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INSTITUT DE RADIOPROTECTION ET DE SÛRETÉ NUCLÉAIRE

WHAT DO WE KNOW ABOUT THE CURRENT STATE OF IAQ IN BUILDINGS?

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First WHO/Europe Indoor Air Conference

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MEMBRE DE ETSON

Indoor air quality in dwellings

- High number of emission sources, various outdoor environments, heterogeneity of buildings, diversity of occupants and habits
  ➔ an **extreme diversity of situations**

- **Determinants of indoor air pollution are well-known**: smoking, proximity to traffic, dry-cleaning shop, attached garage, new furniture/flooring/paints, cooking, cleaning products, insecticides, incense/candle burning, low air change rate, water damage, etc.

- **Indoor air quality is associated with socio-economic status**
  (Brown et al. 2016; Ferguson et al. 2020)

Indoor air quality in dwellings

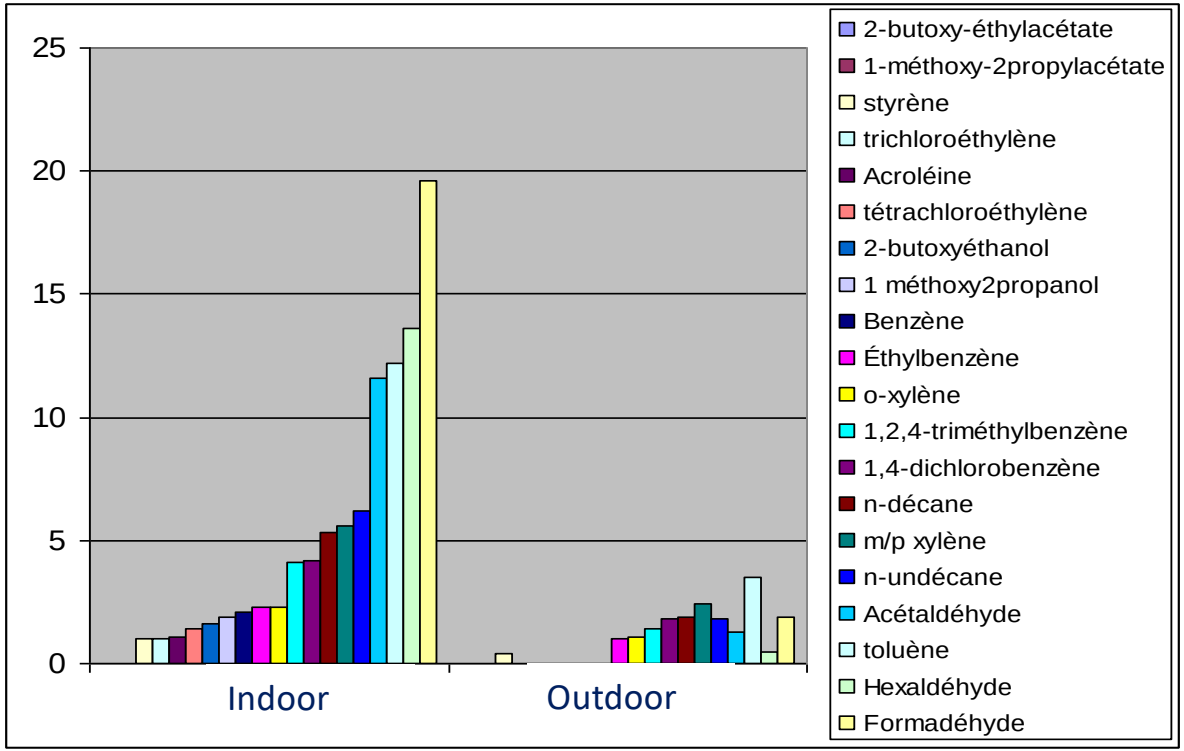
First French housing survey, 2003-2005

567 dwellings representative of the French housing stock

Median concentrations in the main bedroom, passive sampling for 7 days

(Kirchner et al. 2007)

