EVALUATION OF SELECTED PORTABLE SOLUTIONS FOR ASSESSMENT OF INDOOR AIR QUALITY

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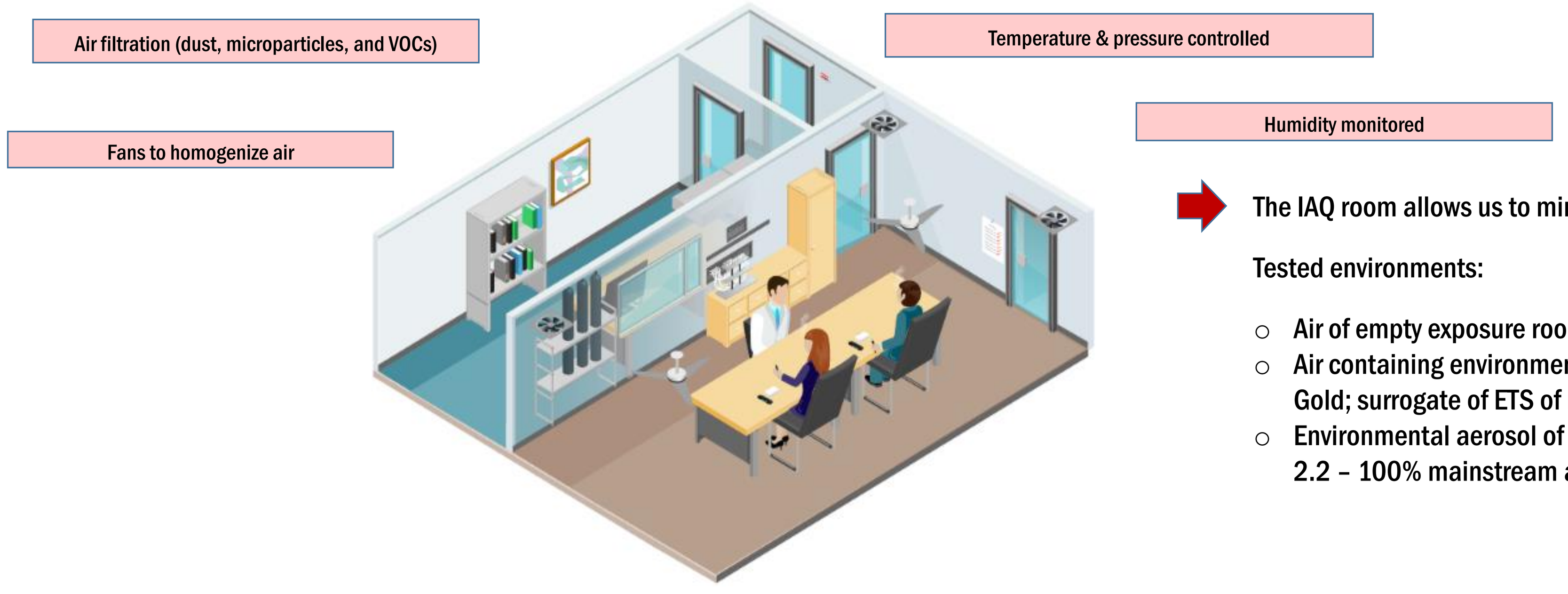
1. Introduction and objectives

- The interest in indoor air quality (IAQ) has increased over the past years because of awareness of its direct relationship with the health and comfort of building occupants [1].
- This trend is reflected in the increasing number of commercially available sensors aimed at monitoring air purity and characterizing the levels of pollutants in air [2].
- Although a huge variety of sensors are available on the market, appropriate selection of sensors remains challenging, particularly for measurement of pollutants at low concentrations [3].
- The present project aimed to select some relevant (trans)portable solutions that allow online analysis of selected IAQ markers, by evaluating commercially available sensors and direct reading technologies with appropriate analysis selectivity .

