



INDOOR AIR QUALITY: DETERMINATION OF THE SECONDARY SOURCES OF FORMALDEHYDE

FORMUL'AIR FORmaldéhyde et siMULations dans l'AIR

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ABOUT THE PROJECT

- ✓ People spend more than 80% of their time indoors
- ✓ Indoor VOCs concentrations can be consistently higher than outdoor environments

Formaldehyde

- ❖ Human carcinogen
- ❖ One of the main indoor pollutants
- ❖ Target value 2015 : $30 \mu\text{g}/\text{m}^3$
- ❖ Target value 2023 : $10 \mu\text{g}/\text{m}^3$

FORMALDEHYDE

Primary sources

Direct emission from building materials, cleaning agents, disinfectants, pesticide formulations, paper products, cigarette smoke, etc.

Secondary sources

Indoor chemical reactions of VOCs that contribute to increase the indoor formaldehyde levels.

ABOUT THE PROJECT

Aim: To identify the secondary sources contributing to increase the indoor formaldehyde concentration

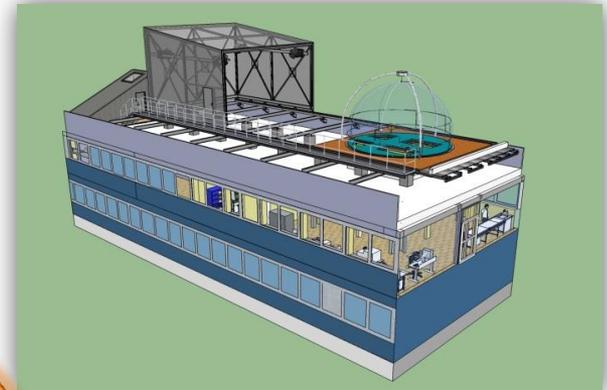
Ventilation impact

**Numerical
simulations**



Field measurements

Classrooms



**Simulated
environment studies**

VOC -> Formaldehyde

FORMaldéhyde et **siMUL**ations dans l'**AIR** :
détermination des sources secondaires de
formaldéhyde.

METHODOLOGY

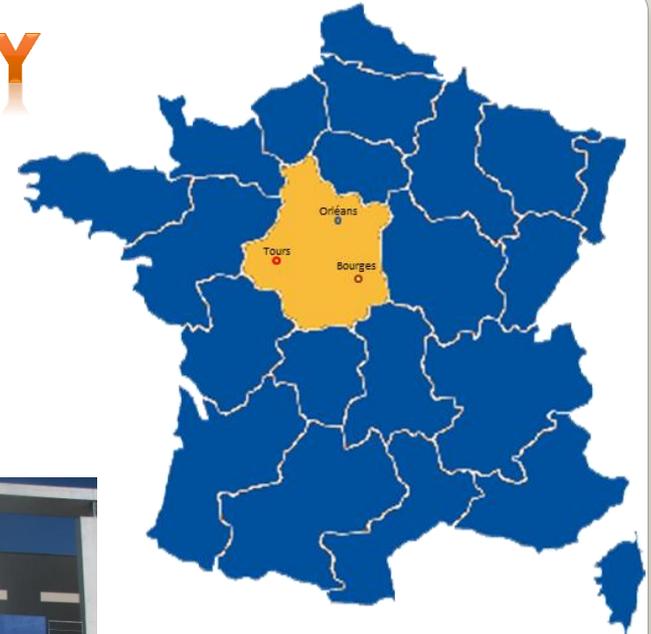
This study is conducted in three classrooms in Centre of France:

- ✓ a high school (Lycée) in Orléans,
- ✓ an elementary school (école) in Bourges,
- ✓ a high school (collège) in Tours.



Indoor carbonyl compounds and other VOCs are monitored in parallel by active sampling devices (NDPH and Air toxic cartridges), PTR-TOF-MS and HCHO, O₃ and NO_x analyzers.

Comfort and confinement parameters are also considered



Outdoor O₃, NO, NO₂ and PM₁₀ concentrations are monitored by the stations of Lig'Air.

