

# **VOCs in European homes and schools**

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# Indoor air – Health effects

#### Exposure to indoor air pollutants, chemicals and biological contamination is associated with

- respiratory system
- nervous system
- cardiovascular system
- carcinogenicity
- respiratory irritation







#### **Birth and infancy**

- Respiratory problems wheeze, rhinitis, atopic asthma, respiratory infections
- Low birthweight and pre-term birth



### **Pre-school**

- Respiratory problems wheeze, allergies, asthma, risk of respiratory diseases and pneumonia
- Eczema and atopic dermatitis
- Greater hyperactivity, impulsivity and inattention



### School age

- Respiratory problems wheeze. rhinitis, asthma, throat irritation, nasal congestion, dry cough
- Eczema, dermatitis, conjunctivitis, skin and eye irritation
- Reduced cognitive performance, difficulty sleeping

RCPCH (2020) https://www.rcpch.ac.uk/sites/default/files/2020-01/the-inside-story-report january-2020.pdf

# VOCs in European homes

- 65 individual VOCs
- Most commonly measured and health relevant VOCs in European homes (incl. UK) are:
  - aromatic hydrocarbons (14) chemicals)
  - alkanes (9)
  - aldehydes (8)
  - aliphatic hydrocarbons (5)
  - terpenes (6)
  - chlorinated hydrocarbons (4)
  - glycol and glycol ethers (3)
  - esters (2)

Science of the Total Environment 839 (2022) 156201





Chemicals in European residences – Part I: A review of emissions, concentrations and health effects of volatile organic compounds (VOCs)



Christos H. Halios<sup>a,1</sup>, Charlotte Landeg-Cox<sup>a,1</sup>, Scott D. Lowther<sup>a,1,2</sup>, Alice Middleton<sup>a</sup>, Tim Marczylo<sup>b</sup>, Sani Dimitroulopoulou<sup>a,\*</sup>

ABSTRACT

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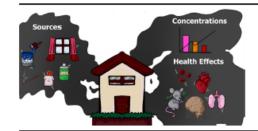
#### HIGHLIGHTS

#### GRAPHICAL ABSTRACT

· A systematic search was conducted de signed to capture evidence on concentrations, emissions from indoor sources, and health effects for VOCs measured in European and UK residences 65 individual VOCs were identified. · Health end points from inhalation expo

sure to these VOCs were identified and discusse d. Reported emission rates from indoor

sources will provide a valuable source as input for modelling tools.



#### ARTICLE INFO

Editor: Philip K. Hopke	One of the more important classes of potentially toxic indoor air chemicals are the Volatile Organic Compounds
Keywordz	(VOCs). However, due to a limited understanding of the relationships between indior concentrations of individual
VOCs	VOCs and health outcomes, there are currently no universal health-based guideline values for VOCs within Europe in-
Indoor	cluding the UK. In this study, a systematic search was conducted designed to capture evidence on concentrations, emis-
European mesidences	sions from indoor sources, and health effects for VOCs measured in European residences.
Emissions	We identified 65 individual VOCs, and the most commonly measured were aromatic hydrocarbons (14 chemicals), al-
Health effects	kane hydrocarbons (9), aldehydes (8), aliphatic hydrocarbons (5), terpenes (6), chlorinated hydrocarbons (4), glycol

