Indoor air quality in schools: from knowledge to actions

Feedback from the French IAQ Observatory

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Outline

1. **A few words about the French IAQ Observatory**
2. **The School Nationwide Survey (2013-2017)**
3. **What are the solutions?**
   - Reduce the sources
   - Promote ventilation
   - Regulate
   - Raise awareness

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❶ The French IAQ Observatory

The French IAQ Observatory

- **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)**

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What do we do?

- **Nationwide monitoring campaigns** to measure indoor air pollution and collect descriptive data
- **Specific studies** (intervention studies) for a specific question
- Regular **review of the literature** and collect of IAQ measurements (worldwide)
- **Dissemination**: local, national and international conferences + newsletters

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Studies organized around 6 programs

1. Dwellings
2. Schools and day-care centers
3. Office buildings
4. Low-energy buildings
5. Hospitals and elderly homes
6. Communication, training, education

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❷ The School Nationwide Survey (2013-2017)

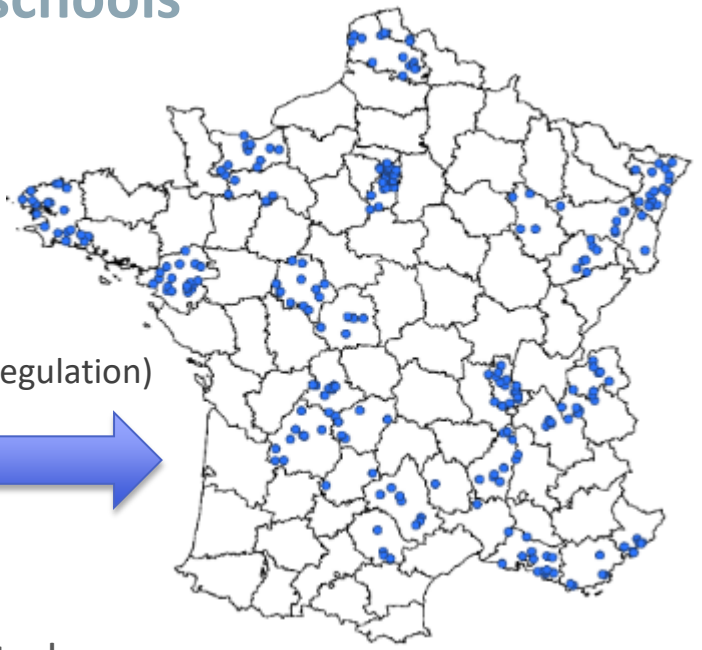
Sampling design

Randomly selected schools

52,582 schools

Stratified on:

- **Schools** (nursery/primary)
- **Environment** (urban/rural)
- **Climatic zones** (French thermal regulation)



Number of schools calculated on the basis of the target precision on the VOC concentrations

308 schools
(602 classrooms)

Raking ratio adjustment (Deming and Stephan)

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Parameters (1)

One week: from Monday to Friday

On-line measurements

- ⇨ Carbon dioxide (CO_2)
- ⇨ Temperature and relative humidity
- ⇨ Particle counting (0,3 to 20 µm)
- ⇨ Noise level (7 days, starting the Friday before the monitoring week)

Air samples

- ⇨ **Active sampling**: $PM_{2,5}$ and SVOCs
- ⇨ **Passive samplers**:
  - VOCs and aldehydes
  - Nitrogen dioxide (NO_2)

Parameters (2)

Settled dust sampling

⇨ **With a wipe** for lead
⇨ **With a specific vacuum cleaner**: metals and SVOCs

Punctual measurements

⇨ Illuminance on tables and boards (illuminance meter)
⇨ Lead in paint by X-Ray fluorescence
⇨ Electromagnetic fields

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Questionnaires

- **Building and classroom description**
- **Occupancy and activities**
- **Perception of teachers**