2. Evaluation approach

In order to assess the impact of smoke-free products on IAQ, an environment-controlled exposure room was built at the PMI facility and equipped with an analytical platform (14 validated and accredited methods covering 28 analytes) [4–7]. This facility was used for the assessment of real and near real time sensors.



The IAQ room allows us to mimic different indoor environments.

Tested environments:

- Air of empty exposure room (BKG)
- Air containing environmental tobacco smoke from a cigarette (Marlboro Gold; surrogate of ETS of MLG – 100% sidestream)
- Environmental aerosol of the tobacco heated system (surrogate of EA of THS 2.2 – 100% mainstream aerosol)

PMI IAQ-controlled exposure room drawing and key facility operating features (further details available in poster TU-PO-01).

A four-step evaluation approach was used:

1. Preselection – Selection of commercially available solutions based on performance (as claimed by the supplier) and target concentrations.

2. Protocol – Establishment of an on-purpose evaluation protocol

3. Comparison – Comparison of online and near-real-time results with those obtained with validated and accredited reference methods

- Assessment in an environment-controlled exposure room
- Simulated conditions: Residential – ventilation rate, 37 m³/h; 2-h sessions; use of single-channel smoking machines

4. Evaluation based on the fit-for-purpose protocol – Definition of acceptance

- Bias <30% relative to validated quantitative methods
- Ability to detect targeted chemicals in tested environments
- Ability to monitor occurrence of pollution events (e.g., smoking and use of incense or candles)

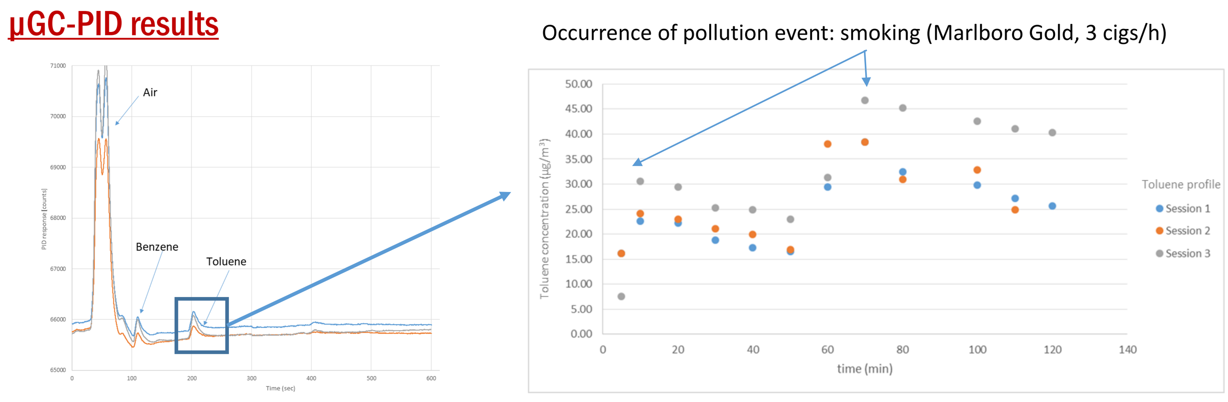
Analytes	Transportable instrument		versus	Reference method	
	Measurement mode	Analyzer detection principle		Measurement mode	Reference method principle
CO	Real time	Electrochemical sensor		Real time	NDIR
Particles PM1, PM2.5, and PM10	Real time	A. Laser light-scattering photometer B. Optical light scattering		Off line	RSP - PM2.5 μ balance
UFP particles: Sub-micron particles	Real time	Charging and current detection principle		Real time	CPC
Formaldehyde	Real time	Fluorescence (derivatization)		Off line	LC-MS/MS (derivatization)
BTEX	Near-real-time	μGC-MS/μGC-PID		Off line	GC-MS
TVOC (C_6–C_{16})	Near-real-time	μGC-MS		Off line	TD-GC-MS
VOCs, carbonyls, TSNA…	Real time	PTR-MS		Off line	GC-MS, LC-MS/MS

List of selected portable solutions for assessment of IAQ and relative reference methodologies. Shown in red are the sensors for which the results are presented in this document.