Abbreviation: 1,4-DCB, 1,4-Dichlorobenzene; 4-AMCH, 4-Acetyl-1-methylcyclohexane; 4-OPA, 4-Oxopentanal; 6-MHO, 6-Methyl-5-hepten-2-one; ACN, acetonitrile; AM, Arithmetic means; BTX, Benzene, toluene, xylene; CEL, Critical exposure limit; CFU, Golony forming units; CL, Confidence Interval; CNS, Central nervous system; CV, Goefficient of Variation; CVD, Gardiovascular disease; DALY, Disability adjusted life yeas; DEHP, Diethylberyl phthalate; DEP, Diethyl phthalate; DHC, Dihydrocarvone 2-methyl-5-isopropenyl-cyclohexan-1-one; DIBP, Diisobutyl phthalate; ECD, Electron capture detector; ECG, Electrocardiogram; EGBE, Ethylene glycol monobutyl ether; EH, Experimental House; Eq/B, Enhanced eosinophil/basophil; ETS, Environmental Tobacco Smoke; ETS, Environmental tobacco anoke; EU-LCI, EU-Lowest Concentration of Interest; FE, Field Experiment; FID, Flame i anization detector; FLEC, Field and Laboratory Emission Cell; GC/ ECD, Gas channatography/electron capture detector; GC/MS, Gas chromatography/ mass spectrometry; GC, Gas channatography; GM, Geometric mean; GM-CSP, Granulocyte-macrophage colony-stimulating factor; GSD, Geometric standard deviation; HPIC, High-performance liquid chromatography; IAQ, Indoor Air Quality; II-4, Interleukin-4; IOP, Isoprene oxidation products; IPOH, 3-Isopropenyl-6-oxo-heptanal; LOP, Limonene ozone reaction product; MEC, Miniature Emissions Chamber; NOEL, No Observed Effect Lovel; OMCTS, Octamethyk yelotetnasilogane; OR, Odds Ratio; PBMC, Peripheral blood mononuclear cells; PHSs, Passive flux sampler; PGME, Propylene glycol methyl ether; PID, Photoionisation detector; RH, Relative humidity; SV, Sample Vessel; SVOCs, Sen i volatile organic compounds; TB, Time of break; TC, Test Cell or Chamber; TE, Time of expiration; TI, Time of inspiration; TPDDIB, 2,2,4-Trimethyl-1,3-pentanediol disobutyrate / TXB; TPDMB, 2,2,4-Trimethyl-1,3-pentanediol monoisobutyrate/ teranol; TSP, Total suspended particles; TVOG, Total volatile organic compounds; UV-VI5, Ultraviolet-via ble spectroscopy; VD, Mid expinatory flow rate; VOCs, Volatile organic compounds; VT, Tidal Volume; WAGM, Weighted Average Geometric Mean.

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# VOCs in European homes (Halios et al., 2022)

Table 1

Individual Volatile Organic Compounds (VOCs) identified through measurements in residences and their calculated Weighted Average Geometric Mean (WAGM).

VOC	WAGM (μg/m <sup>3</sup> )	VOC	WAGM (µg/m <sup>3</sup> )	VOC	WAGM (µg∕m³)
Ethanol	92.00	Isobutane	4.01	1-Methoxy-2-propanol/propylene glycol methyl ether (PGME)	1.35
Formaldehyde	18.04	2-Ethylhexanol	3.70	4-Ethyltoluene	1.33
Toluene	15.90	Dodecane/n-dodecane	3.69	2-Butoxyethanol	1.26
Limonene [inc. <i>p</i> -limonene]	13.65	Hexane/n-hexane	3.66	2-Carene	1.10
Hexanal/hexaldehyde/ hexanaldehyde	13.30	Heptane/n-heptane	3.45	Methyl-cyclopentane	1.04
α-pinene	12.10	Trimethylbenzene (including 1,2,4-Trimethylbenzene)	3.22	Isopropanol	1.00
Butane	12.00	Cyclohexane	2.99	3-Ethyltoluene	0.98
Acetone	11.40	2,2,4-Trimethyl-1,3-pentanediol diisobutyrate (tpddib/TXIB)	2.94	2-Ethyltoluene	0.94
Acetaldehyde	10.14	2,2,4-Trimethyl-1,3-pentanediol monoisobutyrate (tpdmib/texanol)	2.78	Acrolein	0.92
2-Methyl-1-propanol	8.20	Tetracholorethane	2.68	Styrene	0.82
2-Methylbutane	7.80	Methyl-cyclohexane	2.68	Propylbenzene	0.80
1-Butanol	6.16	Tetrachloroethylene/tetrachloroethene	2.24	Tetrachlorocarbon	0.80
Butylbenzene	5.72	Nonane	2.21	Trichloroethane	0.73
Decane/n-decane	5.27	Benzene	1.99	p-Isopropyltoluene/p-cymene	0.56
m + p-Xylene	4.57	Ethylbenzene	1.84	Trichloroethene/trichloroethylene	0.53
Undecane/n-undecane	4.38	Propanal/proprionaldehyde	1.80	Naphthalene	0.50
3-Carene	4.38	Tridecane	1.77	Chlorobenzene	0.42
Pentanal	4.34	Pentane	1.69	Methylbenzoate	0.33
2,2,4 Trimethylpentane	4.33	o-Xylene	1.57	1,3,5- Trimethylbenzene	0.33
Octanal	4.30	α-Pinene	1.56	Pyridine	0.12
Ethyl acetate	4.30	Benzaldehyde	1.55	1,3-Butadiene	0.11
p-Dichlorobenzene	3.90	Octane	1.54	3-Ethenylpyridine/3-vinylpyridine	0.06