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Results at a glance

Positive aspects

- Low NO_2 concentrations
- Lower VOC concentrations compared to dwellings

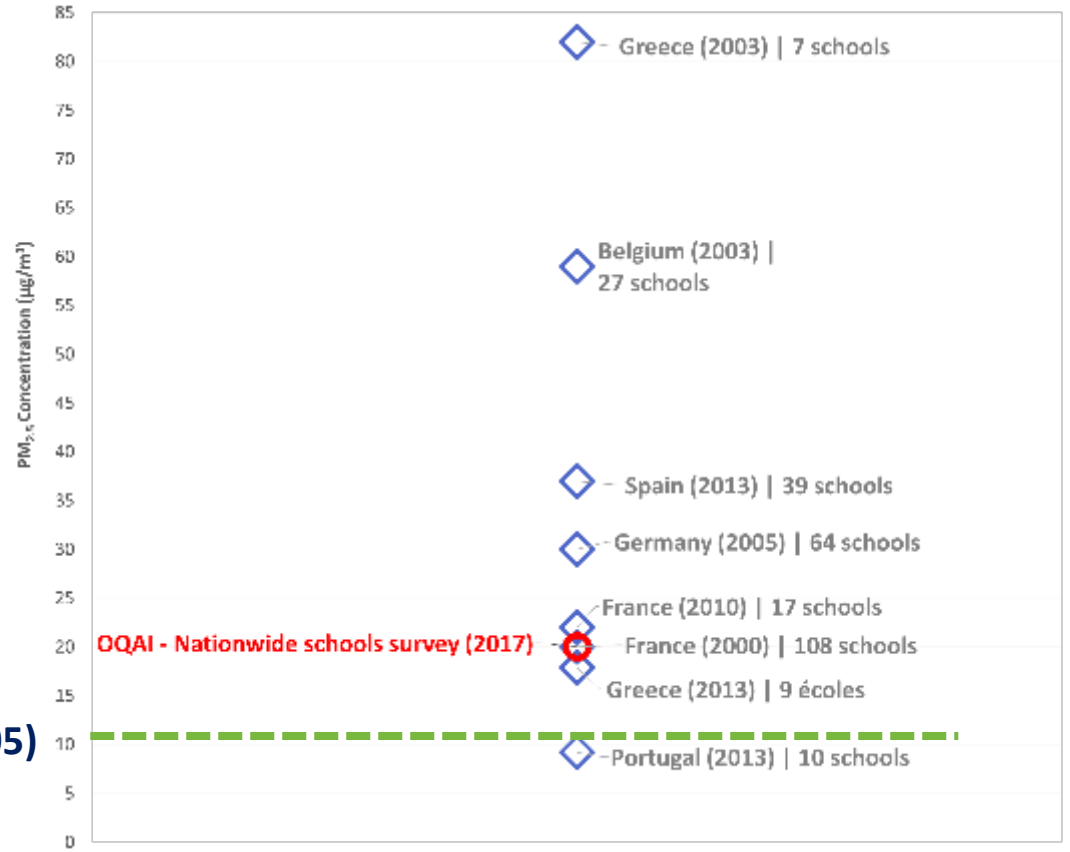
Critical issues

- $PM_{2,5}$
- Semi-volatile organic compounds
- Lack of ventilation, air stuffiness
- Lead in paint

Particles $PM_{2.5}$

Median = **18 µg/m³**

96% > 10 µg/m³, WHO guideline value for outdoor air applicable to indoor air (WHO AQGs, 2005)



Mean concentrations of $PM_{2.5}$ measured in European schools since 2010

Semi-volatile organic compounds

52 target SVOCs

- 16 pesticides
- 2 synthetic musks
- 12 polycyclic aromatic hydrocarbons (PAHs)
- 9 polychlorobiphenyls (PCBs)
- 6 phthalates
- 6 brominated flame retardants (PBDEs)
- Triclosan

