002)[1]

Sampling & Interpretation

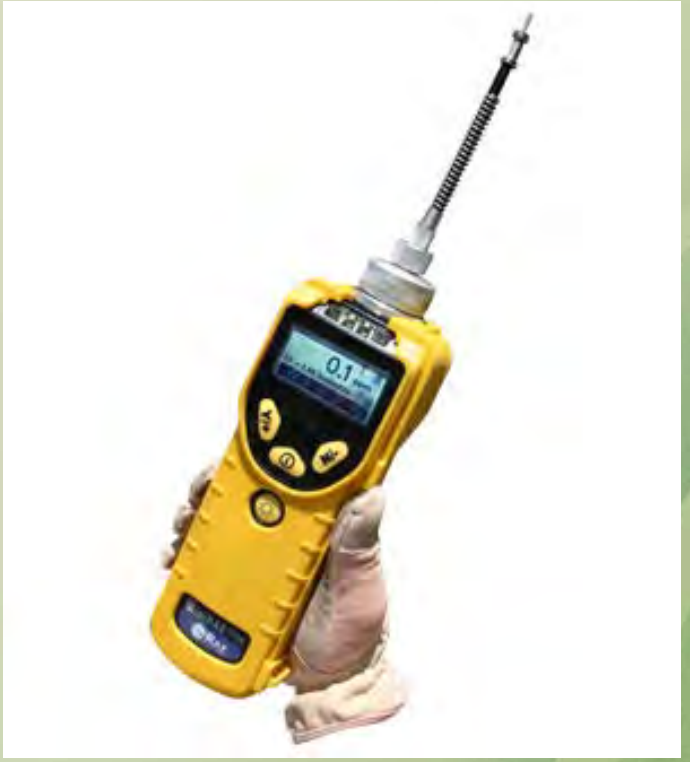
Sampling methods

- √ Direct monitoring
- √ Air trapping + analysis
- √ Personal passive monitoring
- √ Grab sampling

Direct reading monitors

Photoionization detector

- Most commonly used in residential settings
- Provides instantaneous measurements on total VOCs (tVOCs)

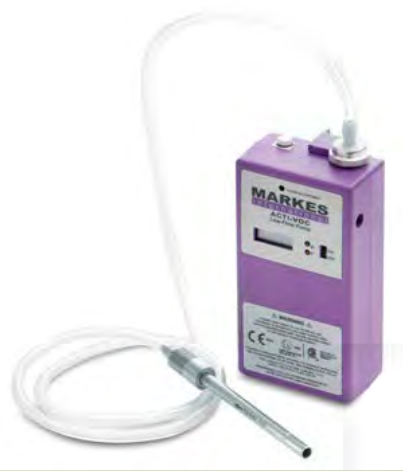


"MiniRAE 3000 PID Monitor", courtesy of Solutions EM

Air Trapping + Analysis

Sorbent tubes + Pump

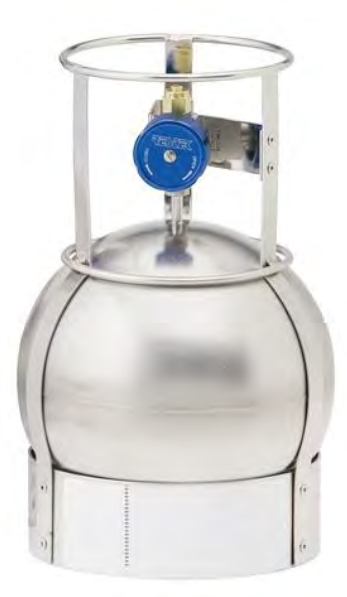
- VOCs attach to sorbent material as air is drawn through by pump
- Analyzed in lab for specific VOCs



Thermal desorption tubes, courtesy Azom.com

Summa Canister

- VOCs collected in canister
- Analyzed for specific VOCs

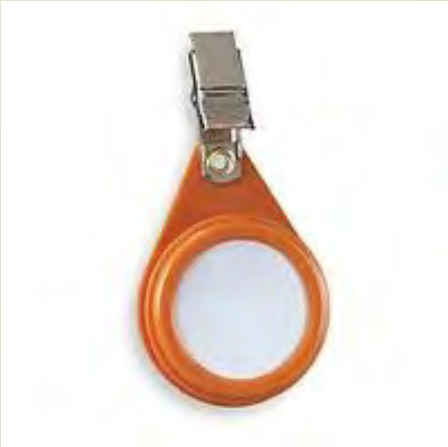


Specialised sampling, courtesy of Markes International

Other Methods

Passive sampling

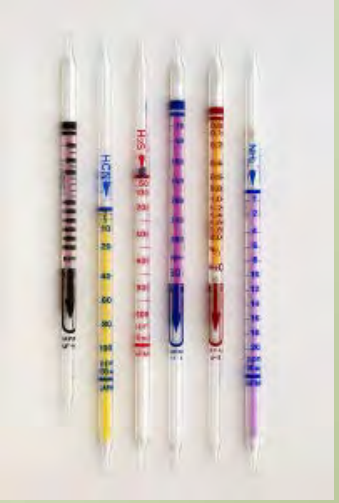
- Typically used in occupational settings
- Analyzed in lab for specific VOCs