Halios CH, Landeg-Cox, Lowther SD, Middleton A., Marczylo T, Dimitroulopoulou S. (2022). Chemicals in European Residences – Part I: a review of emissions, concentrations, and health effects of Volatile Organic Compounds (VOCs). Science of the Total Environment, 156201 https://doi.org/10.1016/j.scitotenv.2022.156201

### Results:

			Health	effect	s followir	inhala	itior
Chemical	Chemical family	Sources	Resp	cv	Neuro	Carc	ľĽ
Acetaldehyde	Aldehyde	Concrete/screed with and without PVC covering, wooden flooring and battens, composite board (MDF, chipboard), plywood, skirting board, expanding foam, finishing plaster, ceiling tiles, gypsum, plaster, vinyl and ingrain wallpaper, polyurethane adhesive mastic, wallpaper paste, latex and dispersion paints, Carpet (nylon with PVC backing), fragranced and unfragranced jar candles, burning stick incense, typical domestic wood stoves, kerosene space heaters, ethanol fireplaces	Y	N	N	Y	'n
Acetone	Ketone	Solid wood (pine, oak, beech), plywood, composite board (MDF, chipboard, OSB), fireboards from coriander biorefinery, glue for wallpaper, finishing plaster, linoleum, silicone, expanding foam, ceiling tile, gypsum board, veneered particle board (UV curing lacquer), surface sprays, glues, burning stick incense, electric air fresheners, kerosene space heaters, ethanol fireplaces, cleaning agent, cosmetics, flea sprays	Y	Y	Y	N	'n
Benzene	Aromatic hydrocarbon	Gypsum board, commercially- available floor coverings (made of PVC or with polypropylene or polyamide fibres), low density polyethylene, polyurethane foam, carpet glue, scatter rugs, solvent-based cleaning and painting products (acrylic and water based paints, matt emulsion), burning fragrance jar candles and burning stick incense, kerosene space heaters, fireplaces with liquids, wood- burning fireplaces	N	Y	Y	Y	,
Ethylbenzene	Aromatic hydrocarbon	Materials for floor coverings (PVC, linoleum, rubber, polyolefin), gypsum board, Carpet, plywood, polyurethane foam and adhesive mastic, solvent- based cleaning and painting products, solvent and water based interior	Y	N	Y	Y	,

			Health		ts foliowir	ng inhali	riton
Chemical	Chemical family	Seurces	Read In case	CY	Neuro	Sers	kz
		coating, carpet glue, burning stick incerce, candles					
forrældeltyde	Aldehude	Coversets load (MDI), and hittiscal (week), prison and hittiscal (week), present adjust hittiscal (week), expanding adjust hittiscal (week), expanding facer, give for wallbacer, reading wathant, fiscilling practic, lasting part machine week) hapachtischer and adjuster, dischalling unterlief, harniture and capacit, flagment and differential, serving adjust facer, give adjuster, harnone and adjuster, ethodal (week), serving adjust hittischer, ethodal (malieux), lasting pibl, circidonettis, lasting adjust pibl, circidonettis, lasting pibl, circidonettis, and capacitis, piblic products, films, patient, piblic products, films, patient, piblic adjuster, ethod adjuster, lasting piblic reading and facers, lasting piblic products, films, patient, piblic adjuster, transfer and facers, palymens, field, buildels ( a cleaning products and corrents), cleaning products and corrents.	¥	n	N	Ŧ	Y
Umoriene [Inc.sl- limonene]	Terpene	ADP, particle barels (reserved and survenserved), adheves for flooring installation, paints, multisuppoor coving products, schema and waten- based interior coartings (polishes and waters), bloockes (e.g. durin/stant), and control products), shampoor, shower geb, moltautist, indexes geb, moltautist, conditioners, painties offliases, electric evaparetars, barring modo-staks, automatic spring, cleaning agents	N	n	N	N	*
nie bline	Anomatic hydrocarbon	Wooden Plooning, <u>fachardated</u> salver-based cleaning and painting product (signification based and water- based interior costing), polyurethane foars, needuu, density boars, commercially available candles, machine avaits liquid/plotingents, paints and costing, adhesises. Used in submers adhesites, and salves, solid les, and salves, adhesites, and salvests.	*	Y	¥	2	Y