Air: URG cartridge

Settledt dust: vacuum cleaner + cellulose cartridge

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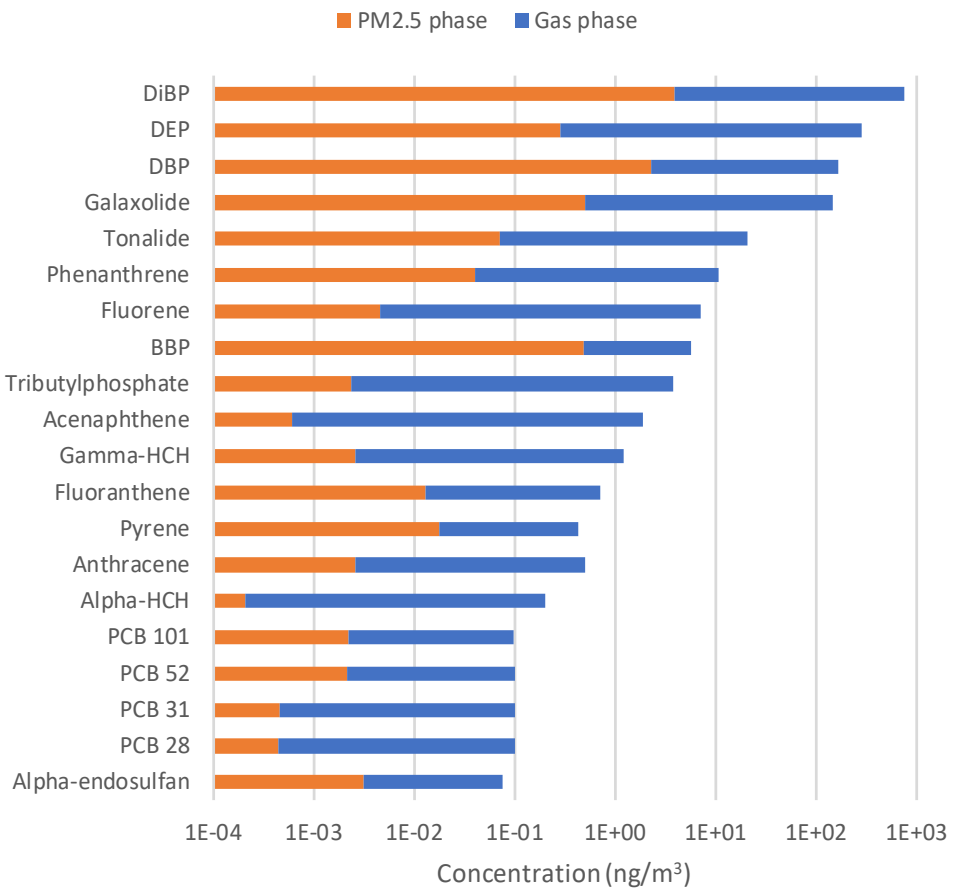
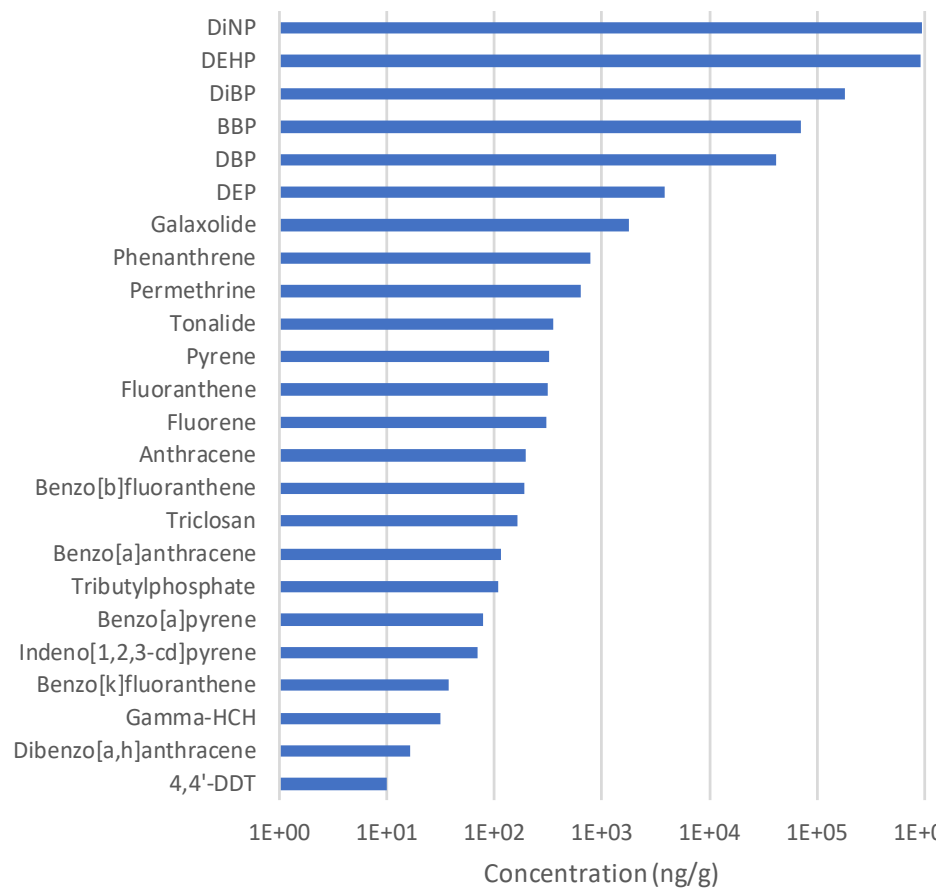
Semi-volatile organic compounds

Median concentrations (> LOD) in the air



Median concentrations (> 10 ng/g) in settled dust



(Wei et al, Indoor Air, 2020)

