

6 March  
2018

# Assessment of low-cost particulate matter and VOC sensors

Laure MOURADIAN

## Purpose of the study

### Assessment of « new » IAQ sensors

- Low cost stand-alone sensors for consumers
- Compact and internet-connected
- Measuring :
  - Particulate matter
  - VOCs
- Assessment of sensitivity, response time
  - On site and in laboratory
  - Regarding the nature of pollutant

# Sensors tested at CETIAT



AWAIR  
PM, VOCs, CO<sub>2</sub>



FOOBOT  
PM, VOCs



LASER EGG  
PM

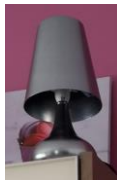


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SPECK  
PM



AERECO  
PM



UNI-T  
PM, VOCs



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# Few / heterogeneous information on sensors characteristics

Information available on manufacturers' technical specifications for particles measurements

A	B	C	D	E	F
<ul style="list-style-type: none"> <li>• Sensitivity: 0,3 – 10 µm</li> <li>• PM2.5, PM10</li> <li>• PM 2.5 ±10%</li> <li>• Response time 10-100 ms</li> </ul>	<ul style="list-style-type: none"> <li>• Sensitivity: 0,3 - 2,5 µm</li> <li>• ± 4 µg/m<sup>3</sup> or ± 20 %</li> <li>• Range: 0-1300 µg/m<sup>3</sup></li> </ul>	<ul style="list-style-type: none"> <li>• Resolution 1µg/m<sup>3</sup></li> <li>• Range: 0-500 µg/m<sup>3</sup></li> </ul>	<ul style="list-style-type: none"> <li>• Range: 0-500 µg/m<sup>3</sup></li> </ul>	<ul style="list-style-type: none"> <li>• Sensitivity: 0,5 - 3 µm</li> <li>• Count of particles : ppL</li> <li>• Transposition n µg/m<sup>3</sup></li> </ul>	<ul style="list-style-type: none"> <li>• Count of particles /size</li> <li>• PM2,5</li> <li>• PM10</li> </ul>

Difficulty connecting sensors to the network or recovering data...

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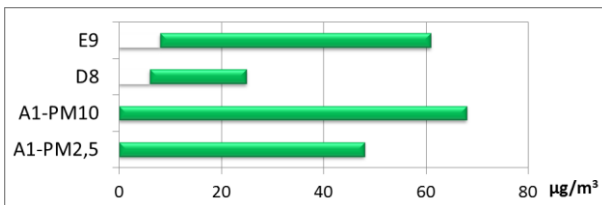
4



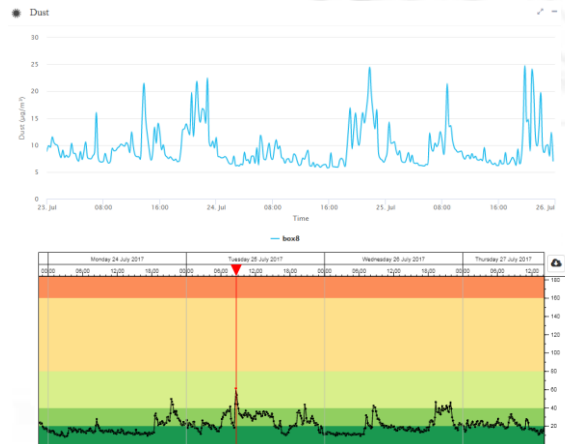
# On-Site measurements

Sensors installed in a house, in the countryside

- Range of measured indoor particulate matter during 1 month



→ Disparity of values (Min – Max)



# Tests at CETIAT

Testing room – 8 m<sup>3</sup>

- External supply fan + high efficiency filter
- Injection of pollutant + indoor comfort fan
- Sensors in central zone

