Monitoring indoor air pollutants: what are our future challenges?

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A few words about the French IAQ Observatory

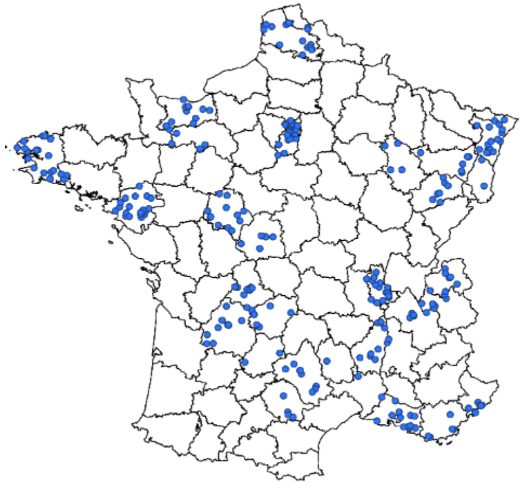
The French IAQ Observatory

RÉPUBLIQUE FRANÇAISE
Liberté
Égalité
Fraternité

- **Created in 2001**
- **Objective: To coordinate and develop indoor air research activities at a national scale**
  - To improve knowledge on IAQ in buildings
  - To provide support for public policies
  - To publish recommendations for professionals and general public
- **Financial support from Ministries in charge of Housing, Health, and Environment, the Agency for Energy Management (ADEME), the Agency for Food, Environmental and Occupational Health & Safety (Anses)**

What do we do?

- **Nationwide monitoring campaigns** to measure indoor air pollution and collect descriptive data

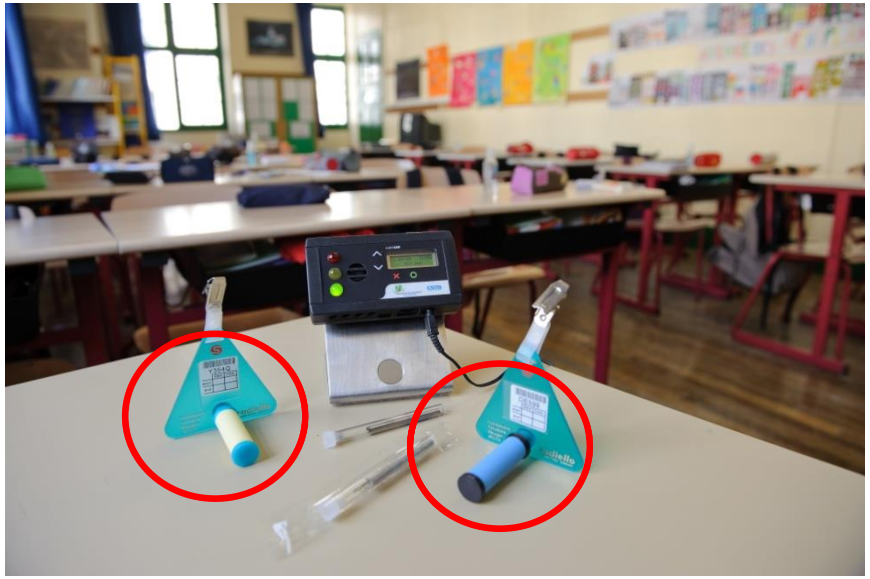


School survey, 2013-2017, 600 classrooms randomly selected

- **Specific studies** (intervention studies) for a specific question

- Regular **review of the literature** and collect of IAQ measurements (worldwide)

What is IAQ monitoring today?