3M organic vapor monitor, courtesy of Grainger

Grab sampling

- Colour change indicates presence of specific VOC and concentration
- No lab analysis required



Detection tubes, courtesy of Sensidyne

Colorimetric tubes, courtesy of Sensidyne

Reference Values

Compound	Value	Organization
Formaldehyde (Residential indoor air guideline)	1 hr: 123 µg/m^3 (100 ppb) 8 hr: 50 µg/m^3 (40 ppb)	Health Canada[2]
Toluene (Residential indoor air guideline)	8 hr: 15 µg/m^3 (4 ppb) 24 hr: 2.3 µg/m^3 (0.6 ppb)	Health Canada[3]
Total VOCs (Office buildings guideline)	< 0.2 mg/m^3: Comfort range 0.2 – 3.0 mg/m^3: Multi-factoral range 0.3 – 25 mg/m^3: Discomfort range 25 mg/m^3: Toxic range No individual VOC should exceed 10% of TVOC concentration.	European Commission Joint Research Centre[4,5]

Additional sources of information

Studies in similar settings

- May provide useful information on typical levels by type of building, city, country (background info)

Occupational exposure limits

- May be useful references in absence of other information
- Should be used with caution as these limits are designed to protect healthy workers from exposures

Interpreting Results

Consider:

- √ objective of sampling
- √ sampling and analysis methods
- √ reference values
- √ nature of complaints/concerns

Field ID:		LON-1				LON-2				LON-3			
Sample ID:		C189899-0001 2011AC44-00001				C189899-0002 2011AC44-00002				C189899-0003 2011AC44-00003			
Station ID:													
Collect Date:		OCT 2011				OCT 2011				OCT 2011			
Sample Location Description:										BLANK			
ample Comments Description:		VOLUME-3312 ML				VOLUME-3960 ML				BLANK			
Listid	Parmname	Value	Units	Qual	Rmk1	Value	Units	Qual	Rmk1	Value	Units	Qual	Rmk
3314L1	Chloroethene	.01	ug/m3	<=W		.01	ug/m3	<=W		.01	ug/m3	<=W	
	Butadiene	0.06	ug/m3	<T		0.06	ug/m3	<T		.01	ug/m3	<=W	
	Acrylonitrile	0.10	ug/m3			0.12	ug/m3			.01	ug/m3	<=W	
	2-methyl-1,3-butadiene	2.06	ug/m3			1.72	ug/m3			.01	ug/m3	<=W	
	Dichloroethene	.01	ug/m3	<=W		.01	ug/m3	<=W		.01	ug/m3	<=W	
	Dichloromethane	0.38	ug/m3			0.36	ug/m3			.02	ug/m3	<=W	
	1,1-dichloroethane	.01	ug/m3	<=W		.01	ug/m3	<=W		.01	ug/m3	<=W	
	Trichloromethane	3.83	ug/m3			3.84	ug/m3			.01	ug/m3	<=W	
	Hexane	1.25	ug/m3			1.15	ug/m3			.01	ug/m3	<=W	
	1,2-dichloroethane	0.40	ug/m3			0.39	ug/m3			.02	ug/m3	<=W	
	1,1,1-trichloroethane	0.15	ug/m3			0.13	ug/m3			.01	ug/m3	<=W	
	Benzene	1.30	ug/m3			1.18	ug/m3			.02	ug/m3	<=W	
	Carbon tetrachloride	0.66	ug/m3			0.57	ug/m3			.02	ug/m3	<=W	
	Cyclohexane	0.53	ug/m3			0.48	ug/m3			.01	ug/m3	<=W	
	1,2-dichloropropane	0.06	ug/m3	<T		0.06	ug/m3	<T		.01	ug/m3	<=W	
	Trichloroethene	0.15	ug/m3	<T		0.14	ug/m3	<T		.02	ug/m3	<=W	
	Bromodichloromethane	0.31	ug/m3			0.27	ug/m3			.02	ug/m3	<=W	
	cis-1,3-dichloropropene	.01	ug/m3	<=W		.01	ug/m3	<=W		.01	ug/m3	<=W	
	1,1,2-trichloroethane	.02	ug/m3	<=W		.02	ug/m3	<=W		.02	ug/m3	<=W	
	Toluene	8.85	ug/m3			8.37	ug/m3			0.10	ug/m3	<T	
	1,2-dibromoethane	.02	ug/m3	<=W		.02	ug/m3	<=W		.02	ug/m3	<=W	
	Tetrachloroethene	0.20	ug/m3			0.19	ug/m3	<T		.02	ug/m3	<=W	
	Chlorobenzene	.02	ug/m3	<=W		.02	ug/m3	<=W		.02	ug/m3	<=W	
	Ethylbenzene	1.07	ug/m3			0.97	ug/m3			.02	ug/m3	<=W	
	m- and p-xylene	2.62	ug/m3			2.45	ug/m3			.05	ug/m3	<=W	
	Styrene	1.17	ug/m3			1.11	ug/m3			0.04	ug/m3	<T	
	1,1,2,2-tetrachloroethane	.02	ug/m3	<=W		.02	ug/m3	<=W		.02	ug/m3	<=W	
	o-xylene	1.17	ug/m3			1.10	ug/m3			0.03	ug/m3	<T	
	a-Pinene	15.1	ug/m3			14.6	ug/m3			.02	ug/m3	<=W	
	1,3,5-trimethylbenzene	0.36	ug/m3			0.32	ug/m3			.02	ug/m3	<=W	
	1,2,4-trimethylbenzene	1.21	ug/m3			1.12	ug/m3			.02	ug/m3	<=W	
	1,3-dichlorobenzene	.02	ug/m3	<=W		.02	ug/m3	<=W		.02	ug/m3	<=W	
	1,2-dichlorobenzene	.02	ug/m3	<=W		.02	ug/m3	<=W		.02	ug/m3	<=W	
	1,4-dichlorobenzene	0.29	ug/m3			0.26	ug/m3			.02	ug/m3	<=W	
	Naphthalene	0.52	ug/m3			0.48	ug/m3			.02	ug/m3	<=W	
	d8-toluene	102.	%R			103.	%R			103.	%R		
	d10-xylene	101.	%R			102.	%R			96.7	%R		