Ventilation

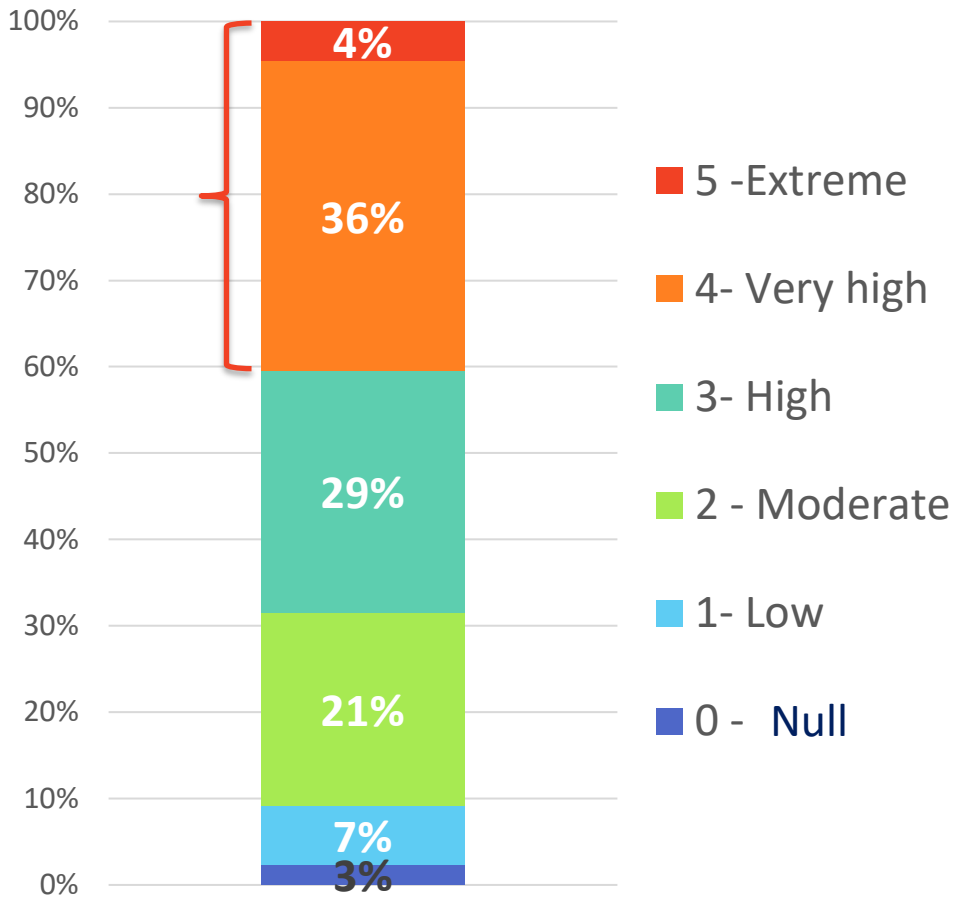
25% of schools have a mechanical ventilation system

Windows are not regularly open

40% of schools have at least one classroom with a very high ICONE index (≥ 4)

Air stuffiness index (ICONE)

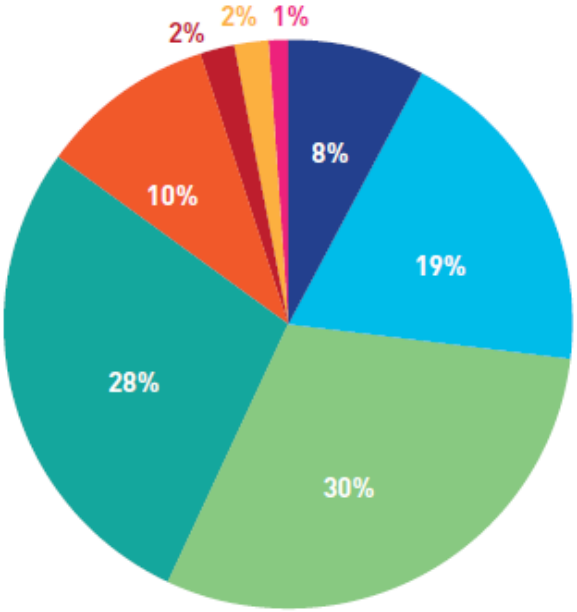
(Canha et al, Indoor Air, 2016)