Passive sampling

Active sampling

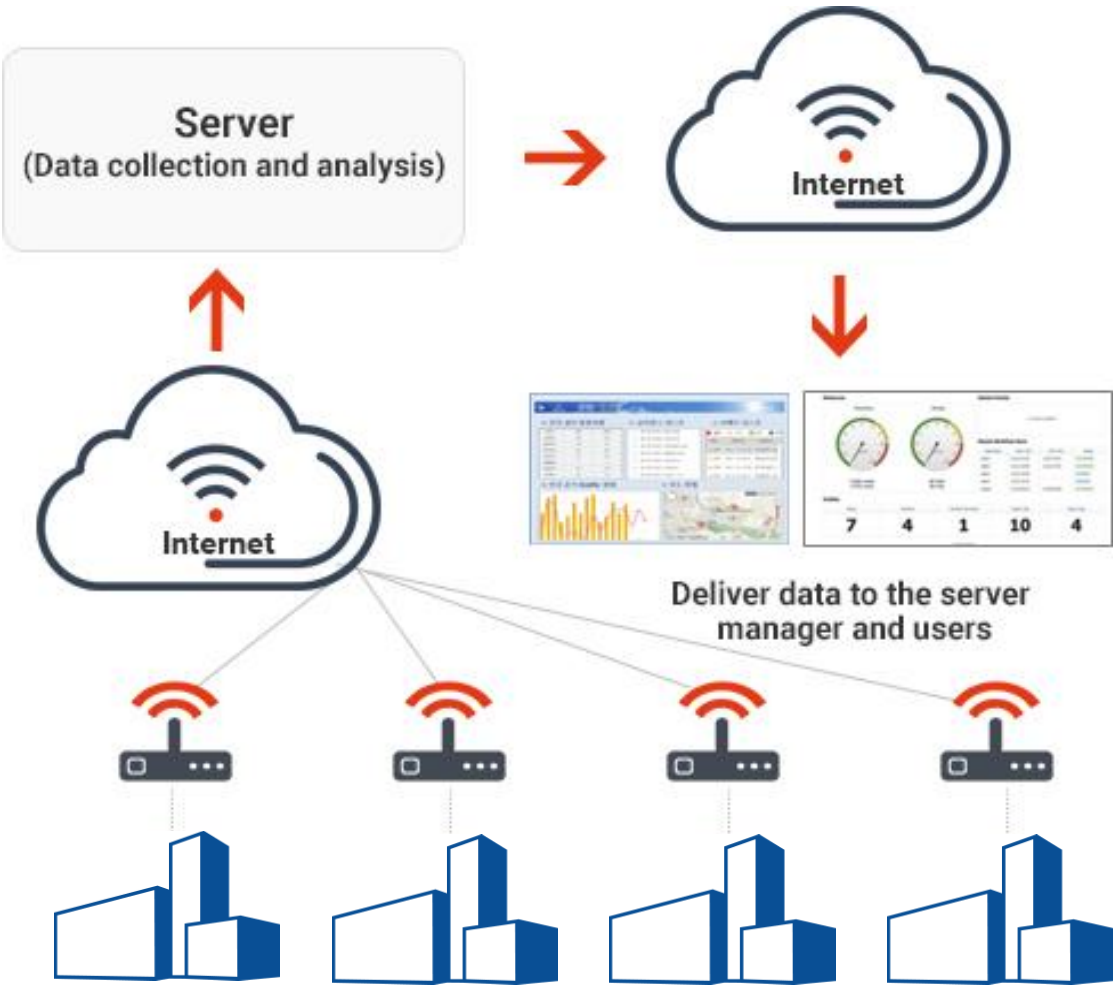
Challenge ❶

Make the monitoring easier

Develop on-line monitoring sensors/systems

Real-time miniaturized sensor systems

Real-time miniaturized sensor systems



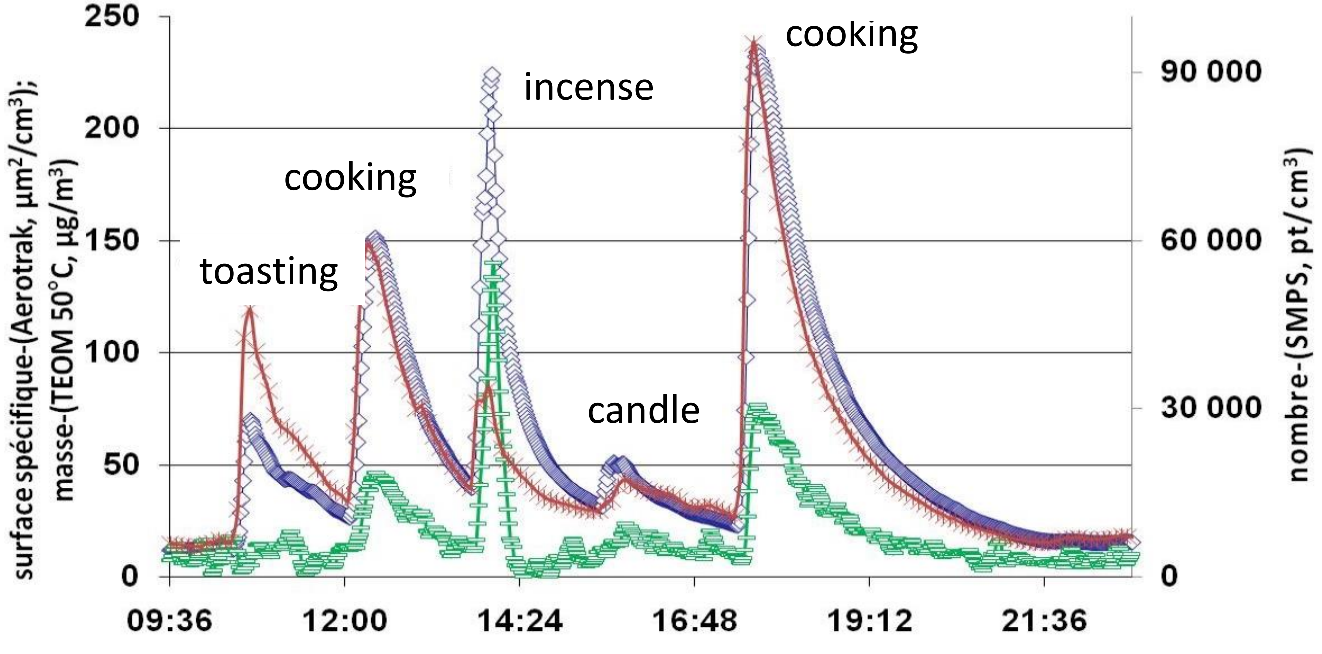
Good IAQ: windows can be kept closed

Medium IAQ: you should open the windows

Poor IAQ: open the windows!

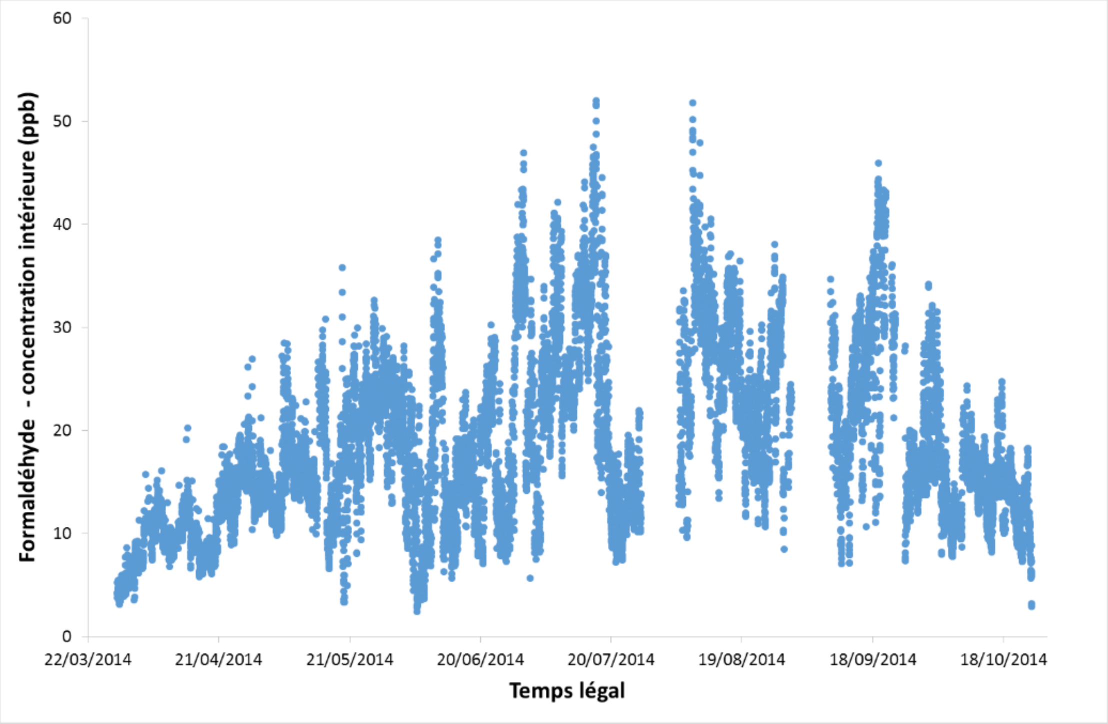
Temporal evolution of indoor air quality