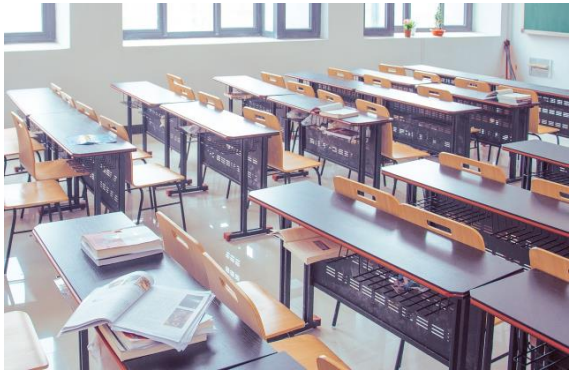
Median concentrations of aldehydes and VOCs in µg/m^3



Indoor air quality in schools

Some specificities

School supplies



High density of furniture

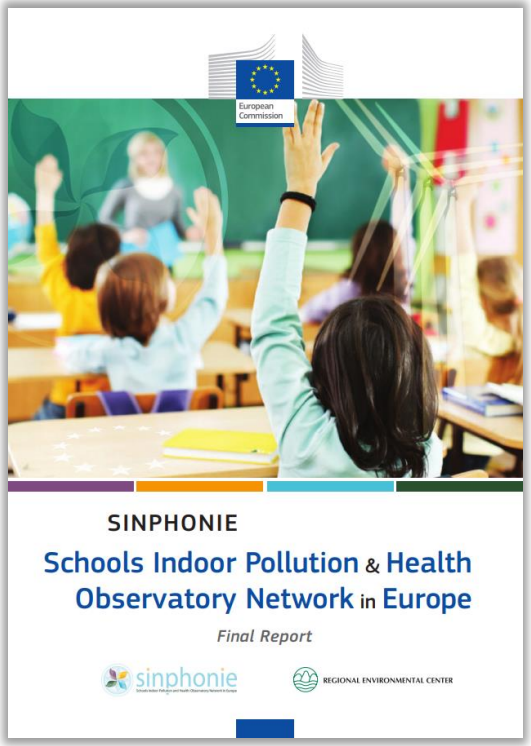
Daily cleaning

Proximity to road traffic

Combined to poor air change because of **infrequent window opening** (noise, security, thermal comfort, omission, etc.) and **no mechanical ventilation system in most of school buildings**