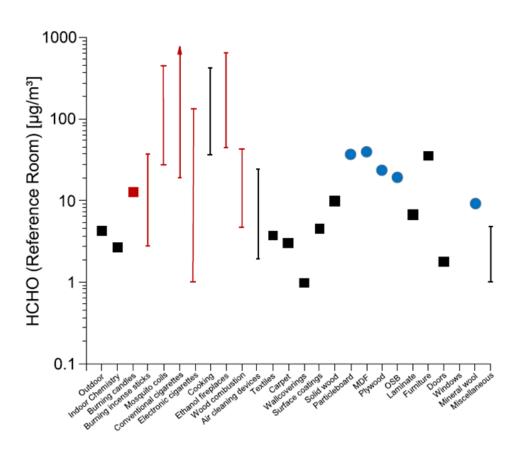
			Health	effect	ts followin	ig in hair	tion
Chemical	Chemical family	Sources	Pete.	CV.	Nouro	Sers.	100
		avrilveeze products and biocides (e.g. disinfectants, pest control products), and close systems (e.g. rooling liquids in refrigerators, oil-based electric heaters).					
Naphthalene	Polycyclic aromatic hydrocarbon	Materials for floor coverings (PVC, involven, rubber, polyvielini, polyurethave foars, insectione or pest ingellant, fingrance jar candles, vaa candles, enti-mosquito incenes sticks, solvent-based cleaning and painting products, with repellents	ŝ	N		Y	
o Xylene	Anomatic hydrocarbon	Wasser Rossing, <u>Exclusivate</u> solven- based clears grant garenting insolut- ing later-based and waster-based instance carring, conservation waster- based, steragers, aparts with carrier and steragers, aparts and carrier, and waster, advances and waster, advances and protects and laterate, advances advances and waster, advances advances and waster, advances and waster advances ad	c	×	· 7.	N	Y
Styrene	Aromatic hydrocarbon	several termination of the termination of termination of termination of the termination of termination of the termination of terminat	e	N	7	٧	Y
Carbon tetrachioride/ <u>1s</u> trachiorocarbon	Chlorineted hydrocarbon	Cleaning agents	r.	¥	Υ.	Ŷ	N
Tetrachiaroethy lene	Chlorinated hydrocarbon	Writing utervals containing liquid or gel ink. Cleaning products for general household cleaning, products used to	÷.	N	Υ.	٣	۷