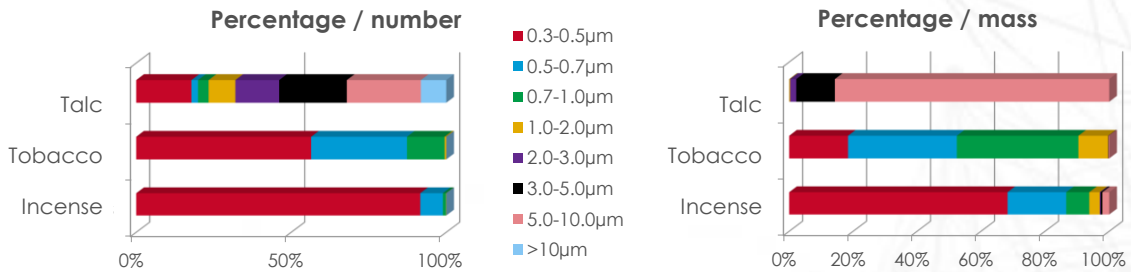
Reference measurement/particles:

- Counter of Particules (COP) TSI 3330
- 7 channels 0,3 to 10 µm
- Transition from number to µg/m<sup>3</sup> by calculation + hypothesis on particles density (2.8)

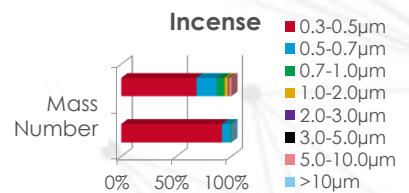
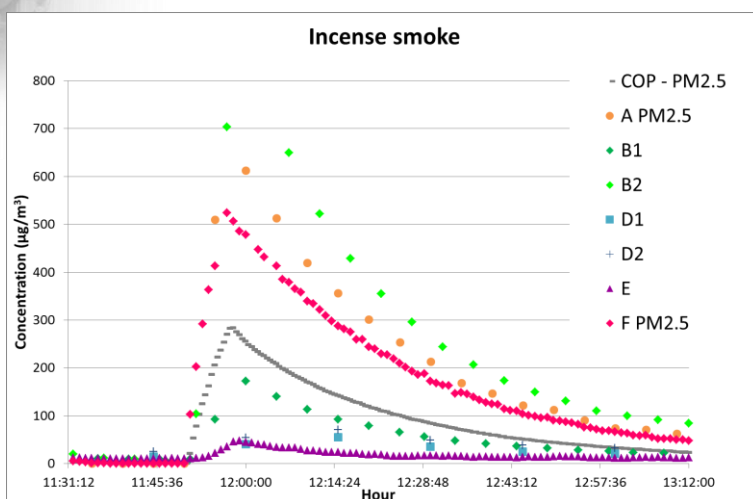


# Particles generated

Talcum powder, tobacco smoke and incense smoke were injected in the test room



# Sensor response to incense smoke



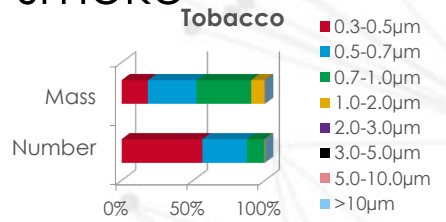
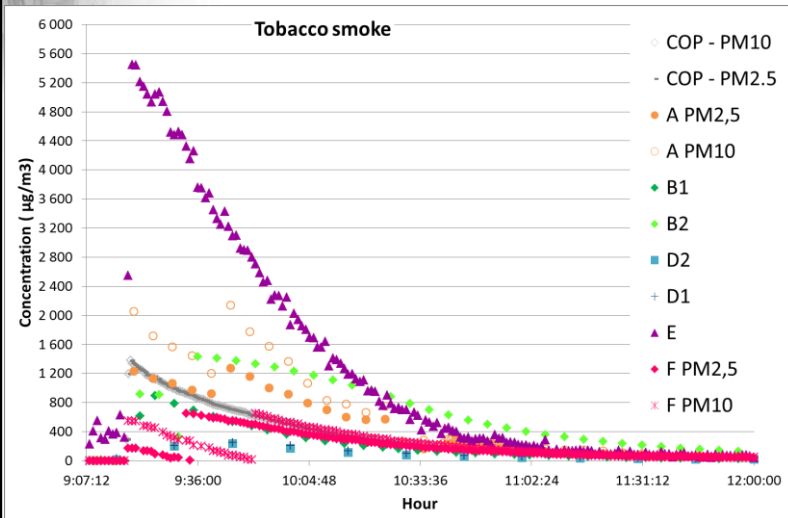
Incense smoke is mainly composed of very small particles