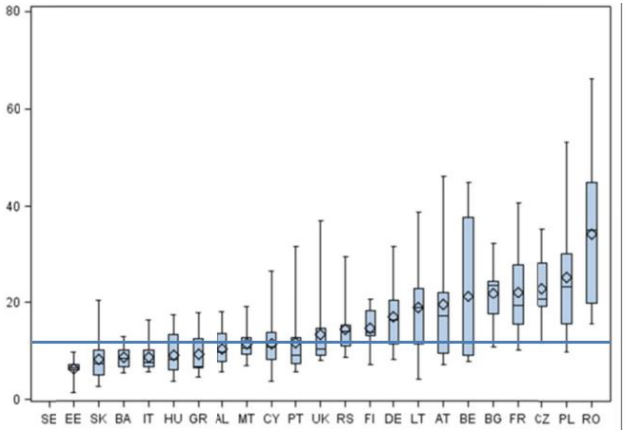
Images: Pixabay

Indoor air quality in schools: European SINPHONIE project

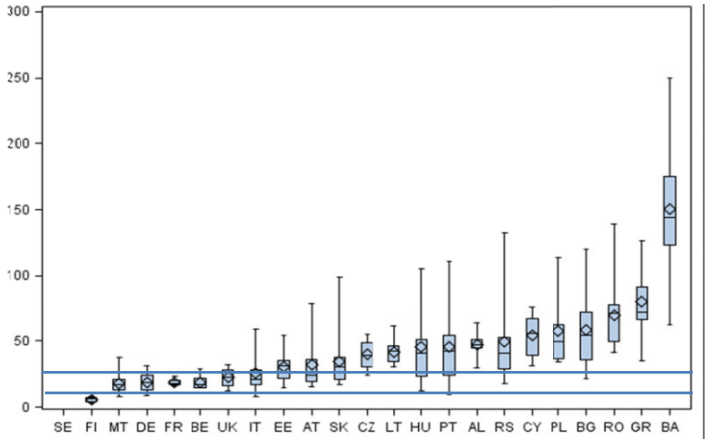


Measurements carried out in 2011-2012 in 337 classrooms belonging to 140 buildings of **112 schools in 23 countries**

Distribution of formaldehyde concentrations
Passive sampling for 5 days (Monday-Friday)



Distribution of PM2.5 concentrations
Active sampling for 5 days (Monday-Friday)



Concentrations in µg/m^3

What about offices?

Some specificities

High density of office equipment

Daily cleaning

In some high-rise buildings, windows cannot be open

Office buildings appear to be **mostly equipped with mechanical ventilation and better maintained**

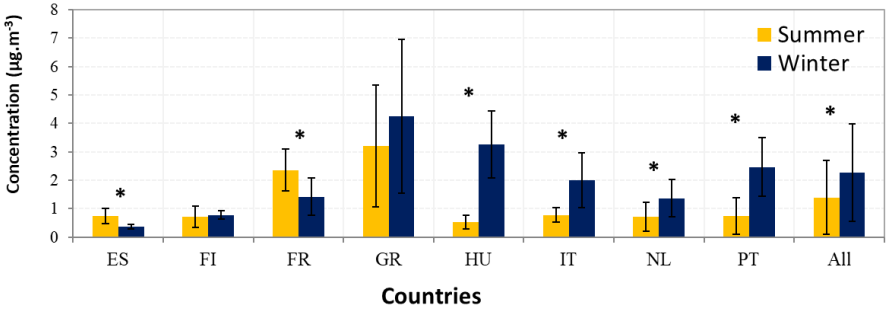
Images: Pixabay

Indoor air quality in offices: European Officair project

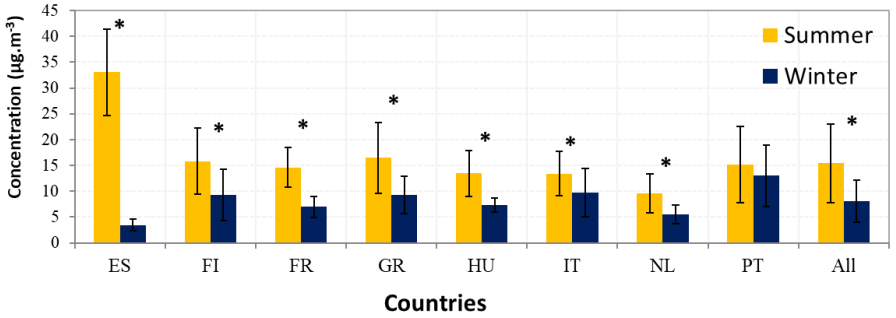
- **148 rooms in 37 buildings from 8 countries** instrumented in summer 2012 and winter 2012-2013, recently (< 10 years) built or retrofitted

- **Seasonal variations** in indoor concentrations (* = statistically significant difference) (Mandin et al. 2017)

BENZENE - Passive sampling for 5 days (Monday-Friday)



FORMALDEHYDE - Passive sampling for 5 days (Monday-Friday)