Highest value per school among the instrumented classrooms

Lead in paint

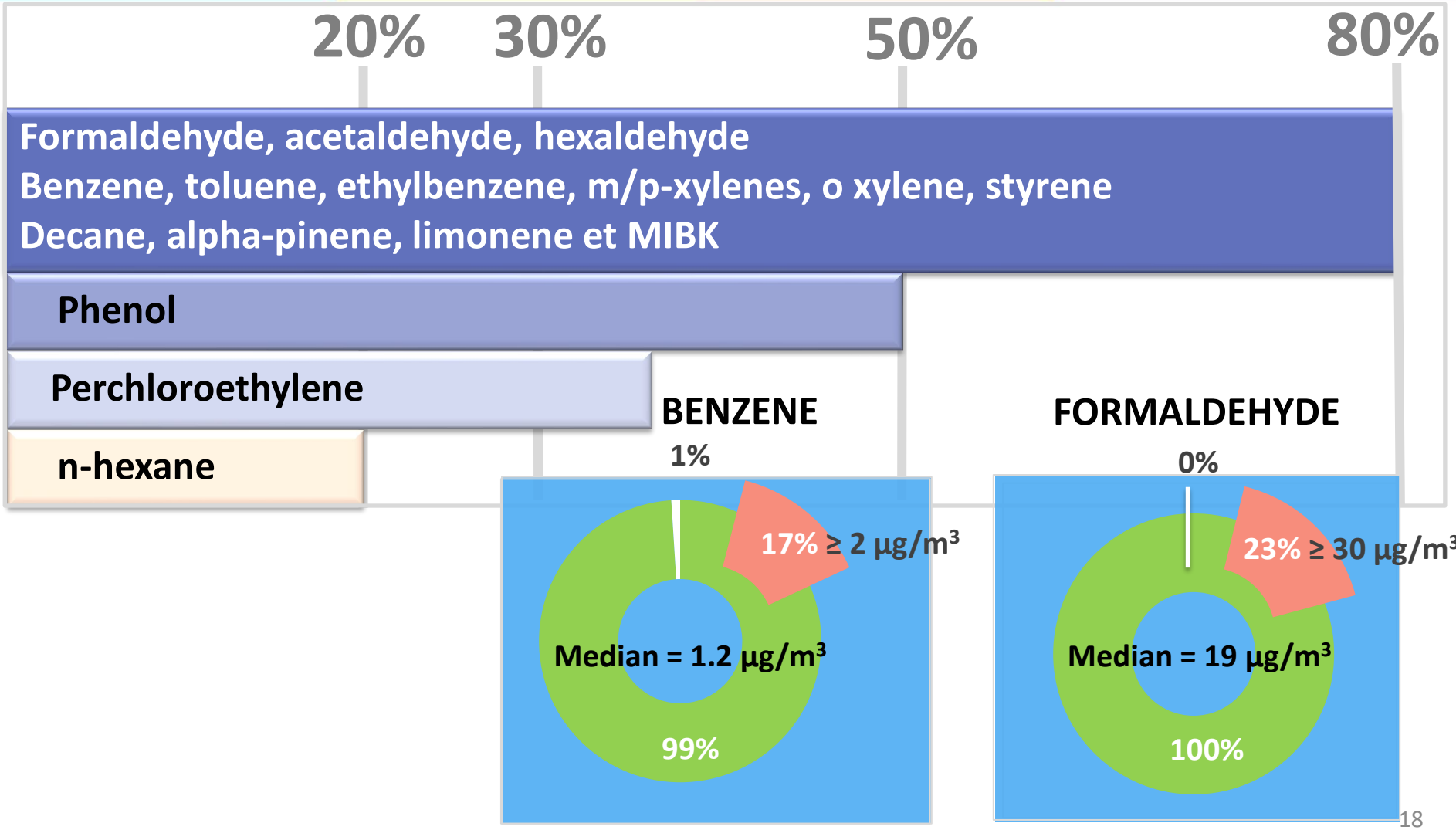
15% of schools have at least one classroom with deteriorated paint containing more than 1 mg/cm² of lead



n=28,487 measurements

- Furniture (cupboards and shelves)
- Shutters
- Walls, baseboards, molding, chair rails
- Radiators, heating pipes
- Windows (frames, casement)
- Pillars
- Doors (frames, opening frame)
- Black boards

Volatile organic compounds and aldehydes



Compared to dwelllings?

Comparison with IAQ Observatory nationwide study in dwellings (2003-2005)

Concentrations

Schools < Dwellings (*p-value*<0.05)