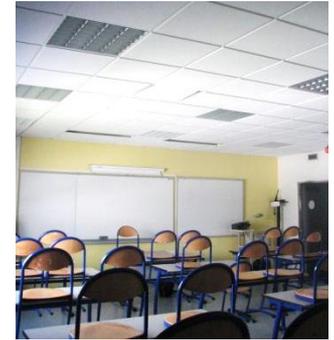
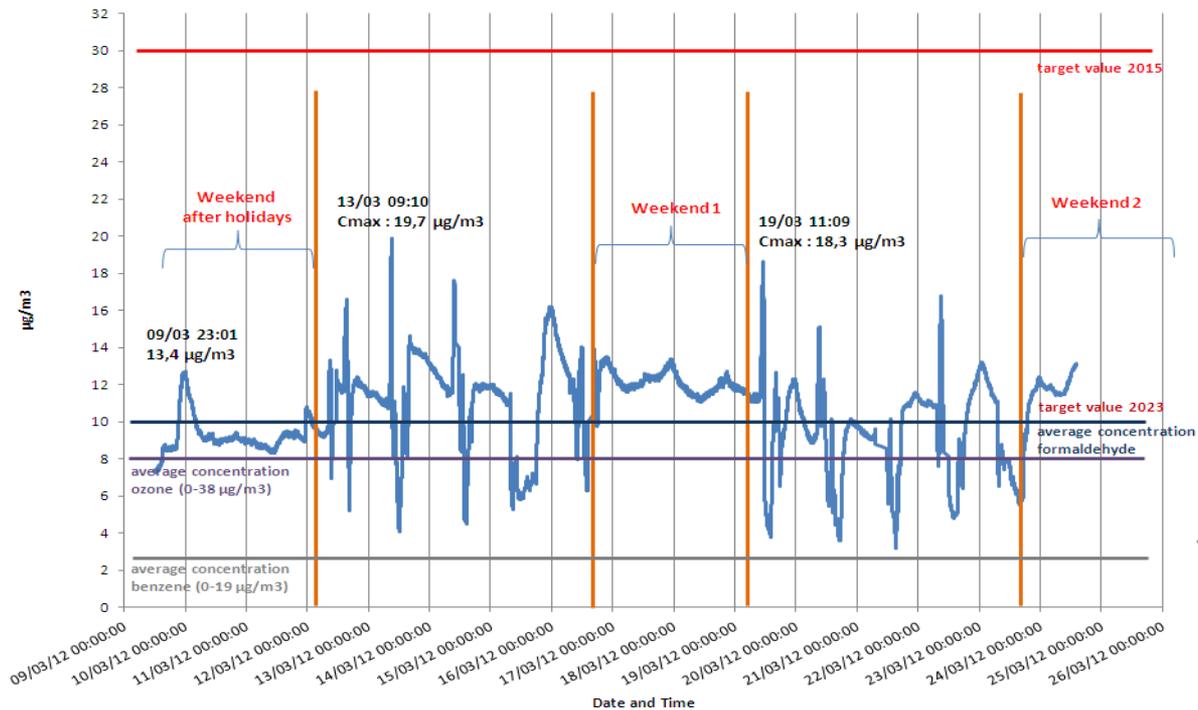
HCHO is also monitored by passive sampling devices inside and outside.

PRELIMINARY RESULTS
HIGH SCHOOL-ORLÉANS : MARCH 2012

PRELIMINARY RESULTS

CONTINUOUS MEASUREMENTS

High school-Orléans : March 2012



- ✓ Indoor formaldehyde levels between 3 and 20 µg/m³.
- ✓ Sharp formaldehyde peaks were observed in the week days, generally when the classes begin or after some breaks.
- ✓ Correlation between formaldehyde and terpenes (C₁₀H₁₆).
- ✓ No correlation between formaldehyde and other VOCs.