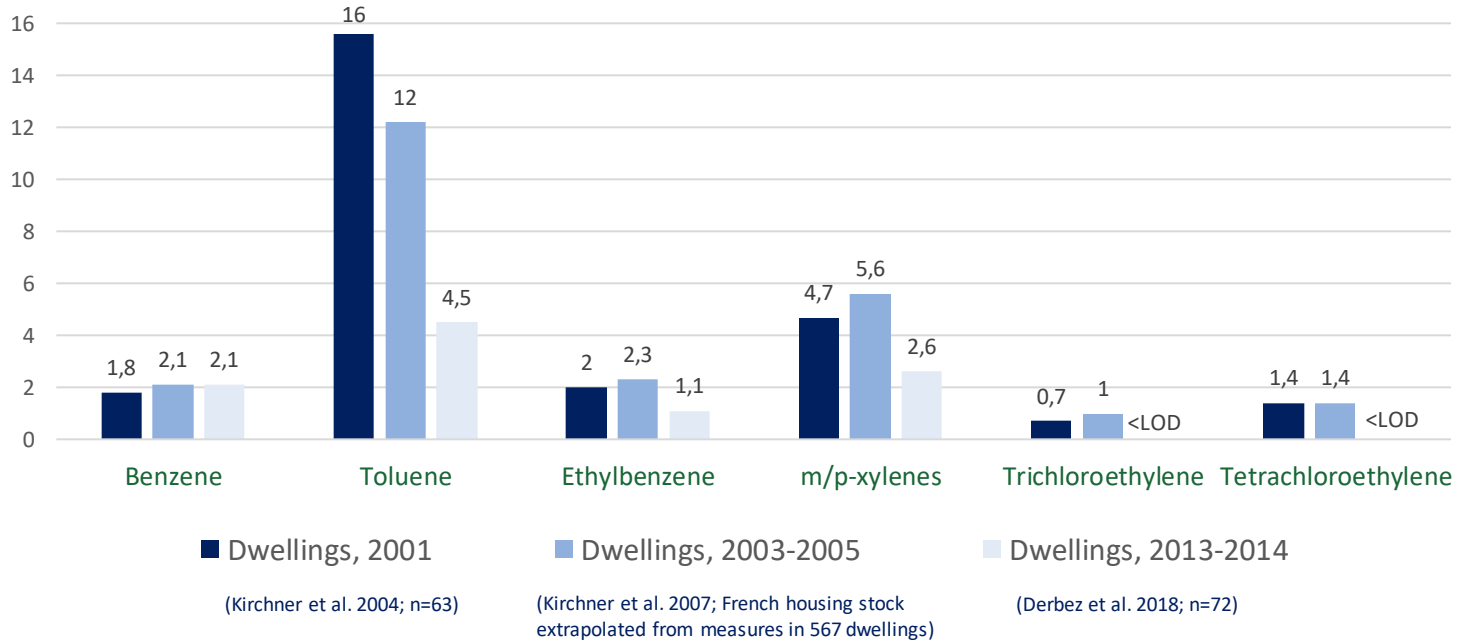


- The use of **fragrance-free cleaning products reduce aldehyde indoor concentrations** (Ventura et al. 2014)

Indoor air quality is permanently evolving

Example in France

Median concentrations (main bedroom) in µg/m^3, passive sampling for 7 days



(Kirchner et al. 2004; n=63)

(Kirchner et al. 2007; French housing stock extrapolated from measures in 567 dwellings)

(Derbez et al. 2018; n=72)