3. Near-real-time observations

μ-chromatography

μGC-PID results



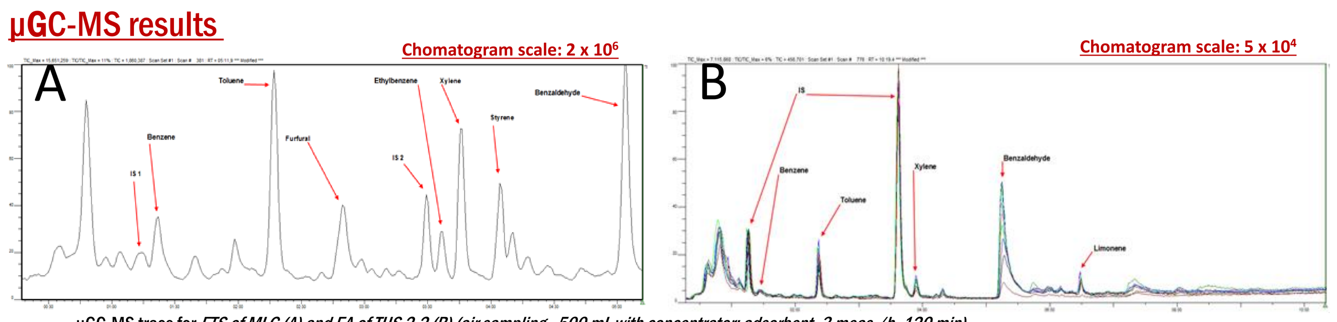
μGC-PID trace for ETS of MLG (air sampling , 200 μL ; 3 meas./h; 120 min).

\+ Good alignment with reference values determined for highly polluted environments (e.g., ETS of MLG, 3 CC/h)

\+ Near-real-time profile for BTEX chemicals

\- Not sensitive enough to measure BTEX at very low concentrations (e.g., EA of THS 2.2 or background samples)

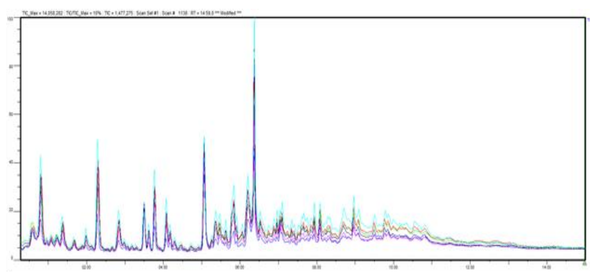
μGC-MS results



μGC-MS trace for ETS of MLG (A) and EA of THS 2.2 (B) (air sampling , 500 mL with concentrator; adsorbent, 3 meas./h, 120 min).

\+ The concentration step and selective detection principle allow for sufficient sensitivity to detect BTEX volatiles in all matrices

\+ Offers an overview of the present VOCs and allows for detection and identification of new airbome pollutants



Overlay of μGC-MS trace for ETS of MLG (air sampling , 500 mL with concentrator; adsorbent, 3 meas./h, 120 min)