			Health	h effect	ts followir	ig inhais	16-04
chenical	chemical family	Sources	Reig .	CV	Neuro	CHIC	10
[Tetrachloroeth ylene]		clean gloss, mirrors, and windows. Paint or stain naised products. Leave- on masks or peets for treatment of the face. Dampaos, including dual shampooy/conditioner products. Metal cleaning and degressing agents, dry cleaning, <u>protecting</u> and PVC heating haps.					
Toluene	Anomatic hydrocarbon	Materials for filter overing (PRC, Lindown, Ruber, Waydolf), carged backing, polyurithane fram, wind backing, polyurithane fram, wind backing, polyurithane fram, wind and framanca, anist a balancia, satabat and framanca, anist a balancia, satabat and frama polyuch, sarept backing, and frama polyuch, sarept backing, and frama polyuch, sarept backing and and polyuch backing, satabat for satabat polyuch, sarept backing and and polyuch backing, satabat for satabat polyuch, sarept backing and forma glass, backing satabat landshiftergents, backing satabat fasabat polyuch satabat fasabat polyuch satabat fasabat polyuch satabat fasabat polyuch satabat polyuch satabat polyuch polyuch satabat fasabat polyuch satabat polyuch satabat polyuch satabat polyuch polyuch satabat fasabat polyuch satabat polyuch satabat polyuch satabat polyuch polyuch satabat fasabat polyuch satabat polyuch satabat polyuch satabat polyuch satabat polyuch satabat polyuch polyuch sa	Ŧ	Ŧ	¥	N	,
Trachioraethalen #	chiormated hydrocarbon	Refrigerant and heat-exchange liquid, furnigent, cleaning and drying electronic parts; diluent in paints and adhesives; testile processing. Used as insushiald cleanes; with trichforcethane it is used in most typewriter correction fluid.	,	¥	Ŧ	Y	,
Trimethylbenze no [1,2,4- Trimethylbenze noi 1,5,5- Trimethylbenze no]	Aromatic hydrocarbon	Materials for flooring coverings (PVC, Innieum, rubber, polyolefin)	Ŧ	ND	¥	N	,
a – Pinene	Terpene	MDP, chapboard Both veneered and unvaniance], adhesives for flooring installation, rylon carpet FVC, polyent- based interior coatings, passive diffusery, huming unsad-sticks, automatic survey, electric air	N	N	N	N	,

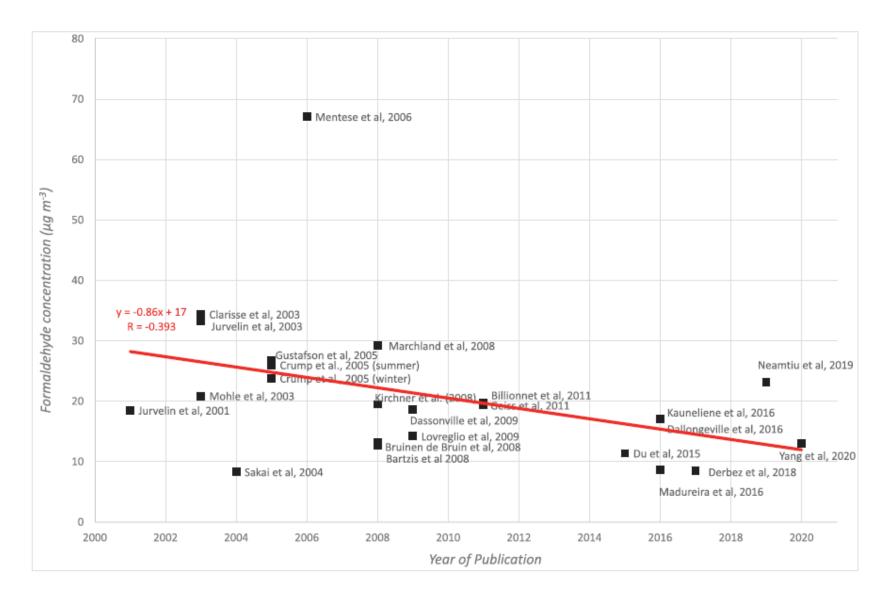
chenical	Chenical family	Sources	Ecie.	CV	Neuro	<u>Carx</u>	11
		freuheners, perfumes, cleaning products and deodorants.					
2-Methybutane (sopentane)	Altans	Puels, perfumes, fragmences. Connection and personal care products. Other releases in the indicer environment: machine usash Baulds/bergents, painte and coating or adhesives, air heatherens, in close systems with minimal releases (e.g. cooling layouts in refragerators, of- based electric netters).	¥	Y	¥	ND	,

Most health relevant and commonly measured VOCs identified in European residences: their sources and health effects.