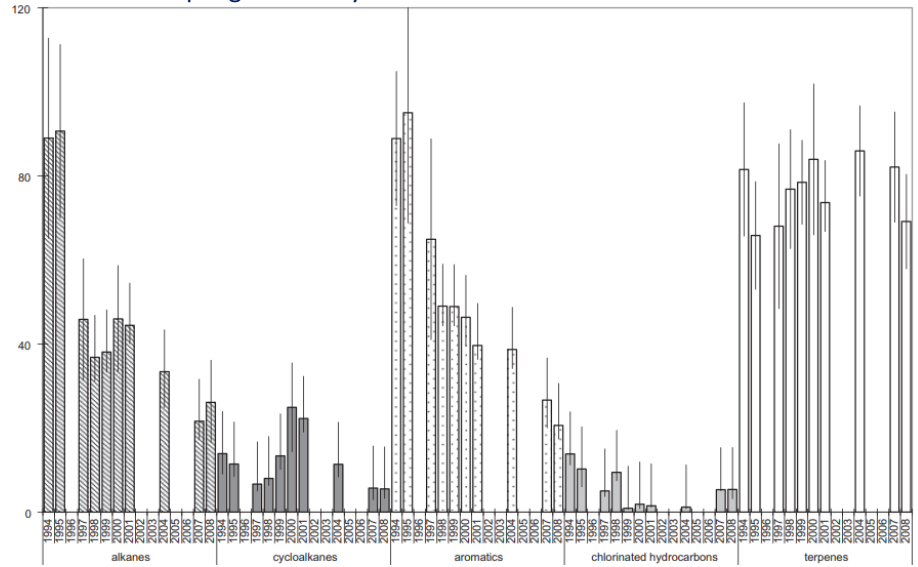
Indoor air quality is permanently evolving

Examples in Germany

Repeated **VOC** measurements (1994-2008) in dwellings from Leipzig

Mean concentrations (child's bedroom or living room) in µg/m^3

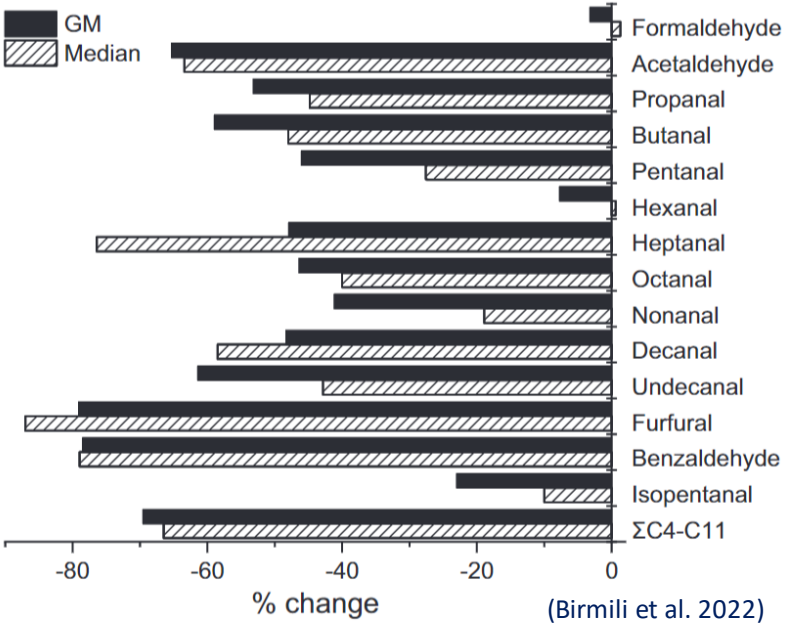
Passive sampling for 28 days (Herbarth and Matysik, 2012)



Year	1994	1995	1997	1998	1999	2000	2001	2004	2007	2008
N	88	266	158	286	287	100	556	377	312	249

Aldehydes: Relative change (%) in median and geometric mean (GM) concentrations between GerES IV (2004-2007; n=579) and GerES V (2013-2016; n=533)

Child's bedroom or living room, passive sampling for 7 days



(Birmili et al. 2022)

New uses, new habits… higher indoor concentrations

(Salthammer et al. 2011)

(Destaillats et al. 2020)

(Azimi et al. 2016)

(Arnold et al. 2023)

And: terpenoids, fluorinated compounds, siloxanes, synthetic musks, pyrethroids, etc. due to the increased use of scented products, personal care products, stain and water repellents, etc. (Weschler C. 2009)