- Source identification and their relative contributions



(Ji et al, 2009)

- Temporal variations

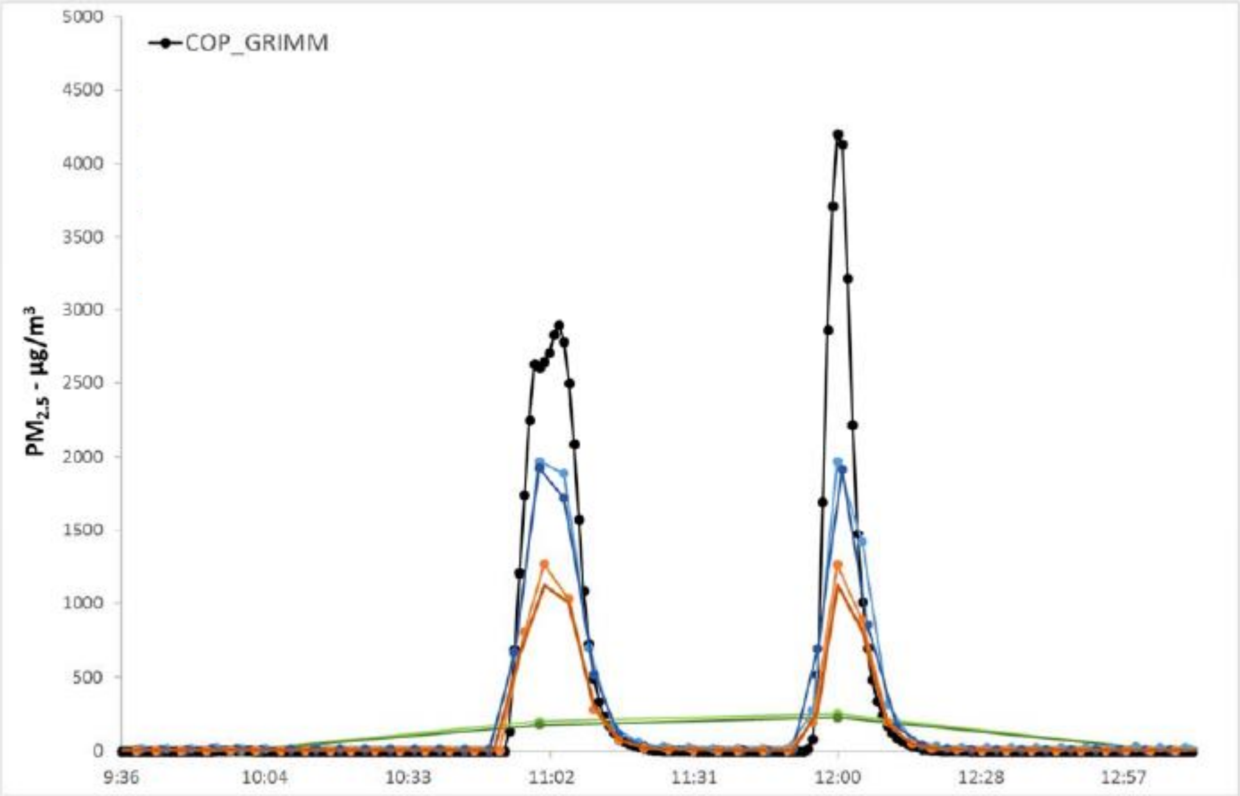


(Ramalho et al, 2016)