function	Emission factor
log-normal	GM=192.5 μg/h, σ <sub>g</sub> =1.42 μg/h
uniform	Min=3 μg/m³, Max=39 μg/m³
uniform	Min=0.54 mg/h, Max=7.52 mg/h
uniform	Min=20 µg/m³, Max >1000 µg/m³
uniform	Min=1 µg/m³, Max=135 µg/m³
uniform	Min=698 µg/h, Max=10637 µg/h
uniform	Min=5 µg/m³, Max=48 µg/m³
normal	μ=700 μg/h, σ=100 μg/h
uniform	Min=2 µg/m³, Max=25 µg/m³
log-normal	GM=1.9 μg/(m² h), σg=1.38 μg/(m² h)
log-normal	GM=3.9 μg/(m² h), σg=1.65 μg/(m² h)
log-normal	GM=2.3 μg/(m² h), σg=1.56 μg/(m² h)
log-normal	GM=0.5 μg/(m² h), σg=2.23 μg/(m² h)
normal	μ=4 μg/(m² h), σ=1 μg/(m² h)
log-normal - normal	GM=79 μg/(m² h), σg=1.37 μg/(m² h)
log-normal - normal	GM=39 μg/(m² h), σg=1.96 μg/(m² h)
n.a.	GM=80 μg/(m² h)
n.a.	GM=48 µg/(m² h)
log-normal	GM=8.5 μg/(m² h), σg=1.8 μg/(m² h)
log-normal - normal	GM=17.8 μg/(m² h), σg=2.54 μg/(m² h)
log-normal	GM=18.2 μg/(m² h), σg=2.7 μg/(m² h)
n.a.	GM=31.0 μg/(m² h)
	log-normaluniformuniformuniformuniformuniformuniformuniformlog-normallog-normallog-normallog-normallog-normallog-normallog-normallog-normallog-normallog-normallog-normallog-normallog-normallog-normal - normallog-normal - normal

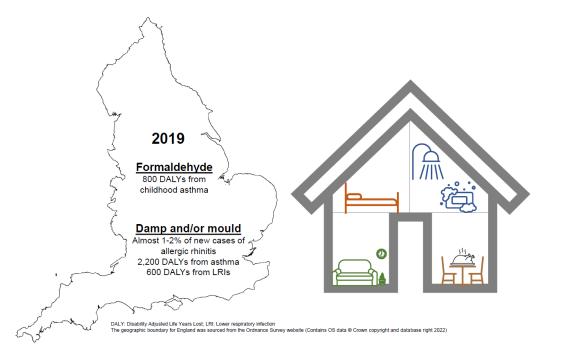


### Formaldehyde in European homes (Halios et al., 2022)



#### Fig. 4. Reported formaldehyde concentrations (2000-2020). Trend line is also reported.

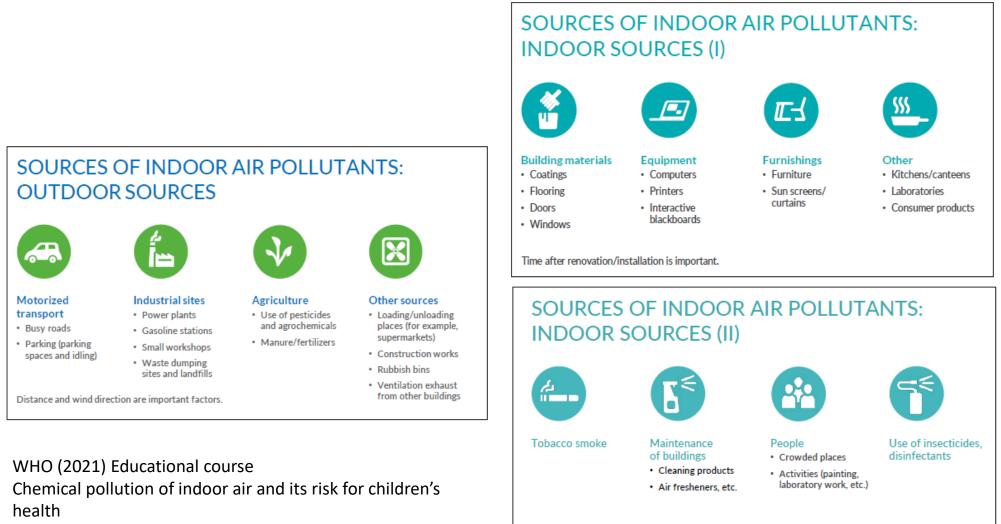
# Burden of Disease -Formaldehyde in English homes (Clark et al., 2023)



Clark, S.N.; Lam, H.C.Y.; Goode, E.-J.; Marczylo, E.L.; Exley, K.S.; Dimitroulopoulou, S (2023). The Burden of Respiratory Disease from Formaldehyde, Damp and Mould in English Housing. Environments, 10(8), 136. <u>https://doi.org/10.3390/environments10080136</u>