Images: Pixabay

New substances on the market

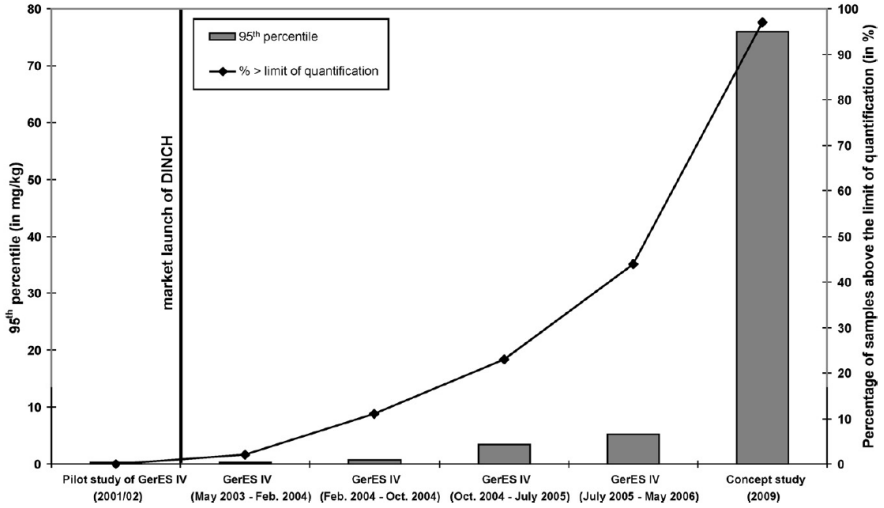


Fig. 7. Percentage of DINCH-positive samples and 95th percentiles.

DINCH in German dwellings (settled dust)

