New measurement and modelling approach to evaluate and predict the impact of building materials on indoor air quality

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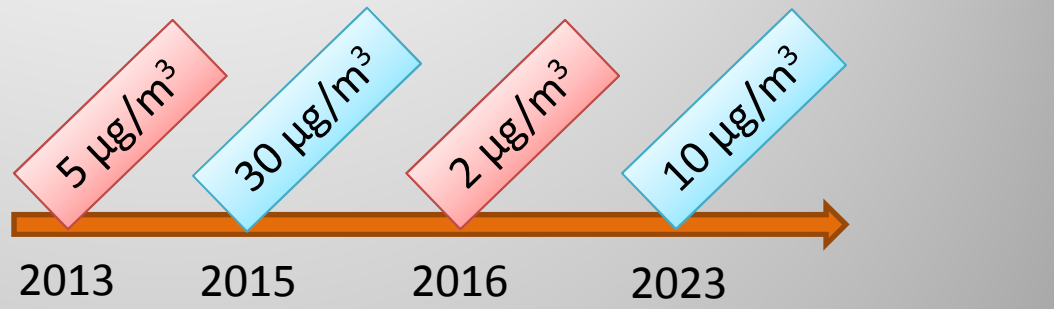
French Legislation

Indoor air quality in public buildings (schools, childcare center…)

- Compulsory measurement of pollutants (benzene, formaldehyde, CO_2) every 7 years (decree n° 2012-14)

- Guide values



Guide values for benzene and formaldehyde (decree n°2011-1727)

Labeling of all building materials (decree n° 2011-321)

28-day test

Exposure concentrations for 11 compounds, including formaldehyde, and TVOC

Role of building materials

Airtight Buildings
+
Emissions from materials

→ Indoor Air more polluted than outdoor air

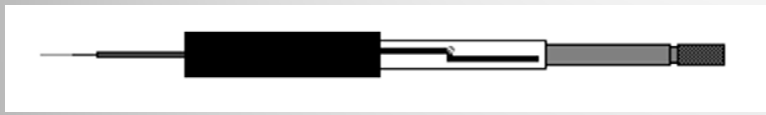
Materials = main sources of VOCs and formaldehyde found in indoor air

Indoor Air Diagnosis

Identification of emissions sources

Predictive Modelling of IAQ

Analytical Methods: Description



Solid-Phase Micro Extraction (SPME)

- Passive sampler
- Amount of pollutants collected on the fiber proportional to its concentration and to exposure time
- Modified SPME fiber: **simultaneous analysis of VOCs and formaldehyde**

1 On-site sampling

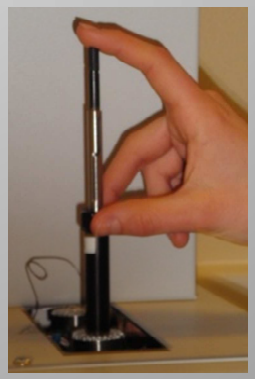
Air

- Vial equipped with a SPME-adapter
- Carried under vacuum
- Filled on-site in a few seconds

Material Emissions

- Emission cell put on the material
- Emission of the material into the cell
- SPME sampling
- Measurement of a **surface concentration**

2 Laboratory Analysis



- Chromatographic analysis
- Mass spectrometer detection

Analytical Methods: Performances

- ✓ Developped for 9 compounds : toluene, p-xylene, styrene, 1,2-dichlorobenzene, tetrachloroethylene, formaldehyde, acetaldehyde, hexanal and α-pinene.

	R^2	LOD ($\mu g.m^{-3}$)	LOQ ($\mu g.m^{-3}$)	RSD (n=6)
Average for the 9 compounds	0.97	0.034	0.114	18

Analytical performances in GC/MS, SPME extraction: 20 minutes

- ✓ Limits of quantification low enough to study indoor air quality

- ✓ Results in good agreement with those obtained by active sampling on Tenax® tubes (VOCs analysis) or DNPH cartridges (formaldehyde)

	SPME (µg.m-3) (n=6)	Normalized method (µg.m-3) (n=3)
Formaldehyde	11.5 ± 1.5	12.3 ± 1.0
α-pinene	101.5 ± 21.0	103.3 ± 8.1
styrene	1.3 ± 0.3	2.4 ± 1.0

- ✓ Relative air humidity do not have any influence on SPME sampling

Case studies

Three sites were studied

- Built with a high environmental quality (HEQ) approach
- New buildings or constructed less than 2 years ago
  - Meeting room in an office building
  - Classroom in a high school
  - Unoccupied house