$$B_2 > A > F > B_1 > D_{1-2} > E$$

→ Differences due to:

- Sampling
- Average values
- Sensitivity

# Sensor response to tobacco smoke

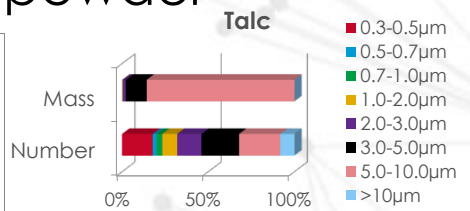
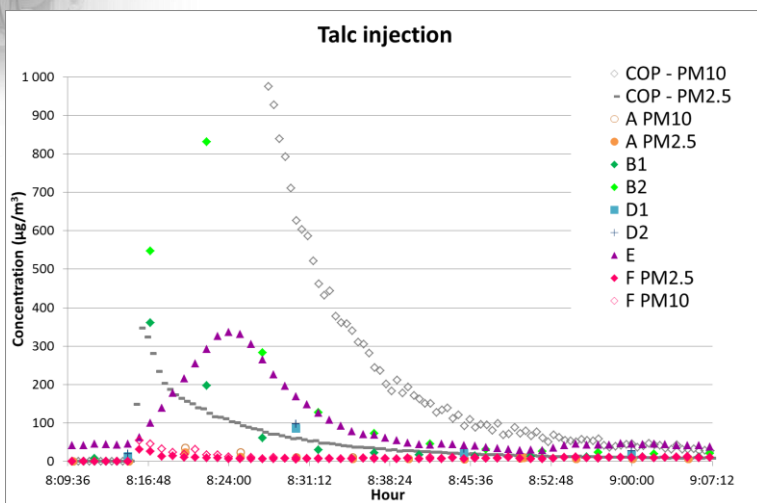


Tobacco smoke is mainly composed of fine particles

$$E > A_{PM10} > B_2 > A_{PM2.5} > F > B_2 > D_{1-2}$$

→ the orders of magnitude of the responses differ with another particle composition

# Sensor response to talcum powder



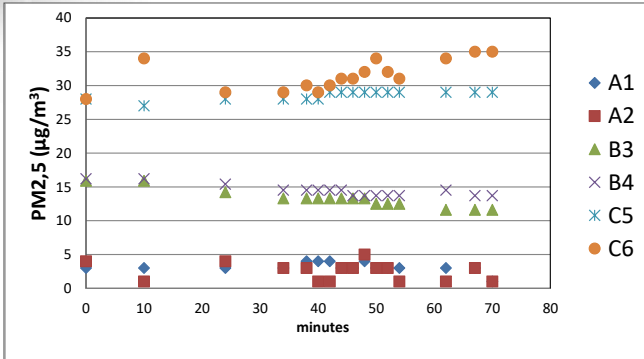
Talcum powder is heavier and deposits more quickly