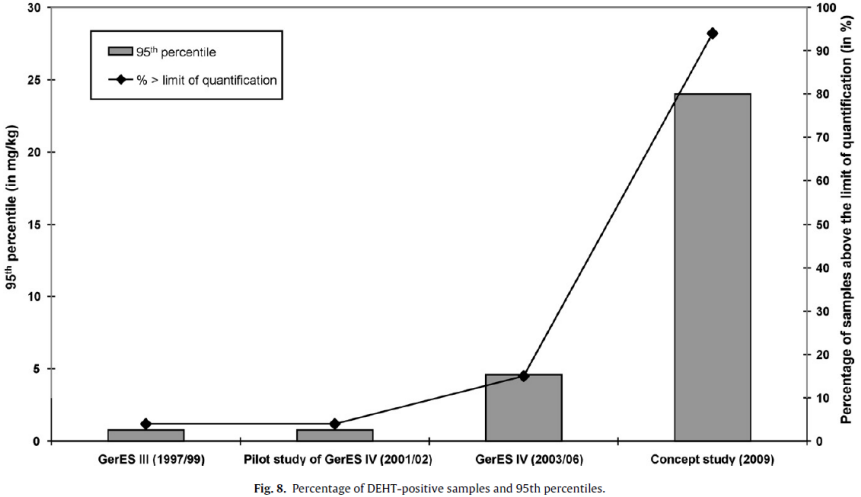


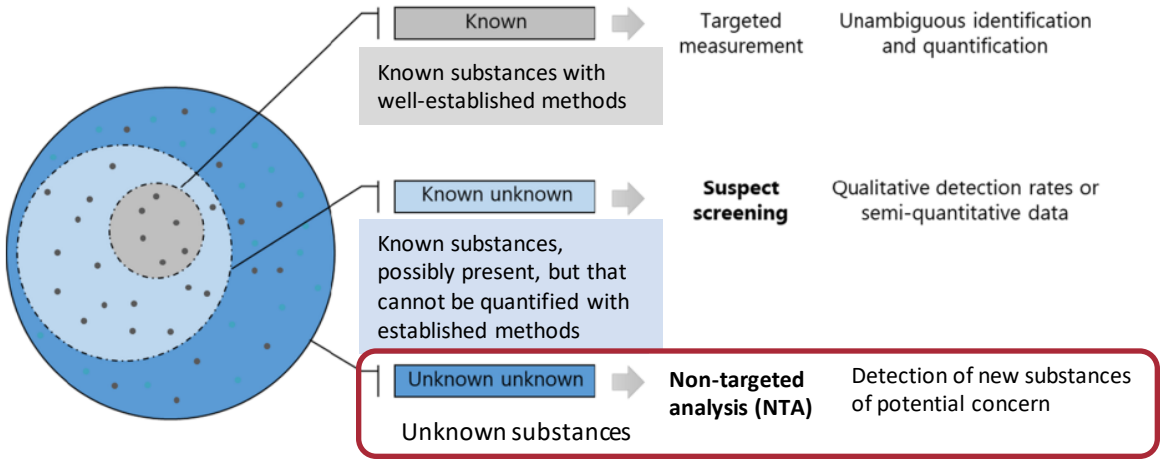
Fig. 8. Percentage of DEHT-positive samples and 95th percentiles.

DEHT in German dwellings (settled dust)

(Nagorka et al. 2011)

Substances identified through new analytical techniques

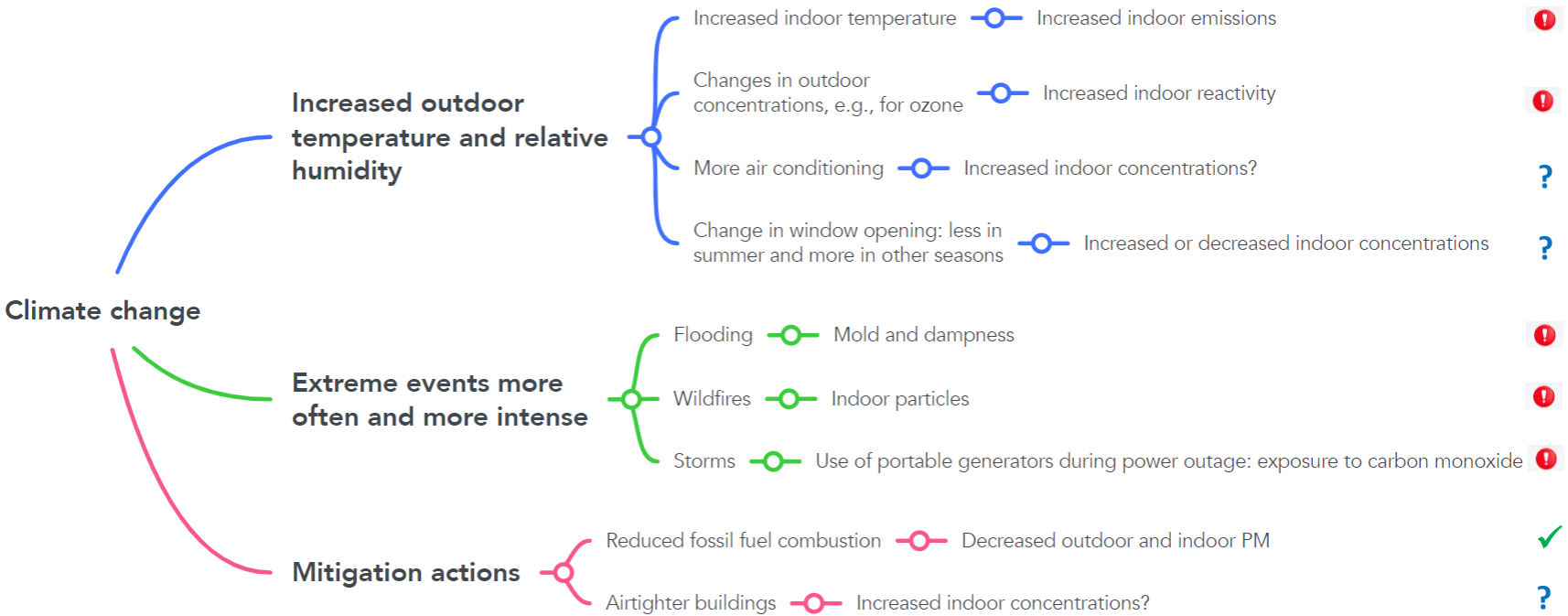
Non-targeted analysis



Chemical substances in indoor air or indoor settled dust, adapted from Pourchet et al. (2020)