Site Description

Ventilation	Mechanical
Occupancy	25 pupils 4 days per week
Furniture	Particle board desks Beech wood chairs
Decoration	Polyester curtain
Walls	Paint
Ceiling	Suspended ceiling
Floor	PVC
Boards	"Classical" whiteboard Interactive board

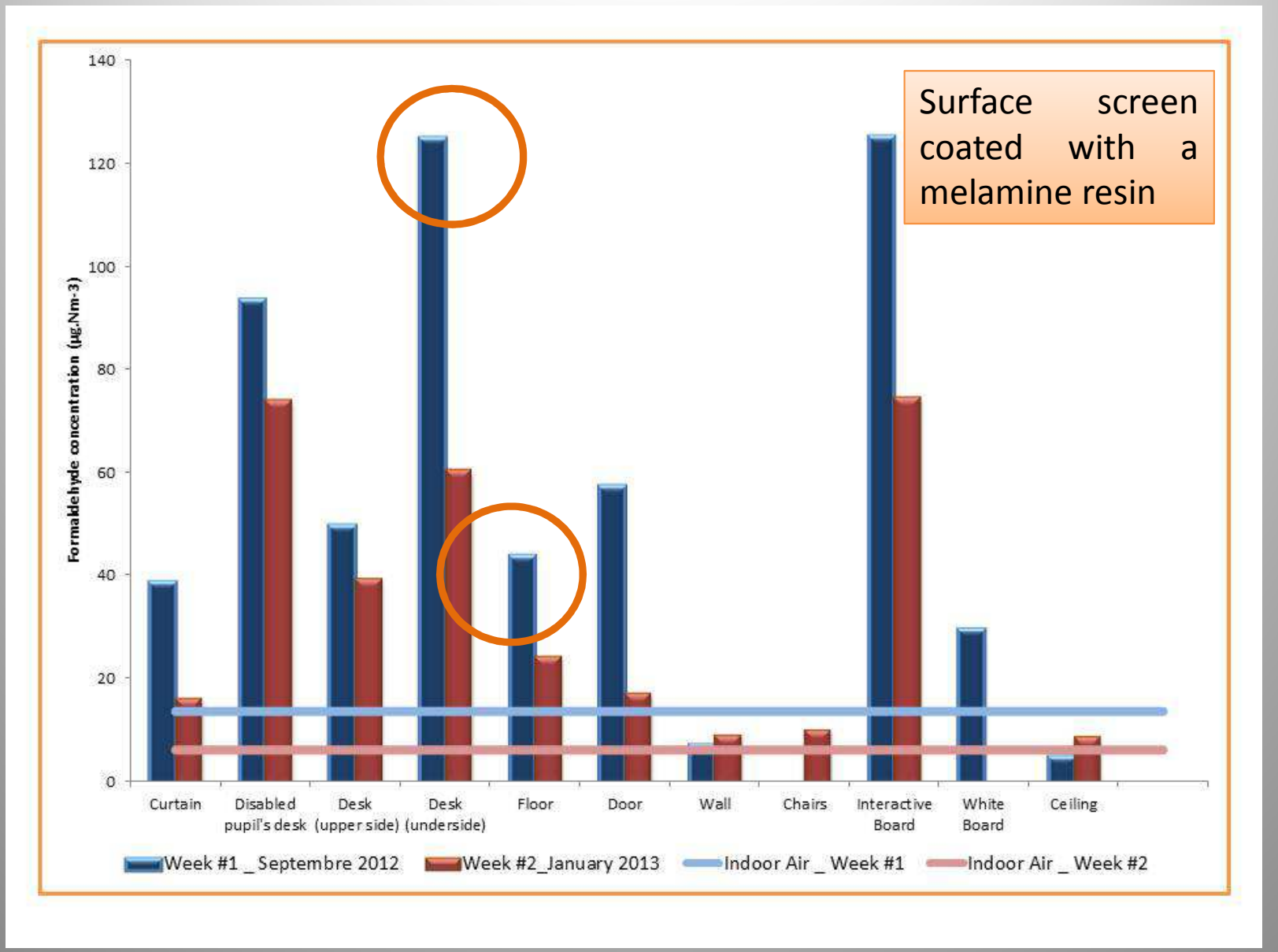
- Six-month study
- Measurement campaigns held every 2 or 3 weeks
- Indoor air, outdoor air, material emissions