$$B_1 > B_2 > E > D_{1-2} > A > F$$

→ Some sensors react very little to talcum dispersion



# Measurement at low level of particles



Indoor concentration of PM2.5  
No particle generation

Basic level : ~5 / 15 / 30 µg/m<sup>3</sup>

Disparity of values even with no particle generation

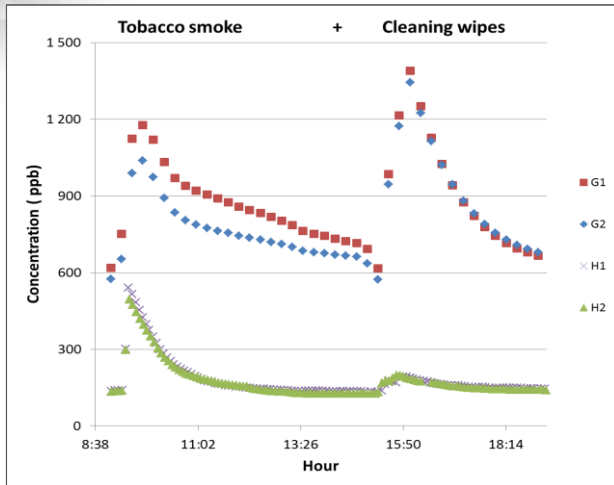
# VOCs measurements

Information available on manufacturers' technical specifications for particles measurements

G	H	I
<ul style="list-style-type: none"> <li>• Sensitivity: hydrogen gas, hydrogen sulfide, ammonia, ethanol, toluene, and formaldehyde</li> <li>• Value in ppb</li> </ul>	<ul style="list-style-type: none"> <li>• Sensitivity: Formaldehyde, iso-butane, toluene, methane, ammoniac, benzene, etc. (*)</li> <li>• Range: 100-1000 ppb</li> </ul>	<ul style="list-style-type: none"> <li>• Range : 0-9,9 mg/m<sup>3</sup></li> <li>• Resolution 1mg/m<sup>3</sup></li> </ul>

- 2 sensors give ppb values
- 1 sensor give mg/m<sup>3</sup> value (which hypothesis for gas density ?)

# Sensor response to VOCs

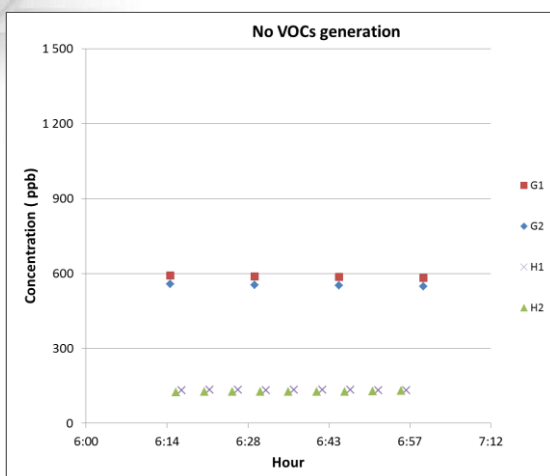


Comparison of two sensors  
With two different sources of VOCs

→ Values differ between sensors G and H

→ the order of magnitude of the responses differ  
Tobacco/cleaning wipes

# Measurement at low level of VOCs



Indoor concentration of VOCs for 2 sensors in the CETIAT testing room

No VOCs generation

Basic level : 130 / 600 ppb

Disparity of values even with no VOCs generation

# Conclusions

## Measurement results

- High disparity between sensors
- Impact of data sampling and average
  - Time lag
  - Lower peak value
- Impact of the pollutant composition
  - Sensor responses are different / nature of pollutant
  - Particles: incense, tobacco, talc
  - VOCs : tobacco, incense, cleaning wipes
- Few informations available
  - Sensitivity /selectivity
  - Data processing
  - Ambient conditions influence

## Assessment of IAQ Sensors

- Need to characterize the generated pollutant
  - Nature and Composition
  - Properties (density, ...)
- Periodic calibration is needed
  - Complex pollutant
    - Not only one gas for VOCs
    - Several Particles generations (fine, very small, ...)
  - On-site ?

# Which use of « low-cost » sensors (PM · VOCs) ?

## For individual use

- OK for information purposes only
- What is the influence of residents activities (cooking, cleaning, ...) on some IAQ metrics

## Not ready for fine DCV use

- reliability of data and connexion, durability, calibration, ...



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Thank you for your attention