Still some limitations with IAQ sensors

Some remain very expensive

PM$_{2.5}$ from incense burning at 2500 µg/m^3 and 4000 µg/m^3



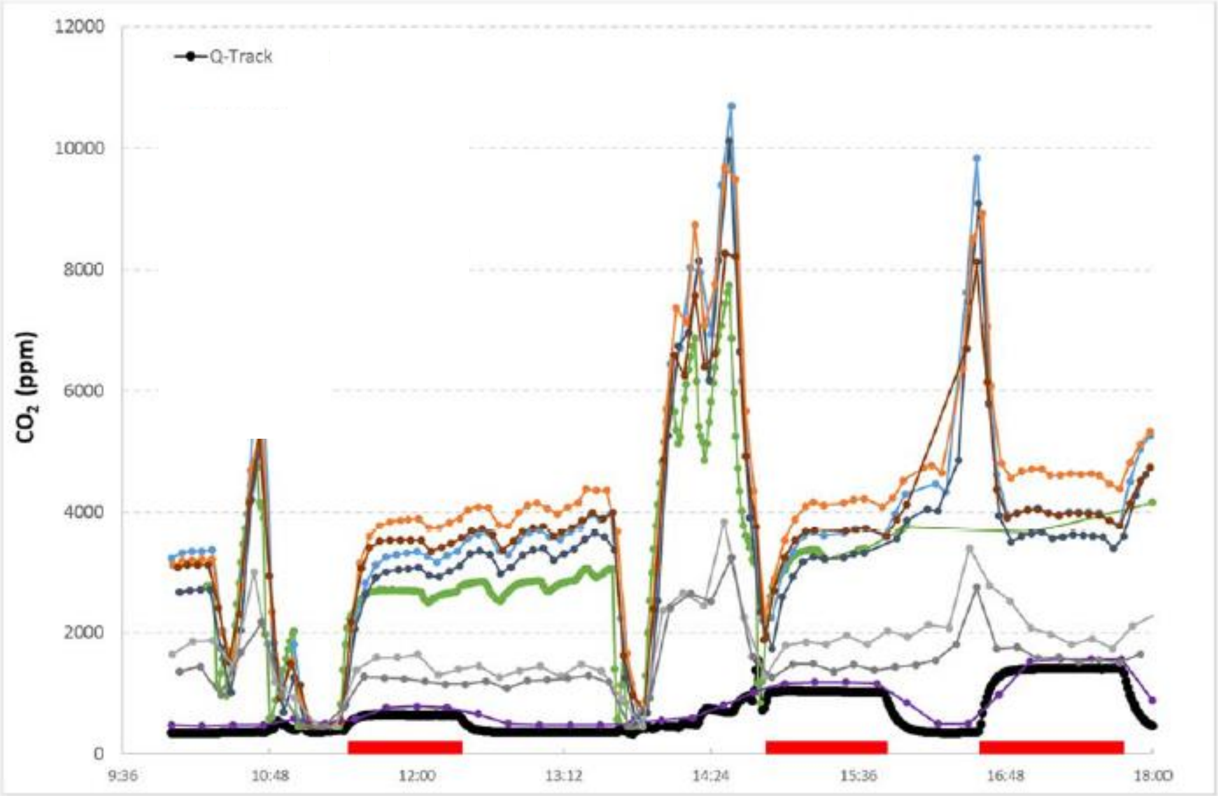
(Ramalho et al., 2019)

Low-cost ones:

- Not all reliable
- Interferences with humidity
- Few pollutants can be measured with smart sensors
- No calibration
- Drift over time
- Etc.

Still some limitations regarding monitoring

CO_2 at 640, 1000 and 1400 ppm



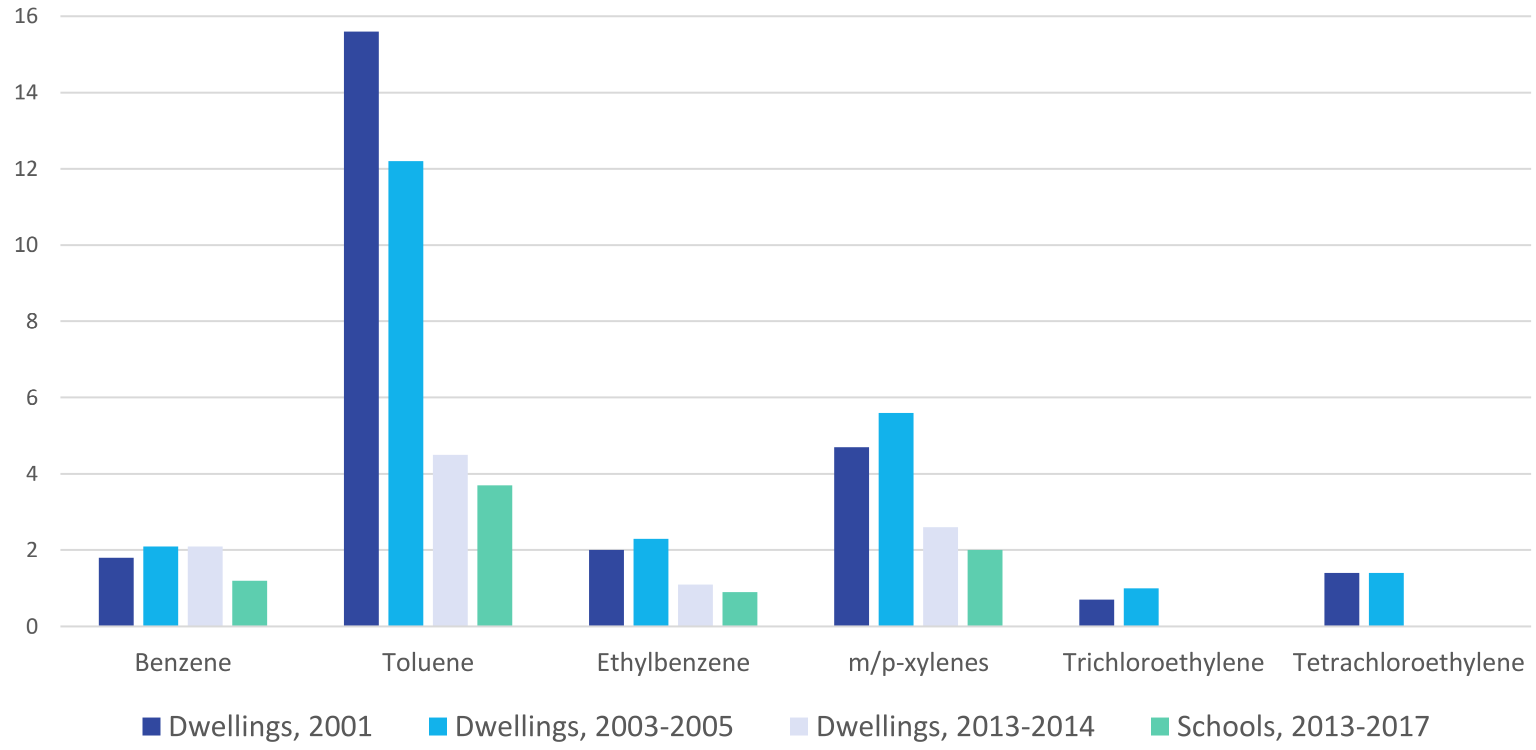
(Ramalho et al., 2019)