- We estimated the burden of disease from asthma associated with residential formaldehyde concentrations, among children in England, using the most up-to-date epidemiological evidence available
- In 2019, exposure to formaldehyde in England was associated with approximately:
  - 4,000 cases of asthma

### Sources of IA pollutants - schools



<u>9789289055628-eng.pdf (who.int)</u>

# WHO – tool to assess combined exposure to chemicals in schools

#### World Health Organization Europe

#### Methods for sampling and analysis of chemical pollutants in indoor air

Supplementary publication to the screening tool for assessment of health risks from combined exposure to multiple chemicals in indoor air



WHO (2020) https://apps.who.int/iris/bitstream/handl e/10665/334389/9789289055239eng.pdf

#### World Health Organization Europe

Screening questionnaire for selection of sampling sites for assessment of risks from combined exposure to multiple chemicals in indoor air



Supplementary publication to the screening tool for assessment of health risks from combined exposure to multiple chemicals in indoor air in public settings for children

WHO (2021) https://apps.who.int/iris/handle/10665/341466



Literature review on chemical pollutants in indoor air in public settings for children and overview of their health effects with a focus on schools, kindergartens and day-care centres





Supplementary publication to the screening tool for assessment of health risks from combined exposure to multiple chemicals in indoor air in public settings for children

WHO (2021) https://iris.who.int/handle/10665/341467

# Priority chemicals in European schools

No.	Chemical family		Substances	Chemical Abstracts Services (CAS) number
1	Oxygenated	Aldehydes	Formaldehyde	50-00-0
2	volatile organic compounds (oxy-VOCs)		Acetaldehyde	75-07-0
3	Volatile organic	Aromatic hydrocarbons	Benzene	71-43-2
4	compounds (VOCs)		Ethylbenzene	100-41-4
5				95-47-6
				108-38-3/106-42-3
6			Styrene	100-42-5
7			Toluene	108-88-3
8			1,2,3-trimethylbenzene	526-73-8
9			1,4-dichlorobenzene	106-46-7
10		Esters	Butyl acetate	123-86-4
11		Terpenes	Limonene	138-86-3
12			a-pinene	80-56-8
13		Chlorinated hydrocarbons	Tetrachloroethylene	127-18-4
14			Trichloroethylene	79-01-6
15		Polycyclic aromatic hydrocarbons (PAHs)	Naphthalene	91-20-3
16	Semi-volatile organic compounds (SVOCs)	PAHs	Benzo(a)pyrene	50-32-8
17	Inorganic compounds	Nitrogen dioxide (NO <sub>2</sub> )	NO <sub>2</sub>	10102-44-0

No.	Chemical family	Substances
1	Particulate matter	Particulate matter with an aerodynamic diameter below 10 $\mu m$ (PM_{10})
2		Particulate matter with an aerodynamic diameter below 2.5 $\mu m$ (PM $_{2.5})$
3	Inorganic compounds	Carbon monoxide (CO)
4		Ozone (O <sub>3</sub> )
5	Phthalates	Diethyl phthalate (DEP)
6		Diisobutyl phthalate (DiBP)
7		Di-n-butyl phthalate (DnBP)
8	Musks	Galaxolide
9		Tonalide
10	PAHs	Acenaphthene
11		Acenaphthylene
12		Phenantrene
13		Anthracene
14		Benz[a]anthracene
15		Benzo[b]fluoranthene
16		Benzo[j]fluoranthene
17		Benzo[e]pyrene
18		Benzo[ghi]perylene
19		Benzo[k]fluoranthene
20		Chrysene
21		Dibenz[a,h]anthracene
22		Dibenzo[a,l]pyrene
23		Fluoranthene
24		Fluorene
25		Indeno[1,2,3-cd]pyrene
26		Pyrene
27	Brominated flame retardants	2,4,4'-tribromodiphenyl ether (BDE 28)
28	(BFRs)-polybrominated	2,2',4,4'-tetrabromodiphenyl ether (BDE 47)
29	diphenyl ethers (PBDEs)	2,2',4,4',5-pentabromodiphenyl ether (BDE 99)
30		2,2',4,4',6-pentabromodiphenyl ether (BDE 100)
31		2,2',4,4',5,5'-hexabromodiphenyl ether (BDE 153)
32		2,2',3,4,4',5',6-heptabromodiphenyl ether (BDE 183)
33		2,2',3,3',4,4',5,5',6,6'-decabromodiphenyl ether (BDE 209)
34		1,2-dibromo-4-(1,2-dibromoethyl)cyclohexane (DBE-DBCH)
35	Organophsophate flame	Tributyl phosphate (TBP)
36	retardants (OPFRs)	Tris(2-butoxyethyl) phosphate (TBEP)
37		Tris(1-chloropropan-2-yl) phosphate (TCPP)
38		Tris(2-chloroethyl) phosphate (TCEP)
39	Chlorinated paraffins (CPs)	Short-chain CPs (SCCPs) (C10.13)
40		Medium-chain CPs (MCCPs) (C
41		Long-chain CPs (LCCPs) (C18-30)