Except for **formaldehyde, hexaldehyde and $PM_{2,5}$**

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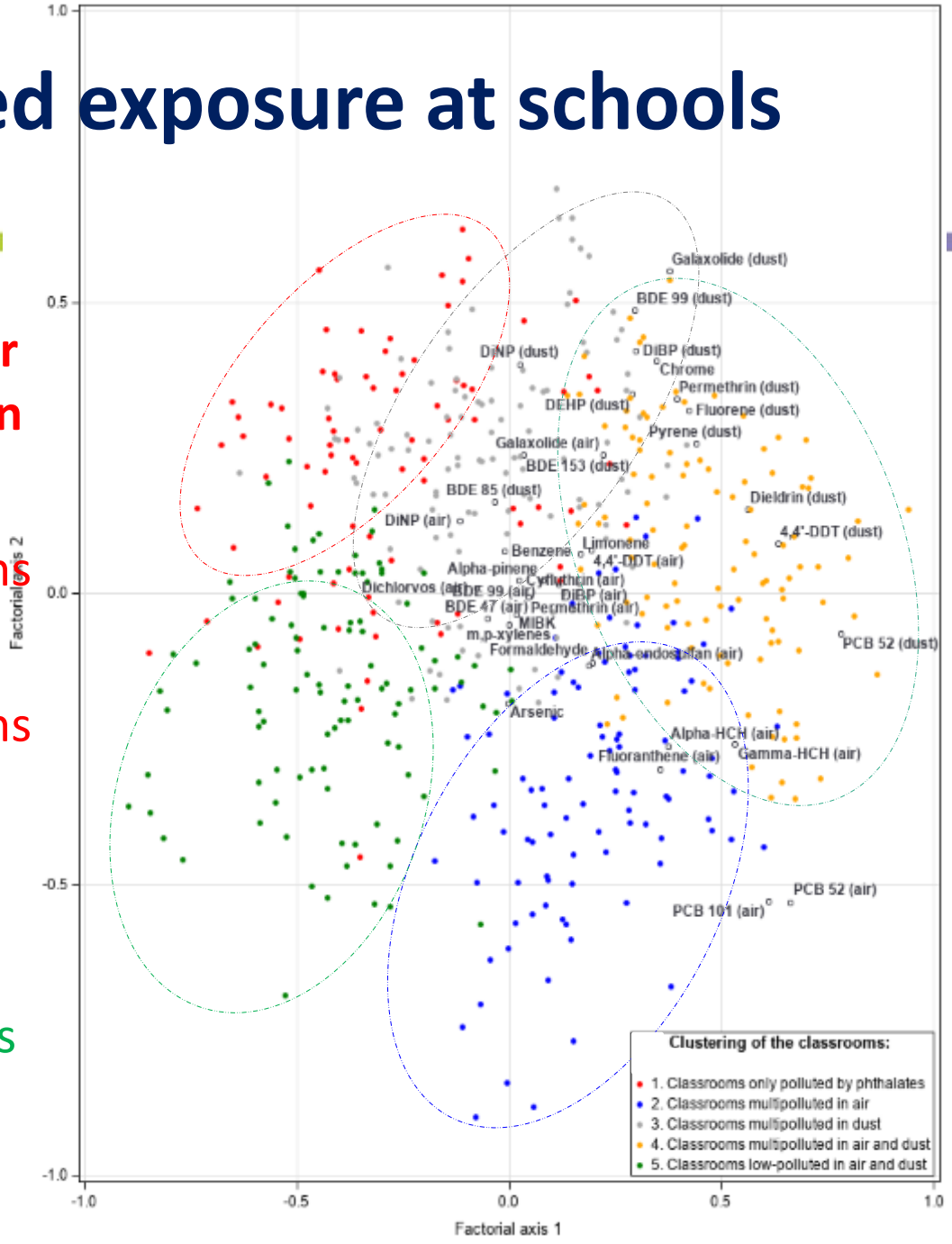
Combined exposure at schools

- **21% of classrooms with higher concentrations of pollutants in both air and dust**
- 19% with higher concentrations in air
- 24% with higher concentrations in dust
- 17% with higher phthalate concentrations only
- 19% with lower concentrations in both air and dust



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Next steps

Data analysis still in process…

- Comfort parameters: thermal comfort, noise, light
- Determinants of indoor pollutants: lindane, formaldehyde

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❸ What are the solutions?

Source control: mandatory labelling

Mandatory labelling system in place since September 2013 for all building materials and decoration products

Based on 10 VOC emissions + TVOC

Classes	C	B	A	A+
Formaldéhyde	>120	<120	<60	<10
Acétaldéhyde	>400	<400	<300	<200
Toluène	>600	<600	<450	<300
Tétrachloroéthylène	>500	<500	<350	<250
Xylène	>400	<400	<300	<200
1,2,4-Triméthylbenzène	>2000	<2000	<1500	<1000
1,4-Dichlorobenzène	>120	<120	<90	<60
Éthylbenzène	>1500	<1500	<1000	<750
2-Butoxyéthanol	>2000	<2000	<1500	<1000
Styrène	>500	<500	<350	<250
COVT	>2000	<2000	<1500	<1000

Focus on cleaning products

- **Building audit:** pictures and commercial references of cleaning products used in 310 schools and day-care centers
- **584 different cleaning products were listed.**
  From 1 to 7 per building; 3 or 4 on average
- **Only 218 safety data sheets available (37%)**
- **In these SDS, 152 different substances**
- **Among these substances:**
  - 49% classified as irritant according to EU classification system
  - 1 classified as carcinogen Group 1 by the IARC
  - 2 considered as endocrine disruptors according to EC proposal