Interpreting Results

Outcome[a]		Action
> Reference	> Background[b]	Levels elevated; follow up investigation required
	< Background	Levels elevated, but do not exceed expected range; follow up on management options
< Reference	> Background	Levels exceed expected range; follow up on management options
	< Background	Levels below reference and expected values; source of complaints may be due to other pollutant(s)/issues

[a]Adapted from Canright and Kollmeyer, 2012[6]
[b]Background levels defined here as range of VOC concentrations found in similar settings

Management

Reducing Exposures[7]

- Limit or prevent smoking indoors
- Consider use of low VOC products
- Do not run motor vehicles or other gas powered engines in attached garages
- Follow all usage and safety instructions when using chemical products
- Store products properly (in tightly sealed containers, if possible, in sheds or garages)
- Use products in well ventilated spaces
- Wear proper protective clothing and devices as instructed by the manufacturer

References

1. Ayers J. Approaches to a total (or grouped) VOC guideline, final report2002 April Contract No.: T/692. Available from: http://environment.gov.ab.ca/info/library/6686.pdf.
2. Health Canada. Residential indoor air quality guideline, formaldehyde2006. Available from: http://www.hc-sc.gc.ca/ewh-semt/alt_formats/hecs-sesc/pdf/pubs/air/formaldehyde-eng.pdf.
3. Health Canada. Residential indoor air guideline, toluene2011. Available from: http://www.hc-sc.gc.ca/ewh-semt/alt_formats/hecs-sesc/pdf/pubs/air/toluene/toluene-eng.pdf.
4. European Commission Joint Research Centre - Environment. Total volatile organic compounds (TVOC) in indoor air quality investigations, report 19. Brussels1997 Contract No.: EUR 17675 EN. Available from: http://ihcp.jrc.ec.europa.eu/our_activities/public-health/indoor_air_quality/eca/eca_report_19.
5. Joint Research Centre - Environment Institute. Report No. 11, Guidelines for ventilation requirements in buildings. Luxembourg1992 Contract No.: EUR 14449 EN.
6. Canright M, Kollmeyer B. Tips for telling the VOC story. The Synergist. 2012 November 26-8.
7. Health Canada. Volatile organic compounds. 2012 [cited 2013 June 17]; Available from: http://www.hc-sc.gc.ca/ewh-semt/air/in/poll/construction/organi-eng.php.

Additional Resources

- Household Products Database. US Department of Health & Human Services http://householdproducts.nlm.nih.gov/
- Environmental Public Health Indoor Air Quality Manual. Alberta Health Services. http://www.health.alberta.ca/documents/Indoor-Air-Quality-Manual-2012.pdf
- VOC Sampling Strategies and Methods, Guide for Indoor Air Quality. Canadian Committee on Indoor Air Quality and Buildings. http://iaqforum.ca/wp-content/uploads/2012/11/Mod2_VOC.pdf
- Indoor air quality in office buildings: a technical guide. Health Canada. http://publications.gc.ca/collections/Collection/H46-2-93-166Erev.pdf