

Passive Formaldehyde Measurements in Simulated and Real Atmosphere for Indoor Air Monitoring

Passive formaldehyde measurements in simulated and real atmosphere for indoor air monitoring

Measuring Air Pollutants by Diffusive Sampling and Other Low Cost Monitoring Techniques

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LCSQA Central Air Quality Surveillance Laboratory **INERIS**

Indoor formaldehyde concentrations: French Observatory on Indoor Air Quality (OQAI) 2006

Formaldehyde Concentration – Weighted distribution of dwellings

Indoor Air Guide Values (French Agency for Environmental and Occupational Health and Safety)

Chronic IAGV $10 \mu\text{g m}^{-3}$

Acute IAGV $50 \mu\text{g m}^{-3}$

Min: $1.3 \mu\text{g m}^{-3}$
Median: $19.5 \mu\text{g m}^{-3}$
Max: $86.3 \mu\text{g m}^{-3}$

Concentration ($\mu\text{g m}^{-3}$)

- Detected in 100 % of the dwellings
- In 87 % of the dwellings concentrations $> 10 \mu\text{g m}^{-3}$

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Indoor formaldehyde concentrations survey

- Detected in 100 % of the dwellings
- In 87 % of the dwellings concentrations $> 10 \mu\text{g m}^{-3}$
Continuous sources: plywood, isolation foam, adhesive resins, cosmetic, etc...
Intermittent sources: cooking, cigarette smoke...
- Formaldehyde health effects
Population short and long term exposure: in France short term guide value: $50 \mu\text{g m}^{-3}$ for a few hours
Long term guide value: $10 \mu\text{g m}^{-3}$
- Formaldehyde surveillance in France
In schools, child care centers...

Necessity to be provided with a validated appropriate method

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How to monitor indoor formaldehyde concentration levels ?

- Indirect standard methods**
For formaldehyde indoor concentration monitoring and population exposure survey
Active sampling ISO 16000 – 3
Passive sampling ISO 16000 – 4
- On-line in development methods**
- On-line commercial methods**
For source emissions and concentration variation monitoring

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How to monitor indoor formaldehyde concentration levels ?

- Indirect standard methods**
For formaldehyde indoor concentration monitoring and population exposure survey
Active sampling ISO 16000 – 3
Passive sampling ISO 16000 – 4

Objectives: studying passive sampling ability in comparison with active sampling to measure formaldehyde in:

- Simulated atmosphere studies**
Exposure chamber
- Real atmosphere studies**
Indoor air environments (offices, dwellings, malls...)

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Formaldehyde monitoring: standard methods

Reaction with DNPH and HPLC analysis

$$\text{R1-CHO} + \text{H}_2\text{N-NH-C}_6\text{H}_3(\text{NO}_2)_2 \xrightarrow{\text{H}^+} \text{R1-CH=N-NH-C}_6\text{H}_3(\text{NO}_2)_2 + \text{H}_2\text{O}$$

Aldehyde 2,4-DNPH Hydrazone HPLC analysis

Active sampling
Sep Pack cartridge
+ O_3 KI filter

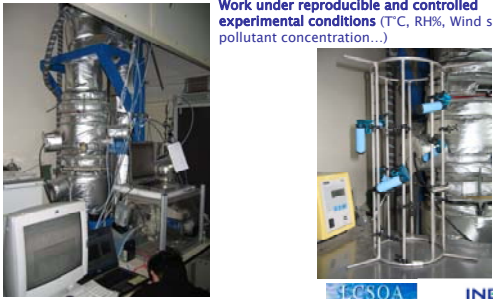
Passive sampling
Radiello cartridge
Fondazione Salvatore Maugeri
ISO 16000 – 4

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Passive Formaldehyde Measurements in Simulated and Real Atmosphere for Indoor Air Monitoring

Formaldehyde monitoring methods validation: Exposure chamber study


Work under reproducible and controlled experimental conditions (T°C, RH%, Wind speed, pollutant concentration...)