Challenge ❷

Identify the “key compounds”

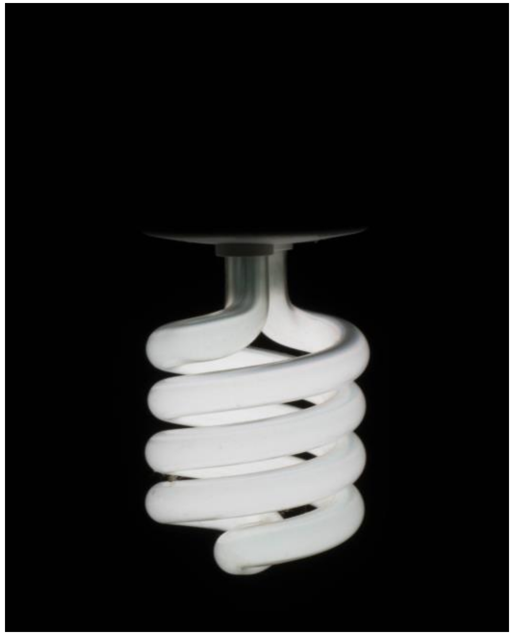
What the relevant airborne pollutants to look for?

Median concentrations in µg/m^3



(Kirchner et al., 2007; Canha et al., 2016; Derbez et al., 2018; Dassonville et al., 2019)

New uses and habits … new indoor pollution



(Salthammer et al., 2011)

(Schripp et al., 2013)

(Azimi et al., 2016)

Images: Pixabay

Emerging chemicals

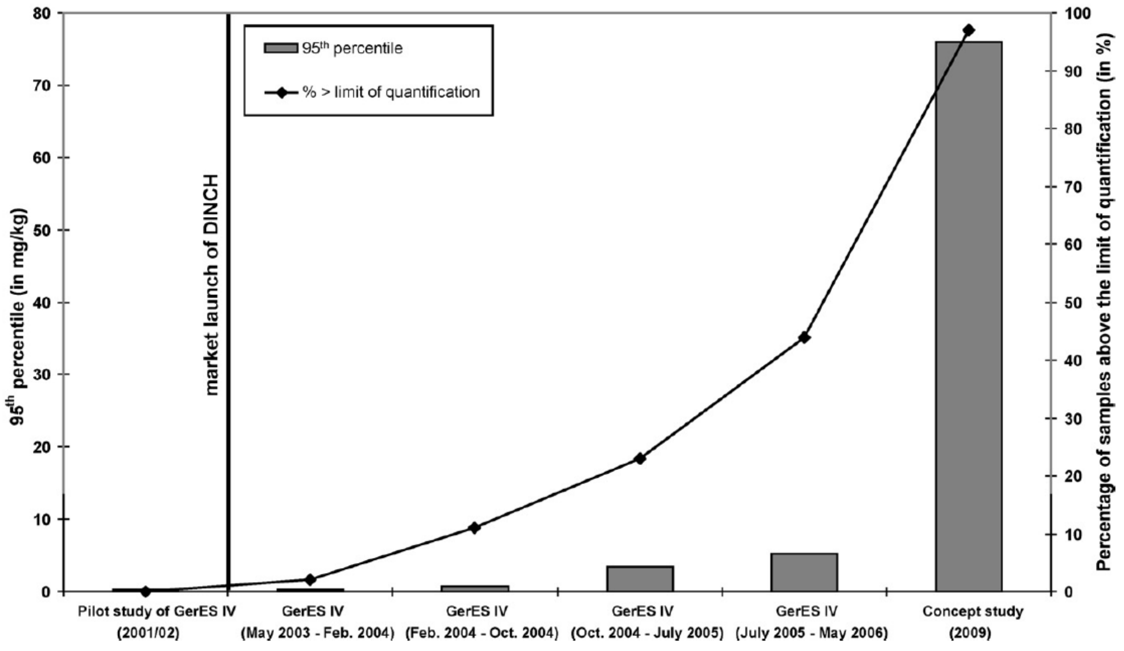


Fig. 7. Percentage of DINCH-positive samples and 95th percentiles.