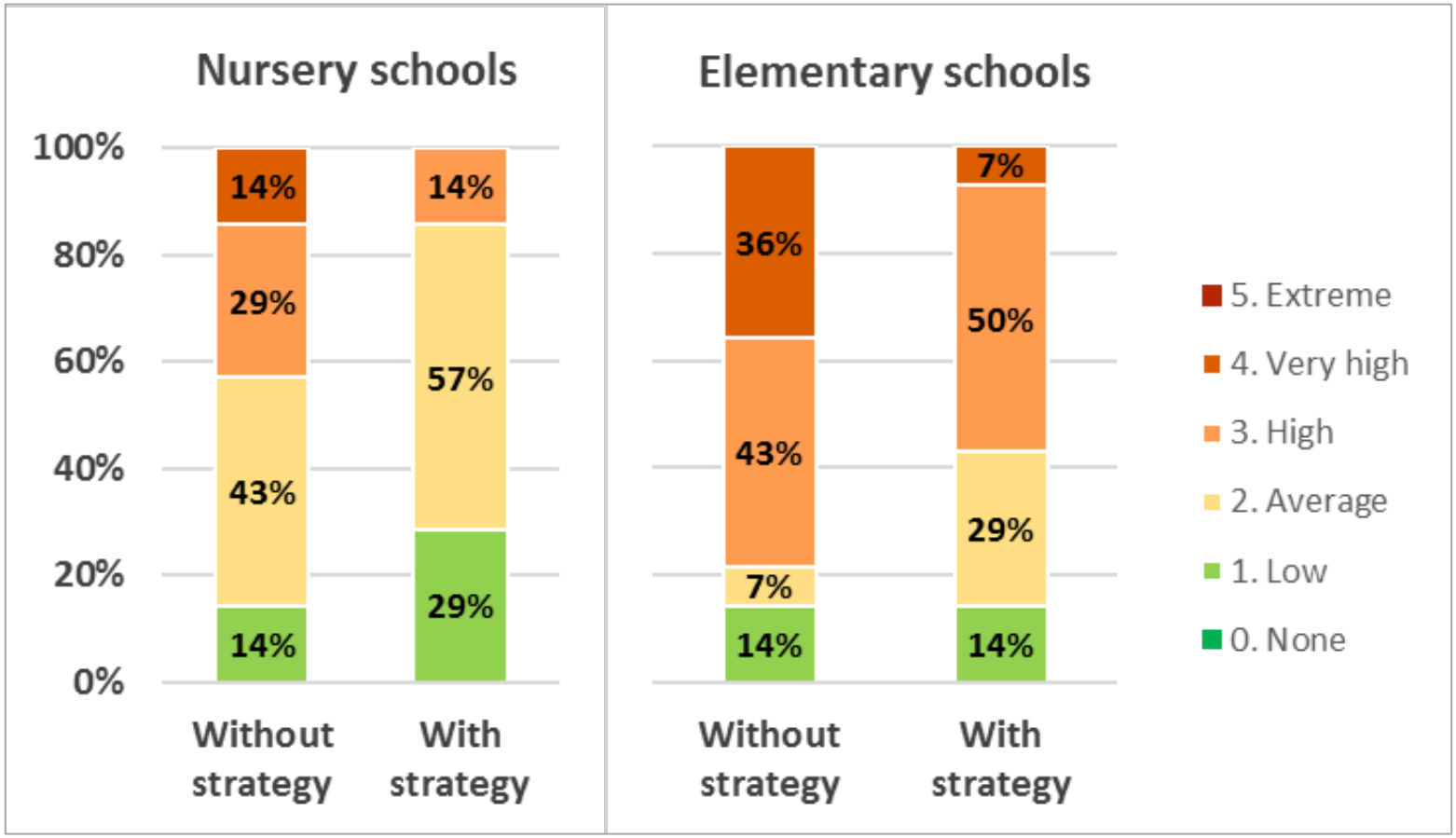
(Wei et al, Indoor Air, 2016)