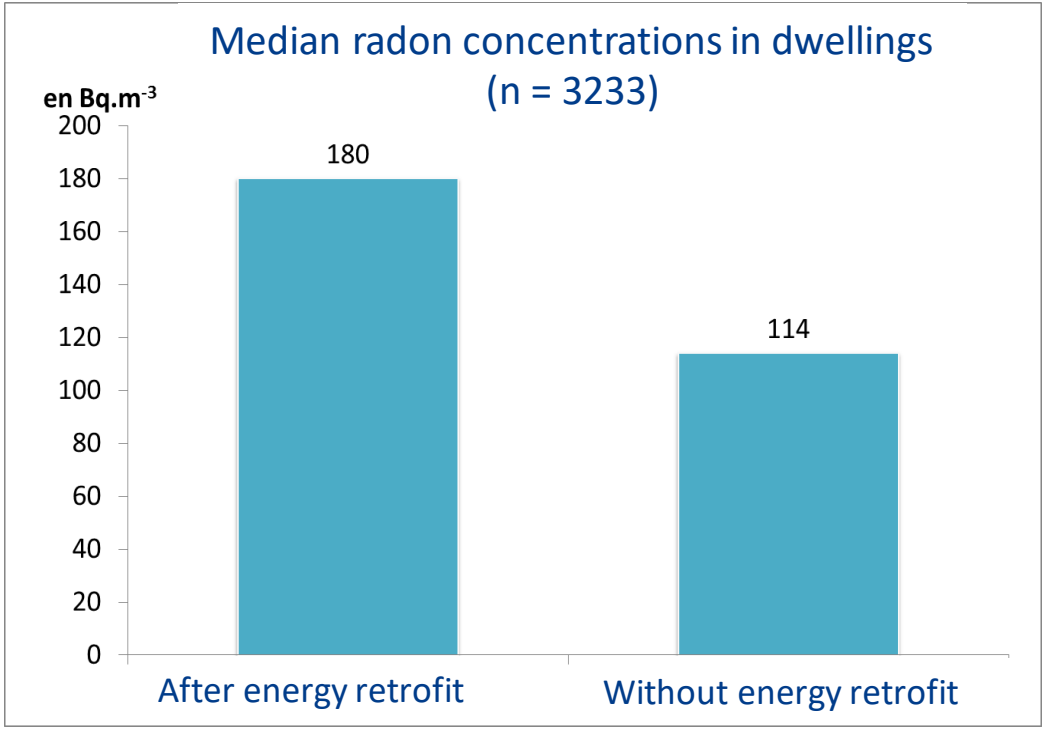
- **Few studies on indoor air**, e.g., (Ding et al. 2022; Manz et al. 2023)
- **More and more studies on indoor dust**, e.g., nearly 2350 substances identified in home settled dust with certainty or acceptable confidence by Rostkowski et al. (2019, EU NORMAN network)

And what about IAQ under climate change?



Inspired by (Kinney P. 2022; Mansouri et al. 2023)

For building stock adaptation: a combined IAQ and energy performance approach is absolutely needed



Ventilation was only considered in 25% of the home retrofits

Similar observations in other countries such as Switzerland (Yang et al. 2019)

(Collignan et al. 2016)

To conclude

- **We already know a lot**
- We know **enough to act to improve IAQ**
- We need **to keep on monitoring indoor air**:
  - to identify pollutants or situations that could be at risk for health
  - to assess the efficiency of policies or interventions
  - to raise awareness among occupants and buildings managers

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