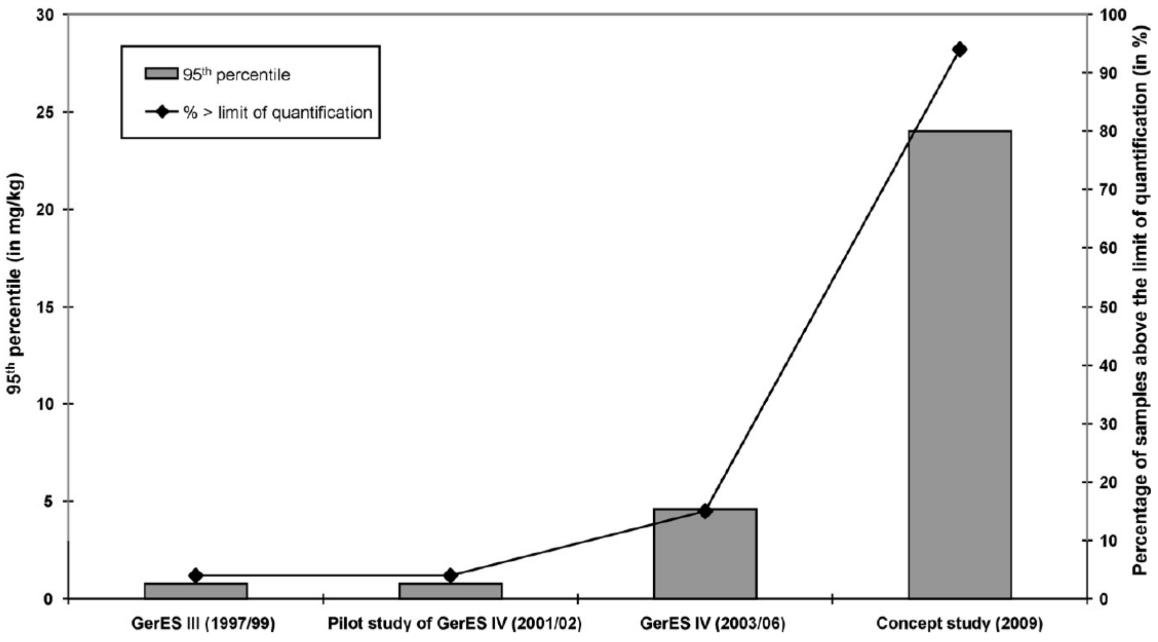


Fig. 8. Percentage of DEHT-positive samples and 95th percentiles.

DINCH in German dwellings (settled dust)

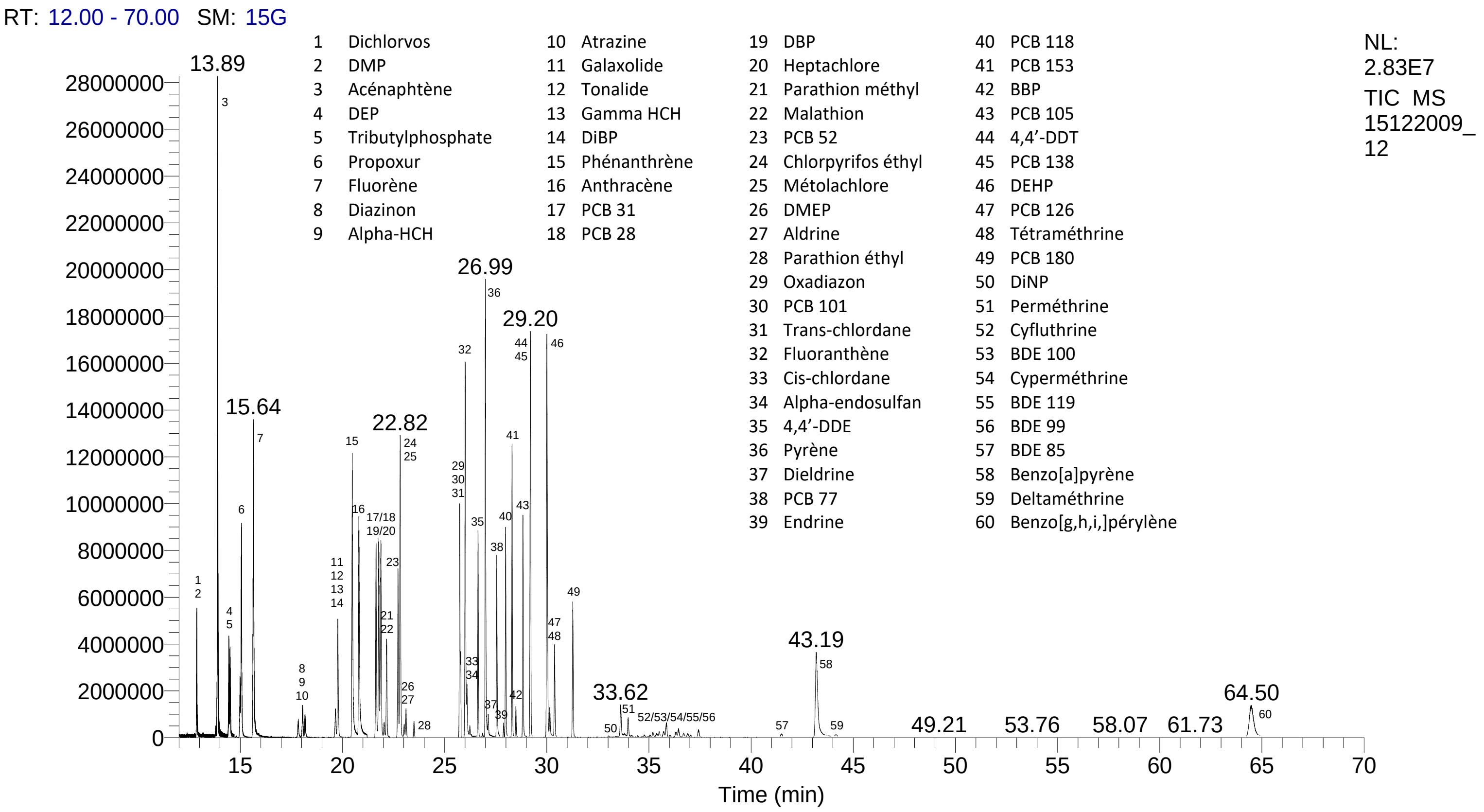
DEHT in German dwellings (settled dust)