Formaldehyde

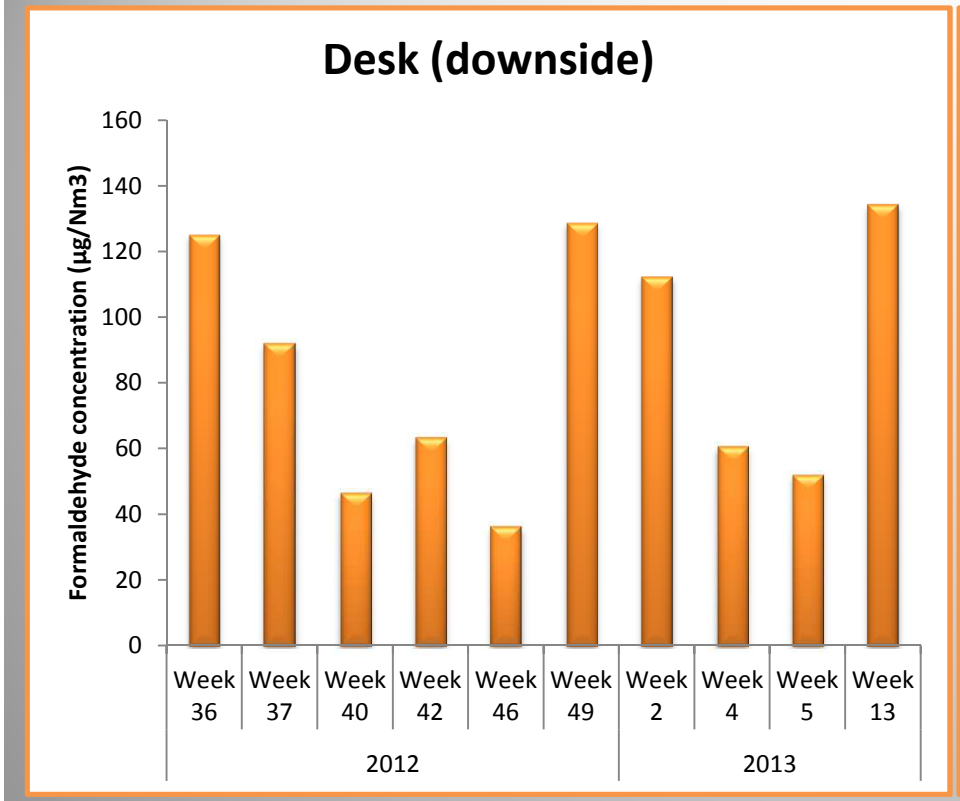
Hexanal

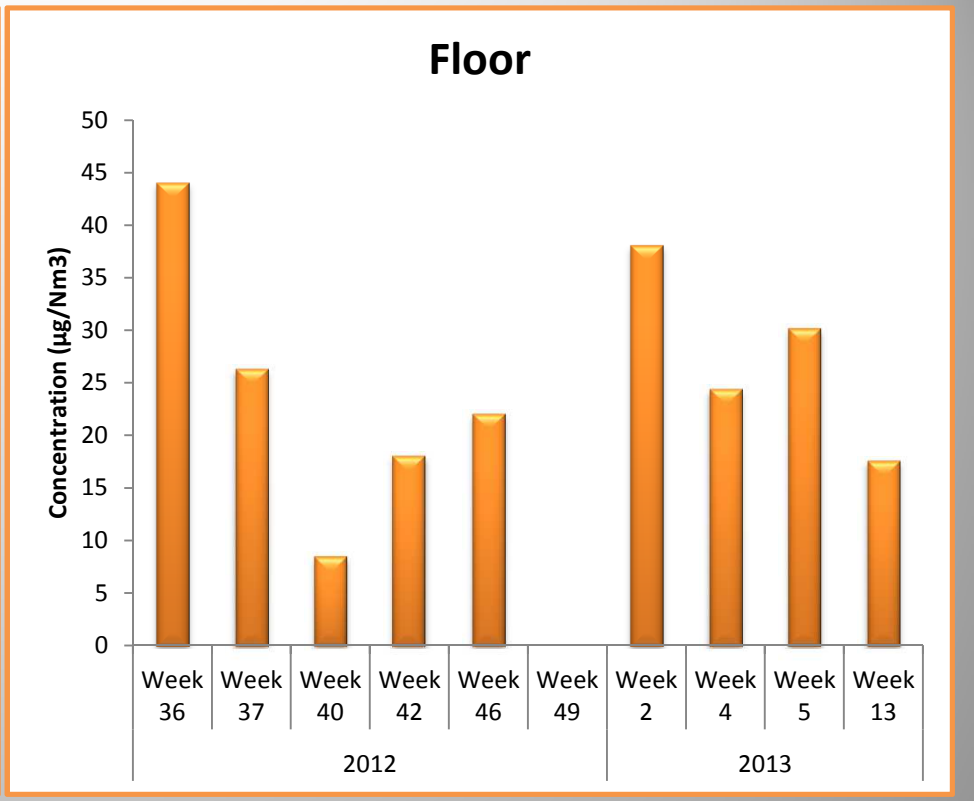
Alpha-pinene

Identification of formaldehyde sources



Evolution of material emissions with time

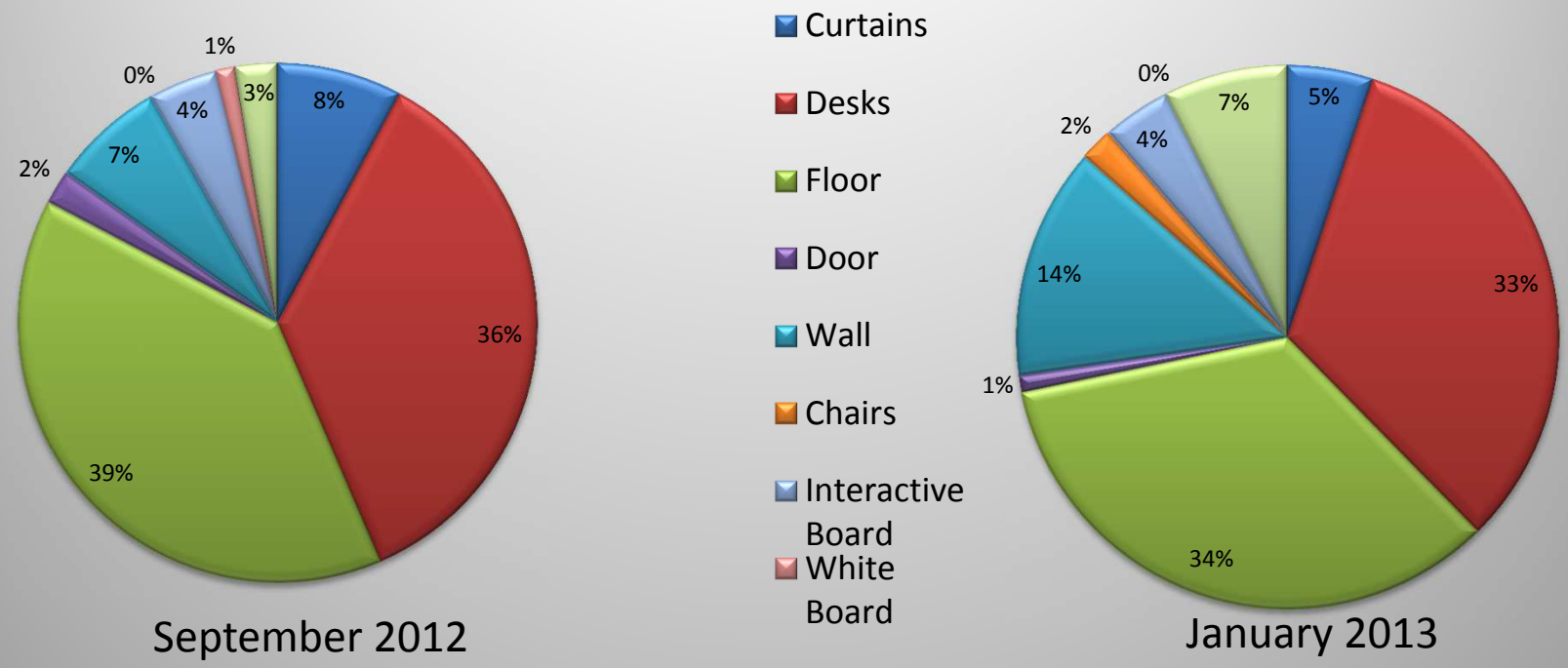




- Important variations of material emissions from one week to another
- Interest to realize on-site measurements
- Difference between material's behavior in an environmental chamber and in real conditions