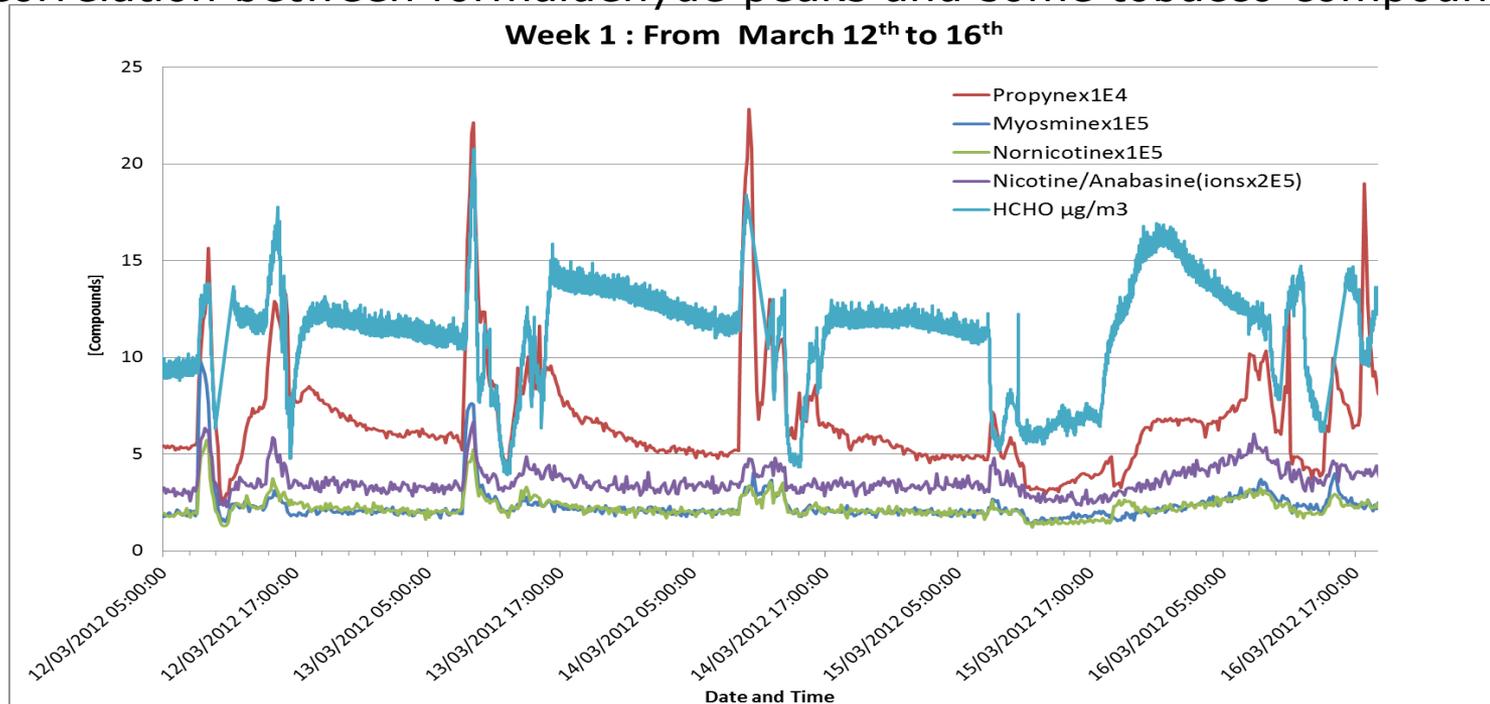
PRELIMINARY RESULTS

CONTINUOUS MEASUREMENTS

High school-Orléans:

Sharp formaldehyde peaks from cigarette ?