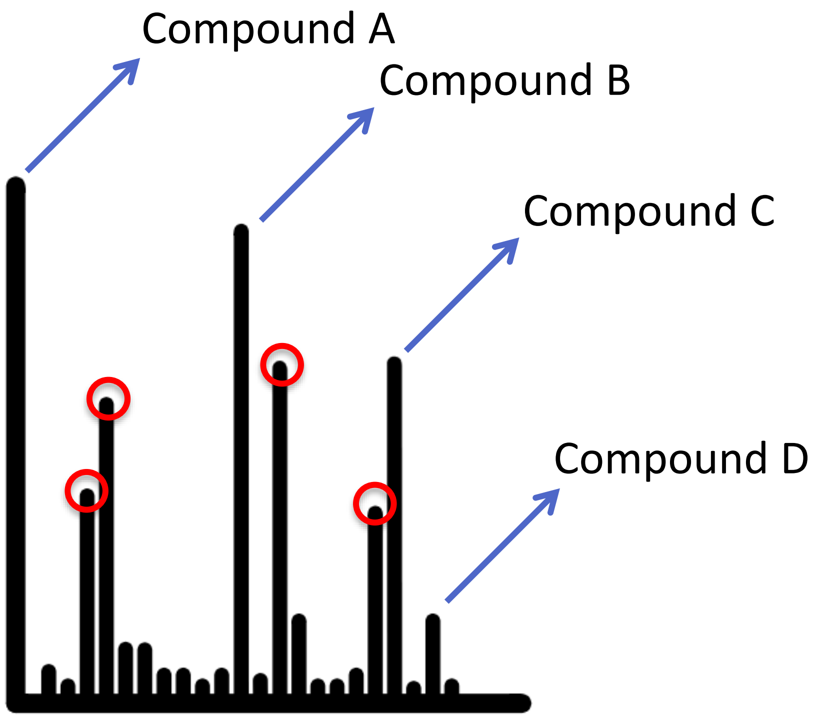
(Nagorka et al., 2011)

Inventory of substances potentially present in indoor air

- In the frame of the IAQ Observatory: regular review of the literature on what is measured in indoor environment in the world
- Last review: in 2018 with the objective to identify the substances to be measured in the next national housing survey
- **Two main steps**:
  1. Set of the **list of substances** (only chemicals):
     - Already measured in indoor air or settled dust (dwelling, school, offices)
     - OR already measured in building material or product emissions
     - OR measured in the product (content)
  2. **Hazard identification** = hazard classifications by national and international agencies
- **2741 substances were listed, among them 206 were identified as priority**

Reanalyzing chromatograms





Reanalyzing chromatograms (pilot study)

- From 10 chromatograms:
  - 1500 proposals of possible substances (50 peaks)
  - **356 substances identified with certainty**
  - Among the most frequently detected: D3, cymene, camphene, 6-MHO, propylene glycol, etc.

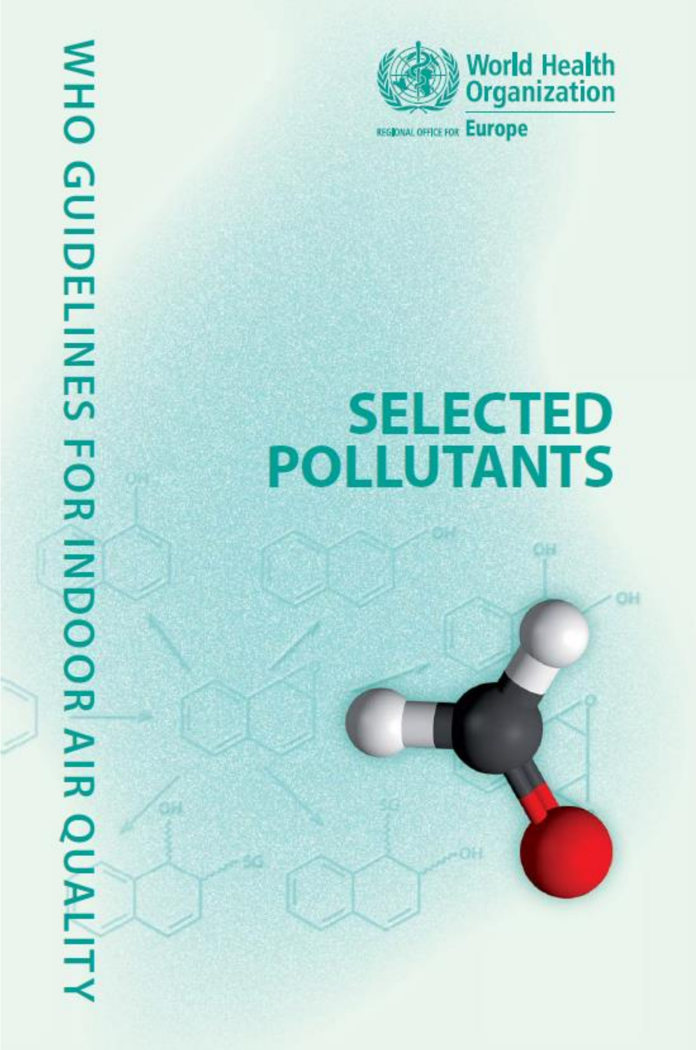
FileName	ID_Chromato	Rank	CAS	Name	RT	Weighted	Simple	Reverse	RI	Width	Purity	Model	Min. Abund.	Amount	Scan	Peak Tailing	S/N (total)	Base Peak
C:\CSTBDATA\	L164T2	1	107835	>Pentane, 2-methyl-	8.4063	91		91		8.2	75%	43 m/z (70)	0.00%	0.58%	211	1.2	387	78024576
C:\CSTBDATA\	L164T2	2	79298	>Butane, 2,3-dimethyl-	8.4063	85		85		8.2	75%	43 m/z (70)	0.00%	0.58%	211	1.2	387	78024576
C:\CSTBDATA\	L164T2	3	2883456	>1,6-Heptadien-4-ol	8.4063	82		83		8.2	75%	43 m/z (70)	0.00%	0.58%	211	1.2	387	78024576
C:\CSTBDATA\	L164T2	1	96140	>Pentane, 3-methyl-	9.0032	84		84		5.8	62%	56 m/z	0.01%	0.16%	301	0.5	256	31357564
C:\CSTBDATA\	L164T2	2	107119	>2-Propen-1-amine	9.0032	83		87		5.8	62%	56 m/z	0.01%	0.16%	301	0.5	256	31357564
C:\CSTBDATA\	L164T2	3	17046229	>Butyl isocyanatoacetate	9.0032	81		81		5.8	62%	56 m/z	0.01%	0.16%	301	0.5	256	31357564
C:\CSTBDATA\	L164T2	1	110543	>Hexane	9.6788	96		96		3.7	60%	57 m/z	0.00%	0.19%	341	1	353	45309056
C:\CSTBDATA\	L164T2	2	96140	>Pentane, 3-methyl-	9.6788	85		85		3.7	60%	57 m/z	0.00%	0.19%	341	1	353	45309056
C:\CSTBDATA\	L164T2	3	17046229	>Butyl isocyanatoacetate	9.6788	82		82		3.7	60%	57 m/z	0.00%	0.19%	341	1	353	45309056
C:\CSTBDATA\	L164T2	1	64197	>Acetic acid	9.984	96		96		>9	75%	43 m/z	0.01%	0.27%	359	0.5	296	42803492
C:\CSTBDATA\	L164T2	2	631618	>Ammonium acetate	9.984	85		85		>9	75%	43 m/z	0.01%	0.27%	359	0.5	296	42803492
C:\CSTBDATA\	L164T2	3	2258426	>Acetic acid, anhydride wit	9.984	84		84		>9	75%	43 m/z	0.01%	0.27%	359	0.5	296	42803492
C:\CSTBDATA\	L164T2	1	141786	>Ethyl Acetate	10.3243	86		86		3.6	77%	43 m/z	0.00%	0.26%	380	1.2	408	163964368
C:\CSTBDATA\	L164T2	2	78988	>Methylglyoxal	10.3243	76		88		3.6	77%	43 m/z	0.00%	0.26%	380	1.2	408	163964368
C:\CSTBDATA\	L164T2	3	617356	>Propanoic acid, 2-oxo-, et	10.3243	75		78		3.6	77%	43 m/z	0.00%	0.26%	380	1.2	408	163964368
C:\CSTBDATA\	L164T2	1	637923	>Propane, 2-ethoxy-2-meth	10.6862	94		94		4.2	87%	59 m/z	0.00%	0.33%	402	1.2	435	123106624
C:\CSTBDATA\	L164T2	2	4359460	>1,3-Dioxolane, 2-ethyl-4-r	10.6862	80		80		4.2	87%	59 m/z	0.00%	0.33%	402	1.2	435	123106624
C:\CSTBDATA\	L164T2	3	36687997	>2-Butanone, 3-ethoxy-3-n	10.6862	79		81		4.2	87%	59 m/z	0.00%	0.33%	402	1.2	435	123106624
C:\CSTBDATA\	L164T2	1	78831	>1-Propanol, 2-methyl-	11.1303	87		87		9.9	75%	43 m/z (57)	0.01%	0.24%	440	1.1	233	24128920
C:\CSTBDATA\	L164T2	2	109660	>Pentane	11.1303	84		88		9.9	75%	43 m/z (57)	0.01%	0.24%	440	1.1	233	24128920
C:\CSTBDATA\	L164T2	3	75285	>Isobutane	11.1303	84		89		9.9	75%	43 m/z (57)	0.01%	0.24%	440	1.1	233	24128920

