Low-cost sensors for indoor air quality : performance assessment in simulated real conditions

Caroline Marchand, Amandine Fievet, Olivier Ramalho, Jessica Queron, Laurent Spinelle

……………………

Low-cost sensors for indoor air quality: performance assessment in simulated real conditions

Caroline Marchand[1,*], Amandine Fievet[1], Olivier Ramalho[2], Jessica Queron[1] and Laurent Spinelle[1]

[1] National Institute for Industrial Environment and Risks (INERIS), Verneuil-en-Halatte, France
[2] University of Paris-Est, Scientific and Technical Building Center (CSTB), Champs-sur-Marne, France

[*]*Corresponding email: caroline.marchand@ineris.fr*

Keywords: volatile organic compounds, particulate matter, carbon dioxide, field experiments, linear regressions

1 Introduction

As air quality is more and more a matter of interest among the general population, people strongly express the need to access real-time measurements with low-cost sensors easy to use. For indoor air, a lot of small, connected and low-cost sensors can now readily be purchased from the online markets. If their functionalities are very promising, there is a need to evaluate their metrological performances.

2 Materials/Methods

The goal of this project was to perform both laboratory (at CSTB) and field (at Ineris) assessments of five different commercial sensors for CO_2 (carbon dioxide), TVOC (total volatile organic compounds) and PM (particulate matter). For each sensor, two units were tested to evaluate their reproducibility. This abstract is focused on the field experiments that were carried out in January 2018. PM and VOC were generated by indoor activities such as incense/perfumed candle combustion, opening a varnish or a water/oil-based paint can and wood-board sanding in an office room of 25 m^3. All the sensors were gathered on a table with reference instruments (photoionisation detector for TVOC - with a 10.6 eV ionisation lamp - and granulometer for PM). For CO_2 measurements, sensors were set up in an occupied meeting room (reference instrument was a non-dispersive infrared detector, NDIR).

Table 1. Reference instruments.

Pollutant	Device model	Measuring range
COVT	ppbRAE-3000 RAE Systems	0-15000 ppm
$PM_{2.5}$	FIDAS FROG Palas GmbH	0-100mg/m^3
CO_2	Q-TRACK TSI	0-5000 ppm

Sensors performances were evaluated by performing linear regression fit (y = ax+b, R^2) for each type of source between sensor data and the reference instruments. This evaluation required a significant amount of work to match the data from the reference instruments with the data from each sensor, as they can't be synchronized before experiments. Then, all the sensors data were averaged on a 5minutes time step and the linear regression fits were calculated for each type of source, that means an experiment duration between 20 and 90 minutes. The slope of the regression (a) assessed accuracy and the determination coefficient (R^2) assessed sensors ability to dynamically follow concentrations evolutions. Performances varied between sensors and depended on the target pollutants.

3 Results and Discussion

Performances were very different between sensors and depending on the targeted compounds.

For CO_2, the only performant sensor is the one using a NDIR technology, as shown in Figure 1.