Traffic light indicator to help occupants in managing window-opening

CLASS'AIR®

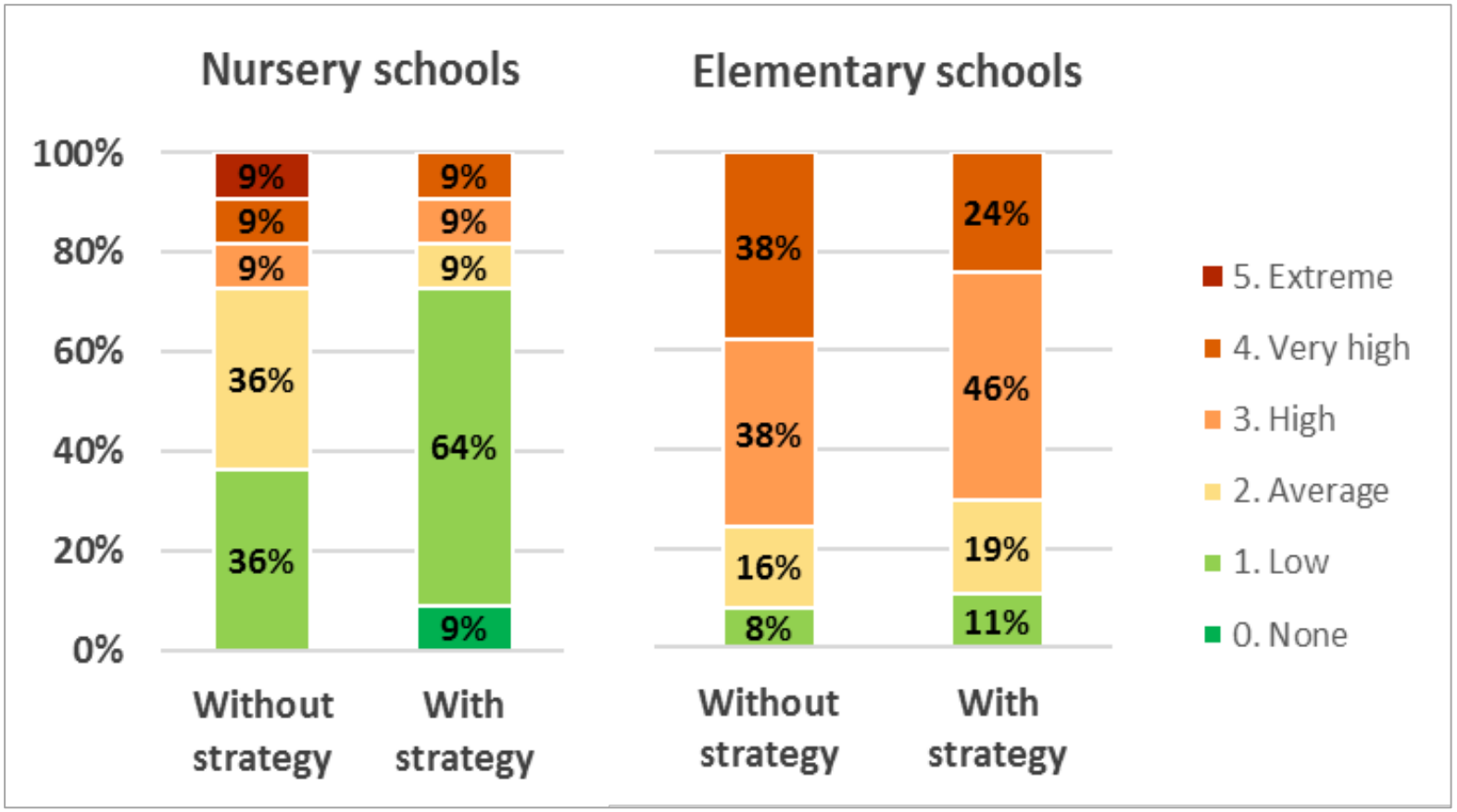
- No need to open the windows
- Windows should be opened
- Windows need to be opened
- Back to green: Windows can be closed

Tested in classrooms without mechanical ventilation



Strategy = traffic light indicator, n=21 classrooms

A simple planning is also efficient



Strategy = window opening schedule, n=48 classrooms

The French regulation on IAQ in schools

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2 options

1. Periodic monitoring every 7 years:
   - Formaldehyde
   - Benzene
   - Carbon dioxide
   - (Tetrachloroethylene)

2. Mandatory evaluation of ventilation

1. Walkthrough survey with a dedicated checklist

2. Mandatory evaluation of ventilation

Calendar:

January 2018: buildings hosting children <6 years + kindergartens + elementary schools

January 2020: high schools

January 2023: other buildings with vulnerable populations

The French regulation on IAQ in schools

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2 sets of guideline values

1. Guidelines for the one-week measurements
- Formaldehyde: 100 µg/m³
- Benzene: 10 µg/m³
- Carbon dioxide: ICONE = 5
- (Tetrachloroethylene: 250 µg/m³)

→ If exceeded, source identification and remediation within one month

1. Guidelines for the summer + winter average
- Formaldehyde: 30 µg/m³
- Benzene: 2 µg/m³

→ If exceeded, occupant information + emission source limitation + improvement of ventilation

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Next ISIAQ Conferences

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Next ISIAQ Conferences

Healthy People in Healthy Indoor Environments

INDOOR AIR 2022

June 12th to 16th
Kuopio FINLAND

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CSTB
le futur en construction

TAPAS
Tackling air pollution at school

Thank you for your attention!

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