Non-targeted analysis (NTA)

- **High throughput analytical techniques** that allow the rapid characterization of thousands of never-before-studied compounds (Sobus et al., US-EPA, 2017) in environmental or biological samples

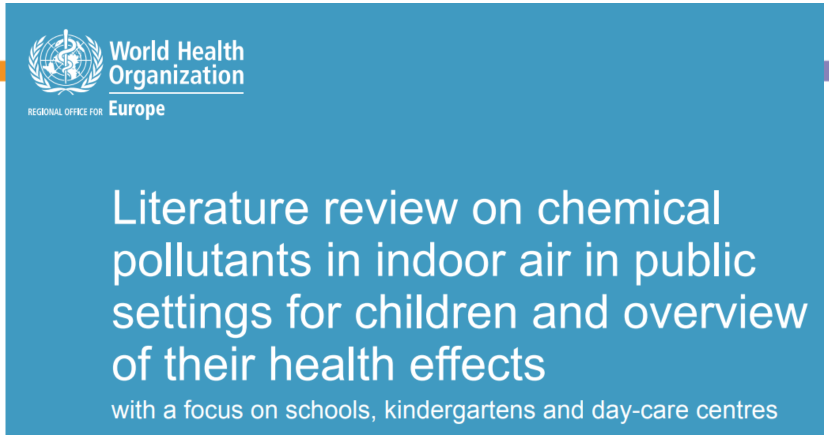
- Application to settled dust samples (Rostkowski et al., 2019, EU NORMAN network):
  - LC-MS and GC-MS showed to be complementary (5% of substances in common)
  - **2350 substances** were identified with certainty or acceptable confidence

To be pragmatic: WHO recommendations



Published in 2010

1. Benzene
2. Carbon monoxide (CO)
3. Formaldehyde
4. Naphthalene
5. Nitrogen dioxide (NO_2)
6. Polycyclic aromatic hydrocarbons
7. Radon
8. Trichloroethylene
9. Tetrachloroethylene



Published in 2021

Chemical priority compounds regarding health effects on children (PM to be added)

ANNEX 1. LIST OF PRIORITY CHEMICALS INCLUDED IN THE SCREENING TOOL FOR ASSESSMENT OF RISK OF COMBINED EXPOSURE TO HAZARDOUS CHEMICALS

No.	Chemical family		Substances	Chemical Abstracts Services (CAS) number
1	**Oxygenated volatile organic compounds (oxy-VOCs)**	Aldehydes	Formaldehyde	50-00-0
2			Acetaldehyde	75-07-0
3	**Volatile organic compounds (VOCs)**	Aromatic hydrocarbons	Benzene	71-43-2
4			Ethylbenzene	100-41-4
5			xylene (o-, m-, p-)	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			α-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_2)	NO_2	10102-44-0

As a conclusion

- **Technical challenges**: IAQ is an opportunity for innovation
- **Research challenges**: to identify pollutants related to health effects and provide relevant information to policymakers

Thank you for your attention!

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