Volatile organic compounds in office buildings: identification of major sources and intervention study to reduce indoor concentrations

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OFFICAIR – Field Campaign Objectives

• To describe IAQ in European modern offices

• To inventory causes (events, sources) of IAQ problems in European modern offices

• To understand better the relationships between IAQ and perceived comfort, health symptoms and performance

• To provide recommendations for healthy and comfortable workplaces
A comprehensive approach

Three complementary steps:

**PHASE 2**

- **37 buildings**
- Measurements in summer and repeated in winter
- From Monday to Friday
- 4 workspaces + outdoors

**PHASE 3**

- **9 buildings**
- Intervention study
- Measurements before and after
- A test office and a control one
1. Detailed study: overall method

- From Monday (9.00) to Friday (17.00)
- 4 locations indoors
  - Coherence with density of offices/occupancy and participating workers
  - Different levels
  - Different orientations (N, S, E, W)
  - Diversity of offices (open space versus cellular)
  - Acceptance of occupants
- One location outdoor
  - Ideally near air intake, avoiding turbulence
  - At the same floor as one instrumented office, on street side
  - Feasibility and security
- 12 VOCs and 7 aldehydes measured with Radiello® passive sampling
- Checklist per room: materials, occupation, activities
Short description of the office rooms (n=148)

• **Open spaces** (64%) > cellular offices (36%)
• 39% of rooms were close (i.e., within 50 m) to a road with **heavy traffic**
• **Floorings**: carpet (51%), synthetic smooth floor (30%)
• **Ventilation**: 90% of the rooms equipped with balanced mechanical ventilation system; 7% with only exhaust and 3% with only supply
• The **windows** were not openable in 22% of the rooms
• One or more **printers or copiers** present in 65% of the rooms
• No use of **air fresheners** in the rooms was reported

(Geiss et al., 2011; Salonen et al., 2009)
IAQ in modern office buildings

Median concentration in µg/m³

VOCs

Aldehydes

Officair Summer

Officair Winter

Comparison

(Beiss et al., 2011; Salonen et al., 2009)
VOC and aldehyde sources

- Principal component analysis
  - **Factor 1**: pollutants associated with outdoor sources: BTEX and n-hexane
  - **Factor 2**: aldehydes originating from ozone-initiated reactions: formaldehyde, acetaldehyde and hexanal
  - **Factor 3**: VOCs generally associated with flooring emissions, 2-butoxyethanol, 2-ethylhexanol, and styrene
2. Intervention study: overall design

• **Week 1**: measurement of IAQ **before intervention** (1 week; 2 areas: intervention and control)

• **During 4 weeks** (in the tested area; blind to workers, managers and cleaners):
  - No deep cleaning
  - Cleaning of furniture water wetted cloth
  - Floor cleaning with a no-emitting cleaning product (chosen by UMIL; emission tests are on-going at IDMEC)

• **W6**: measurement of IAQ **after intervention** (1 week; 2 areas: intervention and control)

• Aldehydes, VOCs, NO$_2$, O$_3$, PM$_{2.5}$, ultrafine particles, T/RH
Results for aldehyde concentrations

A significant change in aldehyde concentrations after versus before in the intervention room

*: p-value between 0.010 and 0.050; **: p-value between 0.001 and 0.010; ***: p-value below 0.001
No change for the other parameters

- Example for PM$_{2.5}$
Conclusion

- First data on indoor air quality in modern office buildings in Europe – A reference data set

- **Outdoor air quality** is still a major determinant

- First time that the **influence of cleaning products** on IAQ (aldehyde concentrations) is shown
ON THE REDUCTION OF HEALTH EFFECTS FROM COMBINED EXPOSURE TO INDOOR AIR POLLUTANTS IN MODERN OFFICES

Thank you for your attention!

Acknowledgements to all the building managers and occupants