Use of low cost IAQ sensors?

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SUMMARY

The difficulty in measuring IAQ indicators like VOCs and particles, lies in the multiplicity of the composition of these pollutants. Analysis of the responses of some low cost IAQ sensors when subjected to real sources of pollution shows that they do not react homogeneously, due to their sensitivity and post-treatments. These sensors can be used by consumers to understand the effect of their actions on the evolution of IAQ indicators, not to rely directly on the values displayed. Calibration with multisource pollutants, robustness and durability assessment are required before using low cost sensors for ventilation control.

KEYWORDS

IAQ, SENSORS, ASSESSMENT, VOCs, PARTICULES

1 NEW TREND OF SENSORS FOR IAQ ASSESSMENT

Taking advantage of the boom in connected objects, the number of new low cost IAQ sensors available on commercial websites increases each month. These stand-alone sensors are compact, affordable for consumers (less than 200 €) and controlled via smartphones. The first of them began to measure CO_2 levels. New ones propose measurement of particulate matter and/or volatile organic compounds (VOCs). CETIAT decided to study last ones and to get 6 of them (Laser egg, Speck, Aereco, Uni-T, Foobot, Awair) in order to better understand how they work and test their responses in a controlled environment. All of them measure particulate matters and 3 of them also measure VOCs. Two sensors of each type were provided; Tests were not performed on both each time, because of the difficulty to connect them to internet or to collect data.

2 ASSESSMENT OF LOW-COST IAQ SENSORS

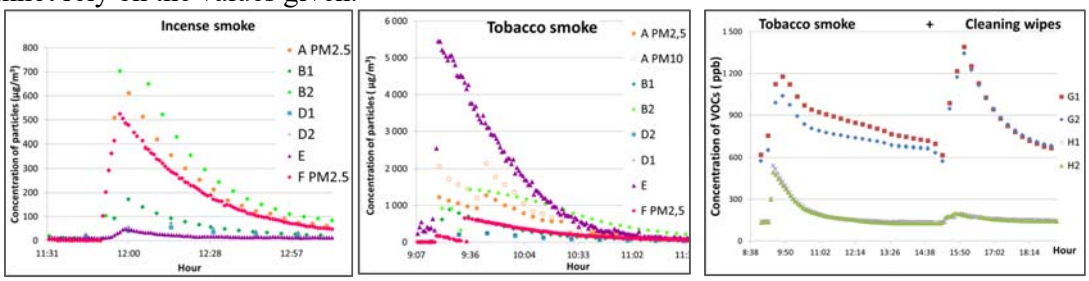
2.1 Heterogeneous measurements and sensitivity

Sensor characteristics available on manufacturers' technical specifications are heterogeneous and not detailed enough to assess uncertainties and robustness. Information collected shows disparities between sensor sensitivities: they do not measure the same pollutants; some sensors measure particles with diameter from 0.3 to 10 µm whereas others are restricted to 0.5-3 µm diameters; for VOCs the list of gas taken into account is usually not exhaustive. Moreover the results are not expressed in the same unit and equivalence between mass concentration (µg/m^3, mg/m^3, $PM_{2.5}$, PM_{10}) and numbers (ppb, ppL) measurements requires strong assumptions either for particles (assumptions on density, sometimes different for each size of particles) or for VOCs (unknown molar mass of a gas cocktail which depends of each pollutant source).

2.2 Measurements in CETIAT test Room

Sensors were installed in a test room of 8 m^3, equipped with an external fan connected to a high efficiency filter in order to renew air between each test. Different types of pollutants were injected in the room and stirred with an indoor fan. Selected results are presented below.
Sensors were exposed to incense smoke (composed mainly by ultrafine particles) and tobacco smoke (composed mainly by fine particles). Figure 1(a) and (b) show the differences of responses between 6 sensors for particles measurements and also the difference of responses

between the two types of smoke, both on values on time response. In another test, sensors A, B and C were placed together exposed to a low and stable pollution level: the displayed values were 5, 15 and 30 µg/m^3. Sensors were exposed also to VOCs pollutant, contained in the incense smoke and in cleaning wipe. Figure 1(c) shows results for two pairs of sensors giving VOCs results in ppb. The values displayed are homogeneous between pairs of sensors (G1 and G2, H1 and H2) and heterogeneous between two types of sensors (G and H); Sensitivity to tobacco smoke or cleaning wipes VOCs pollutant are very different for sensors H or G. Those results show that low-cost sensors react in different ways to different sources of pollutant. The end-user refers to those sensors to follow deviations on usual pollutions; he cannot rely on the values given.



(a) (b) (c)

Figure 1: Sensors do not react with the same sensitivity to incense smoke, tobacco smoke and cleaning wipes

3 CONCLUSION

Before choosing a sensor, it is necessary to ask the question of its use: global information for consumer? Quality information for IAQ assessment at expertise level? Values for demand control ventilation? Depending on the end use, the quality requirements of the quality of measurement are different. For example the RESET^{TM} program (Cheng, 2017) defines three grades of sensors, linked with their potential use: Calibration, commercial or consumer grade. Low-cost IAQ sensors are in the last consumer grade. They may be sufficient to ensure qualitative information and to enable the user to familiarize himself with his IAQ, even if some may overreact or minimise pollution episodes.

The very large disparity in the measurement ranges between all the low-cost sensors tested in CETIAT may result from differences in the sensitivity of the sensors and/or due to averages that reduce extreme values. The difficulty with particles and VOCs is that the composition of the pollutant differs for each source. If sensors are calibrated with one gas or with one specific type of particles, this is not reflective to real pollution. Caron (2016) has shown it for VOCs sensors and Li (2017) has shown the impact of the nature of particles on the sensor post-treatment. The use of low cost IAQ sensors to control ventilation must be preceded by a calibration on multiple sources of pollutants in accordance with ISO 16000-29 and -34 procedures, before any design process. Robustness and durability have also to be assessed.

4 REFERENCES

Caron, A. (2016). *Measuring the dynamics of gaseous pollutants in indoor air: evaluation of the performances of multi-sensor devices.* Ph.D. Thesis, Mines Douai et Université Lille 1 (France), 278 pages.

Li, J., Biswas, P. (2017) *Optical Characterization Studies of a Low-Cost Particle Sensor,* Aerosol and Air Quality Research, 17: 1691–1704

Cheng, L., (2017) *Indoor Air Quality Monitoring 2.0 – Seeing the invisible,* REHVA Journal (N3 June 2017), 32-37.

ISO 16000-29 (2014) *Indoor air - Part 29: Test methods for VOC detectors*

ISO 16000-34 (to be published) *Indoor air - Part 34: Strategies for the measurement of airborne particles*