Use of sensor systems to assess individual exposure to air pollution

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Background. The development of sensor systems for monitoring indoor and outdoor air quality has grown rapidly in recent years. These devices offer a variety of applications: public information/citizen science, air quality compliance/regulation, research in atmospheric sciences, exposure assessment, etc. The use of these technology raises several questions, including their metrological reliability, data management, use and interpretation, and ultimately their relevance to air quality issues (WMO, 2018).

Aims. In this context, the Directorate General for Health (DGS), the Directorate General for Risk Prevention (DGPR), and the Directorate General for Energy and Climate (DGEC) issued a formal request to ANSES on 21 December 2018, asking it to:

- Conduct a review of studies using sensor systems and analyse the profiles of their users;
- Assess the strengths and limitations and the complementarity of the data originating from sensor systems used by citizens, compared to conventional measurements, in assessing individual exposure and getting insight into their health implications;
- Discuss the legal status of the data generated by sensor systems.

This extended abstract focuses on the use of such sensors to assess individual exposure to air pollutants and on the prospective use of the generated data for assessing the health effects of air pollutant exposure (ANSES, 2022a, ANSES, 2022b).

Methods. This work was based on the collection of information from various stakeholders through international consultation and hearings with institutes and non-governmental organisations (NGOs) specialising in air pollution, as well as interviews with manufacturers and distributors of sensor systems, coordinators of projects using sensor systems, and legal experts. In addition, a literature review was carried out to identify elements to answer the questions addressed to ANSES.

Results. Sensor systems offer many opportunities in the area of individual exposure assessment, such as a substantial increase in the number of measurements and improved spatial and temporal coverage, greater acceptability by participants (ergonomics, lightweight),

and a higher temporal resolution enabling, for example, a detailed study of the different microenvironments contributing to an individual's total exposure. However, besides the metrological accuracy of the sensor system, which is still the primary condition for assessing individual exposure, many other key points need to be satisfied, especially those related to the contextualisation and implementation of the sensor systems (representativeness and spatial and temporal coverage, description of the microenvironments frequented, activities planned and unforeseen events).
Identified studies on the use of sensor systems to assess individual exposure (N=62) had a variety of objectives, ranging from the simple measurement of concentrations in the air to a quantitative assessment of individual exposure, or even of the inhaled dose, and the associated health effects (N=11). This analysis showed that sensor systems are particularly relevant for studying the short-term effects of air pollution at the individual level; the use of exposure data generated by sensor systems (deemed valid) for QHRA[1] or QHIA[2] requires consideration of whether these data are aligned with the dose-response relationships established for hourly, daily or annual exposure that will be used to quantify the health risk. Furthermore, data generated by a portable sensor system, integrating the different sources to which an individual is exposed, cannot be considered representative of population exposure. It is therefore essential to ensure that the sensor systems are deployed in sufficient numbers to be representative of the study population.

Conclusions. Despite their limited metrological quality, sensor systems offer many opportunities to address the various indoor and outdoor air pollution issues. Nevertheless, an accurate exposure assessment must be based on studies that meet the criteria/lists of critical points identified in the expert appraisal to reinforce data quality. Sensor systems are therefore seen as devices that complement the data sources or exposure assessment methods already used in exposure science studies. In addition, sensor systems could help optimise mapping (on spatial and temporal scales) and large-scale models, thus helping to improve the estimation of exposure to air pollution. The health interpretation of sensor data should be made with caution as the interpretation functions sometimes integrated into the sensor systems are based on data timescales and thresholds unsuitable for assessing individual health risks. These devices can currently only be regarded as tools to promote awareness, solely enabling them to perform a relative and qualitative comparison of the concentration levels to which they are exposed or to identify possible sources of pollution, so they can act accordingly to reduce their exposure (for example by modifying their travel behaviour). To improve the use of sensor systems for air pollution exposure assessment, ANSES has proposed a series of recommendations to manufacturers and distributors of sensor systems, private users, research actors, and public administrations. To this purpose, Anses encourages the deployment of multidisciplinary projects bringing together skills in metrology, data sciences, exposure assessment, epidemiology, and human and social sciences, given the multitude of disciplines involved in this type of project.

Keywords. Sensors, indoor air, outdoor air, personal exposure, air pollution, health effects, participatory science, profiles, motivations.

References

ANSES. (2022). Use of microsensors to monitor the quality of indoor and outdoor air. (Request 2018-SA-0271). Maisons-Alfort: ANSES, 178 p.

ANSES. (2022). Microsensors to monitor the quality of indoor and outdoor air. Vol. 2 Citizen measurements of air quality. Figures, Knowledge, Actions (Request 2018-SA-0271). Maisons-

[1] Quantitative health risk assessment
[2] Quantitative health impact assessment

Alfort: ANSES, 106 p.

WMO. (2018). Low-cost sensors for the measurement of atmospheric composition: overview of topic and future applications. Geneva: WMO, 68 p.