Good correlation between formaldehyde peaks and some tobacco compounds



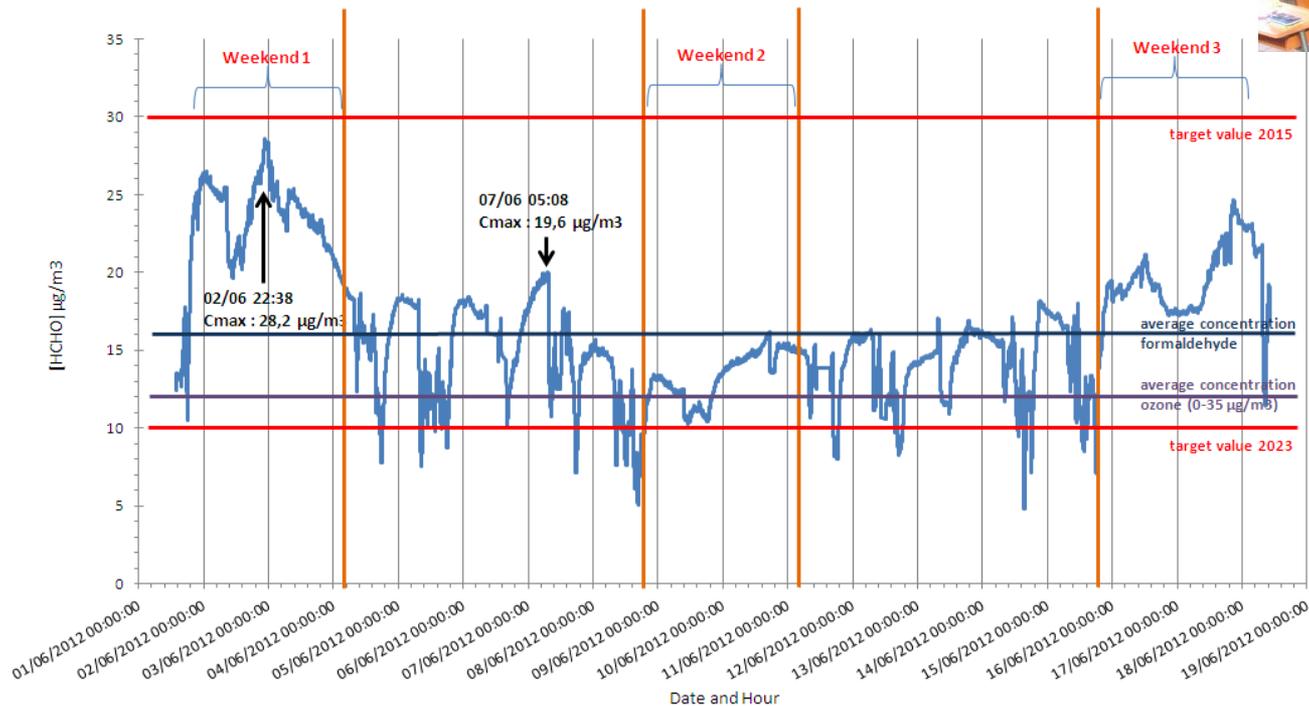
Smokers can increase the indoor pollution, even if smoking inside the buildings is forbidden because compounds can be retained in clothing and hair and can be released into the classroom. Most of the high school students are smokers.

PRELIMINARY RESULTS
ELEMENTARY SCHOOL-BOURGES : JUNE 2012

PRELIMINARY RESULTS

CONTINUOUS MEASUREMENTS

Elementary school-Bourges: June 2012



- ✓ Indoor formaldehyde levels between 5 and 28 µg/m³.
- ✓ The formaldehyde levels have the same tendency that the indoor temperature.
- ✓ Good correlation between formaldehyde and compounds such as limonene, α-pinene, isoprene, butene, octene, 3-hexen-2,5-dione and ozone, but only on the night data where windows and doors are closed.

CONCLUSIONS

- ✓ These first campaigns provide indications of the indoor formaldehyde concentrations levels and variation according to the activities and human habits.
- ✓ Both classrooms have recorded levels of formaldehyde lower than the target value 2015 ($30 \mu\text{g}/\text{m}^3$).
- ✓ In high school, we observe a good correlation between formaldehyde peaks and some tobacco compounds.
- ✓ Secondary formaldehyde is mainly produced by indoor ozone reaction with terpens and unsaturated hydrocarbons. But other reactions pathways could also contribute to the secondary formation of formaldehyde (Reactions with OH and NO_3).
- ✓ Further experiments will be conducted in order to have more evidences and better identify the secondary sources of formaldehyde indoors.

PERSPECTIVES

Chamber simulation experiments (HELIOS platform)

- ✓ Simulation of the classroom conditions.
- ✓ Chemical reactivity of the VOCs found into the classrooms and determination of the formaldehyde yield.

Numerical simulations

- ✓ Ventilation effect
- ✓ Optimization according to the configuration of the classroom.

Next campaigns

- ✓ Winter campaign at the high school in Orléans and elementary school in Bourges (December 2012/January 2013)
- ✓ Summer and winter campaigns at a high school in Tours (2013)

THANK YOU FOR YOUR KIND ATTENTION

ACKNOWLEDGEMENTS

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