WHO, 2020. Methods for sampling and analysis of chemical pollutants in indoor air: supplementary publication to the screening tool for assessment of health risks from combined exposure to multiple chemicals in indoor air, ISBN 978 92 890 5523 9. https://apps.who.int/iris/bitstream/handle/10665/334389/9789289055239-eng.pdf

Potential indoor sources	Pollutants	Source control / mitigation measures
Furniture and wooden products (for example, pressed	formaldehyde, acetaldehyde, benzene,	Choose certified, eco-labelled materials with low VOC emissions
board, plywood, particle board, fibreboard furniture, flooring, panelling, doors)	α-pinene	for floor/wall/ceiling coverings and furniture
Flooring materials (e.g., PVC flooring with adhesive,	formaldehyde, acetaldehyde, benzene, ethylbenzene,	- Implement renovations and refurbishments in the first month o
carpet backings)	xylenes, styrene, toluene	the summer holiday
		- Use woven or knotted textile carpets instead of synthetic ones
Wall paints, solvent-based (water-resistant)	benzene, xylenes, styrene, toluene	Implement renovations and refurbishments in the first month of
		the summer holiday
		- Use water-based paints
DIY products (for example, solvents, paints,	formaldehyde, acetaldehyde, benzene, ethylbenzene,	- Implement renovations and refurbishments in the first month o
wallpapers, glues, adhesives, varnishes, lacquers)	trimethylbenzene, xylenes, styrene, toluene,	
	tetrachloroethylene	the summer holiday
	trichloroethylene, n-butyl-acetate, naphthalene,	- Use smaller quantities of or green alternatives to paints,
	benzo(a)pyrene	solvents, adhesives and science laboratory chemicals
		- Increase ventilation, e.g., open windows when working with
		chemicals
Painted or varnished coatings	benzene, ethylbenzene, xylenes, toluene,	Choose certified, eco-labelled materials
	dichlorobenzene, n-butyl-acetate	
	· · · · · · · · · · · · · · · · · · ·	Limit the use of chemical products
Paint and varnish removers	α-pinene,	Choose certified, eco-labelled materials
stain removers, wood cleaners	tetrachloroethylene, trichloroethylene	Limit the use of chemical products
Electronic equipment (e.g., photocopy machines)	formaldehyde, acetaldehyde	Place photocopiers and printers in separately ventilated rooms
Plastics	trimethylbenzene, styrene	
New books, magazines, newspapers	formaldehyde, toluene	Locate in dedicated rooms /library, well ventilated
Cleaning products	formaldehyde, trimethylbenzene, toluene, limonene, $\alpha$ -	Use fragrance-free cleaning materials,
	pinene, trichloroethylene	
and		
disinfectants	naphthalene	
Dry-cleaned textiles, curtains, carpets	tetrachloroethylene	Use washable textiles for classrooms instead of textiles that
		require dry-cleaning
Air fresheners	dichlorobenzene, limonene	Do not use air fresheners in classrooms,
Human activities (cooking)	formaldehyde, acetaldehyde, benzo(a)	Install extractor fans in kitchens to be on during cooking activity
	pyrene	

### Let's work together



to reduce our exposure to indoor air pollution

# Thank you!

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