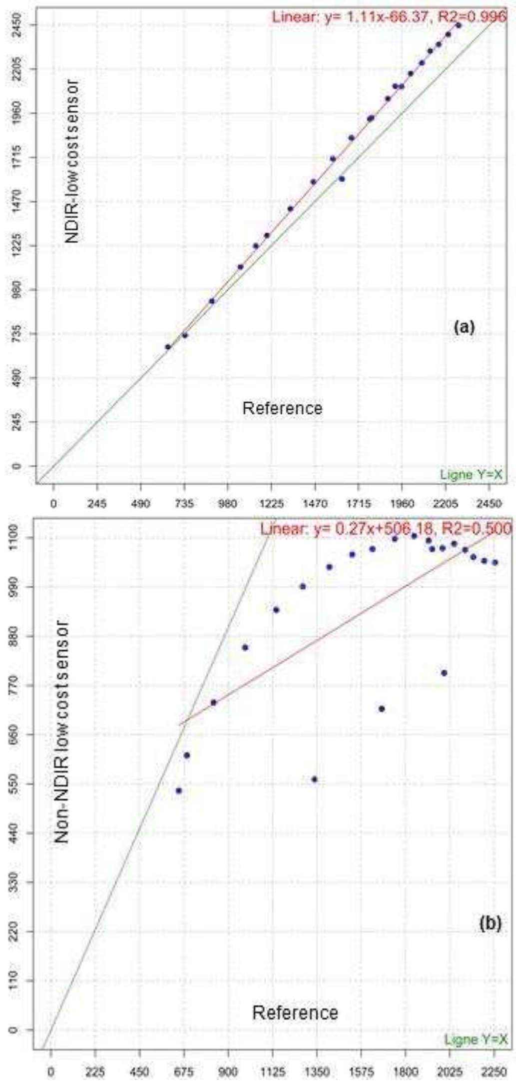

Figure 1 (a) and (b): Example of CO_2 regression during a meeting room with 5 people.

For TVOC, according to the generated mixture (VOC from combustion or VOC from solvent emanations), a same sensor could over or underestimate the TVOC concentration. In case of VOC from solvent emanations, sensor response underestimated, but in case of VOC from combustion, they overestimated as shown in Figure 2. For most of the sensors, correlation coefficients (R^2) of the regression lines were over 0.85.

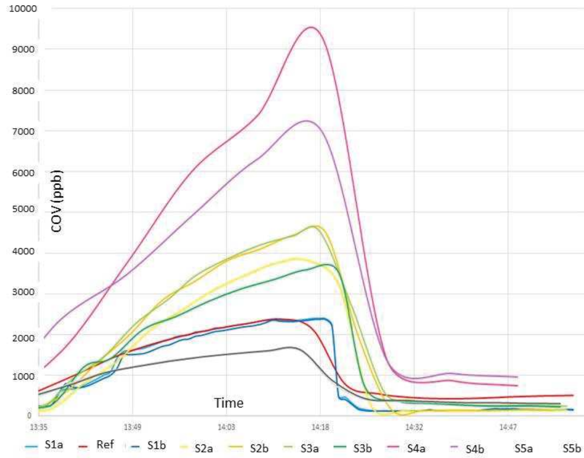

Figure 2: Example of sensors response to VOC from combustion (Sxa and Sxb are 2 different units of a same sensor).

For PM, sensors performances were generally very weak (slope of the regression line and R^2) and the sensors underestimated significantly the concentrations, as shown in Figure 3.

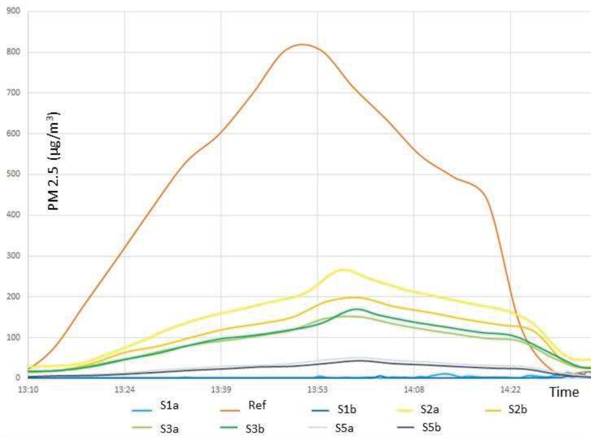

Figure 3: Example of sensors response to PM generation (Sxa and Sxb are 2 different units of a same sensor).

4 Conclusions

Based on the five type of tested sensors, none of them had good performances for the three pollutants. These types of sensors are not suitable for absolute concentration measurements (weak accuracy) but can be useful to follow trends in concentrations (R^2). However, for CO_2, when NDIR technology is used, performances were satisfactory for both uses.

5 Acknowledgement

This study was performed thanks to a specific funding by the French ministry in charge of the environment.