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Formaldehyde monitoring methods validation: Exposure chamber study

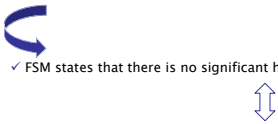
- Experimental conditions
20 °C, 50 % RH, 1 m s⁻¹ wind speed
- « Low formaldehyde concentration conditions »
~ 10 µg m⁻³
- « High formaldehyde concentration conditions »
~ 25 µg m⁻³
- Different time experiment for passive tube exposure 8 and 48 h.
- Several active tube samplings to cover the whole passive tube exposure period
- Different ozone concentrations (0, 20 and 100 ppb)
- For each experiment, 6 passive and 2 active tubes
- 2 experiments for each concentration and time exposure conditions



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Exposure chamber experiments: ozone concentration influence on passive sampling

- ✓ Experiments have shown a strong effect of ozone on active sampling (formaldehyde underestimation when working without O₃ filter) which is not the case for passive sampling.
- ✓ FSM states that there is no significant hydrazone ozonolysis when [O₃] < 100 ppb
- ✓ Radiello passive samplers: No difference on formaldehyde uptake between experiments carried out with and without ozone

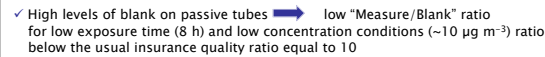


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Exposure chamber experiments: exposure time and concentration influence

Concentration condition	Exposure time	Passive (µg m ⁻³)	Measure / Blank	Active (µg m ⁻³)	Difference Active-passive (%)
Low	8 h	7.6	2	5.2	-37
High	8 h	25.8	4	20.3	-24
Low	48 h	6.7	5	7.9	17
High	48 h	17.8	15	16.7	-7

- ✓ High levels of blank on passive tubes → low "Measure/Blank" ratio for low exposure time (8 h) and low concentration conditions (~10 µg m⁻³) ratio below the usual insurance quality ratio equal to 10
- ✓ For high concentration conditions and 48 h exposure time, this ratio is satisfactory so is the difference between concentrations measured by each method (-7 %)




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Exposure chamber experiments: exposure time and concentration influence

Radiello high levels of blank can affect formaldehyde measurement

- ✓ Difference between active and passive is high
- ✓ Radiello measurement reproducibility (6 tubes exposed) is mediocre

Formaldehyde measurement should not be performed under low exposure time and low concentration conditions



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Indoor environment experiments



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Indoor environment experiments: exposure time and concentration influence

Indoor environments	Exposure time	Passive ($\mu\text{g m}^{-3}$)	Measure/Blank	Active ($\mu\text{g m}^{-3}$)	Difference Active-passive (%)
Shopping mall	8 h	19.0	5	13.5	-34
Furniture shop	8 h	40.0	10	34.3	-15
Firm office	48 h	22.2	17	27.9	23
House office	48 h	39.4	31	41.1	1
House dining room	48 h	38.6	28	37.8	-1
House living room	48 h	57.6	42.4	51.3	-2

- ✓ Passive tubes high levels of blank can affect formaldehyde → difference between active and measurement
- ✓ Good agreement between both techniques when the ratio measure/blank is > 10
- ✓ In houses, difference is very low (-2 - 1%) in comparison with the values measured during exposure chamber experiment (-37 - 17%) and the campaign in the shopping mall (-34 - 15%)

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Indoor environment experiments: wind speed influence

- ✓ In houses, difference is very low (-2 - 1%) in comparison with the values measured during exposure chamber experiment (-37 - 17%) and the campaign in the shopping mall (-34 - 15%)

↕

- ✓ Chamber experiment: 1 m s^{-1} simulated wind seed
- ✓ Shopping mall and furniture shop: air exhaust system
- ✓ Houses: no ventilation

↪ Influence of wind speed ?

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Conclusions

- ✓ Particular attention should be addressed when working under low formaldehyde concentrations with low exposure duration of **passive Radiello sampling tubes** because of the **high blank level**.
- ✓ **Wind speed** seems to influence formaldehyde uptake on **passive Radiello sampling tubes**.
- ✓ A comparison of standard active and passive methods has shown a **general good agreement in houses**.

↪ Ability of passive Radiello sampling to measure formaldehyde in indoor environments but...

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Perspectives

- ✓ **Wind speed** : further investigations should be carried out to improve knowledge on such phenomena (exposure chamber experiment).
- ✓ **Levels of blank**: some experiments are carried out by the FSM to improve Radiellos levels of blanks (influence of transport, extraction solvent purity...)
- ✓ **Exposure time**: Radiello passive tube should be tested (in simulated and real atmosphere) under longer exposure time (4 to 7 days). Longer times are more representative of population exposure and 4 days have been chosen for formaldehyde survey in French schools.

↪ Experiments still have to be done to fully validate formaldehyde passive sampling (influence of exposure time, RH, T°C, wind speed, extreme conditions...)

↪ However, there is no surveillance framework to guide this tests...

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