Classification of formaldehyde sources

Considering the surface of each materials…

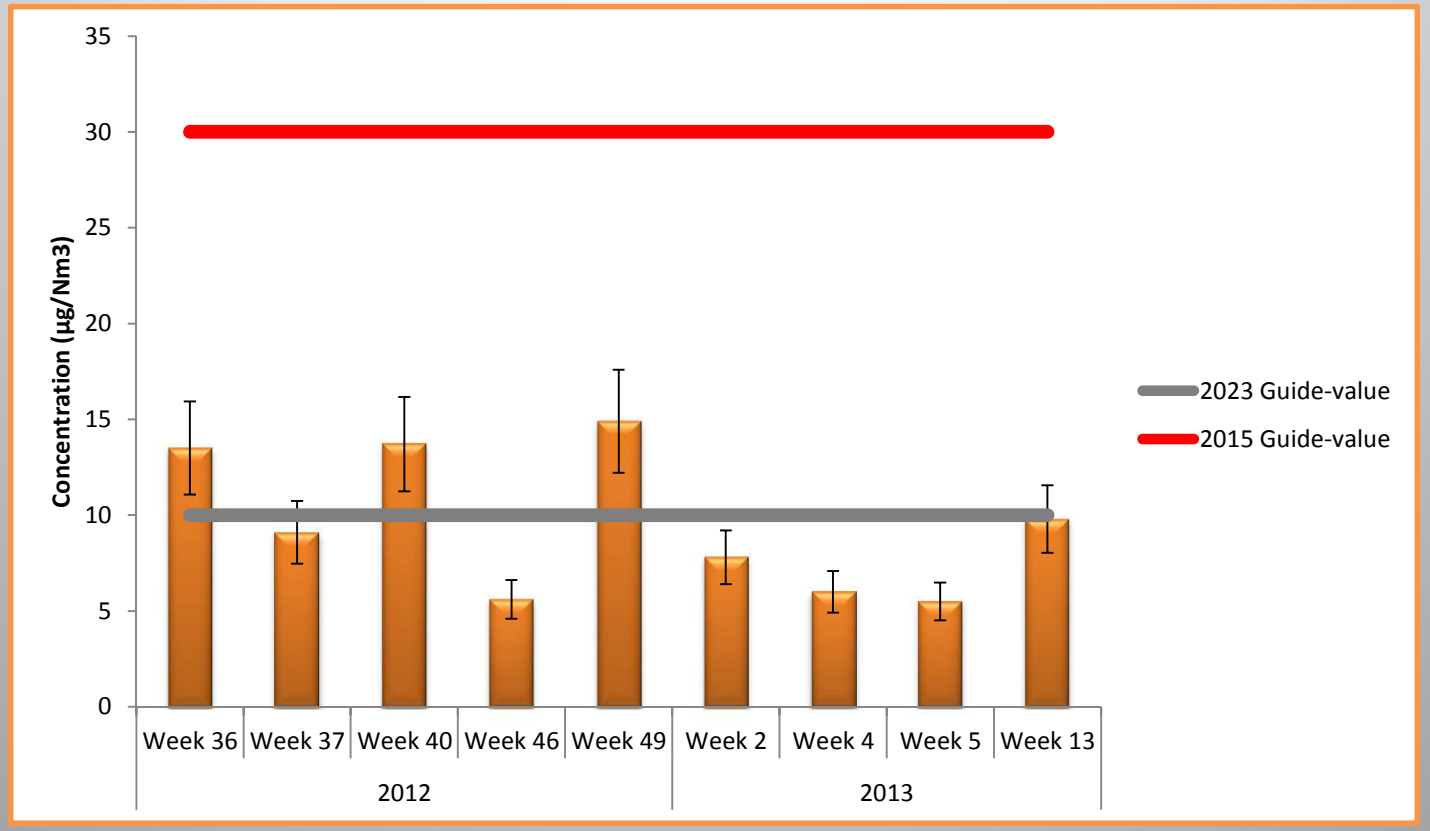


September 2012

January 2013

- Even if the material formaldehyde emission changed a lot, **the ranking between the materials did not change**
- Main contributor: **floor** because of its **high surface** in the room. Formaldehyde may come from the adhesive used for its setting up
- Important impact of the **furniture made of particle board**

Impact on indoor air quality



Indoor air concentration well controlled, even in presence of numerous emission sources, thanks to an efficient ventilation (3.3 vol/h)

(Air exchange rate was determined by the injection of a tracer gas)

Conclusion

- ✓ Simple, fast and sensitive analytical method to study on-site indoor air quality and building material emissions
- ✓ Interest to realize in situ measurement and to study materials in their “real” environments
- ✓ Identification of emissions’ sources

Thanks for your attention

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