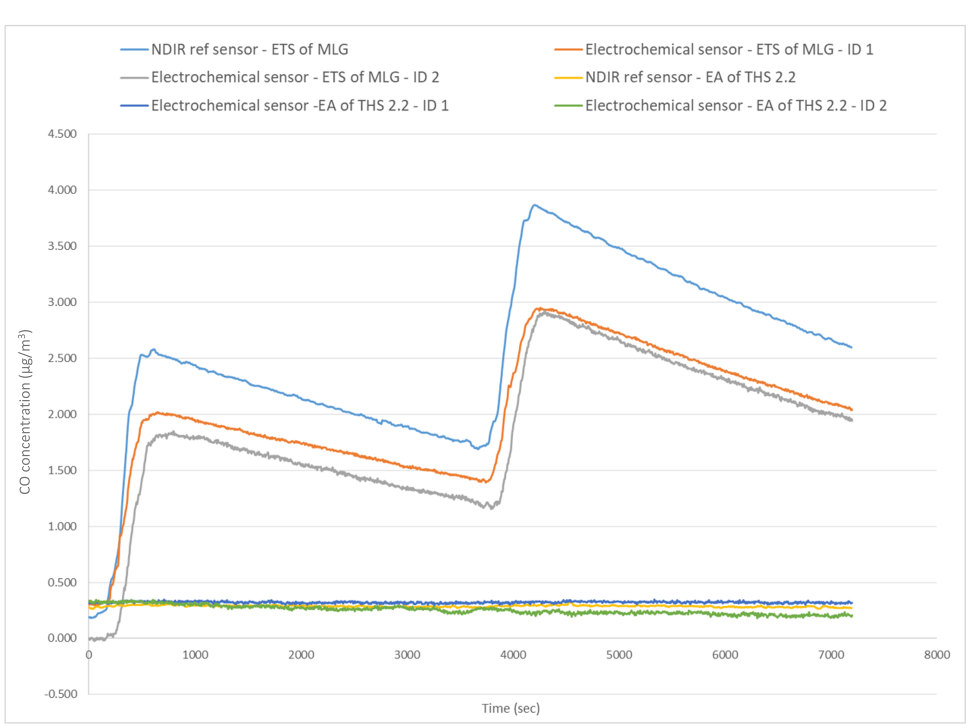
4. Real-time results – snapshot & observations

Electrochemical sensor: CO

\+ Average results show good correspondence with reference values

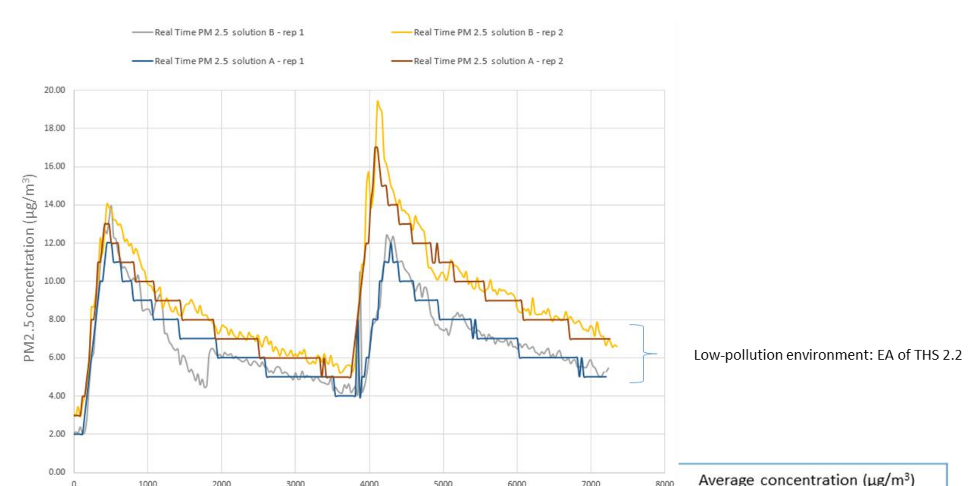
\- Bias observed at higher concentrations

\+ Dedicated development enabled establishment of a control methodology for calibration of the electrochemical sensor



Comparison of CO measurements between reference & electrochemical sensors: overlay of CO content profiles acquired during the 2-h exposure to the ETS of MLG & EA of THS 2.2

Light scattering: particles



Average concentration (μg/m³)	PM1	PM2.5	PM10
Real-time PM2.5 sensor A	8.76	9.03	9.60
Real-time PM2.5 sensor B	8.66	8.69	8.78
Reference RSP gravimetric measurement	N/A	<LOQ (10)	N/A

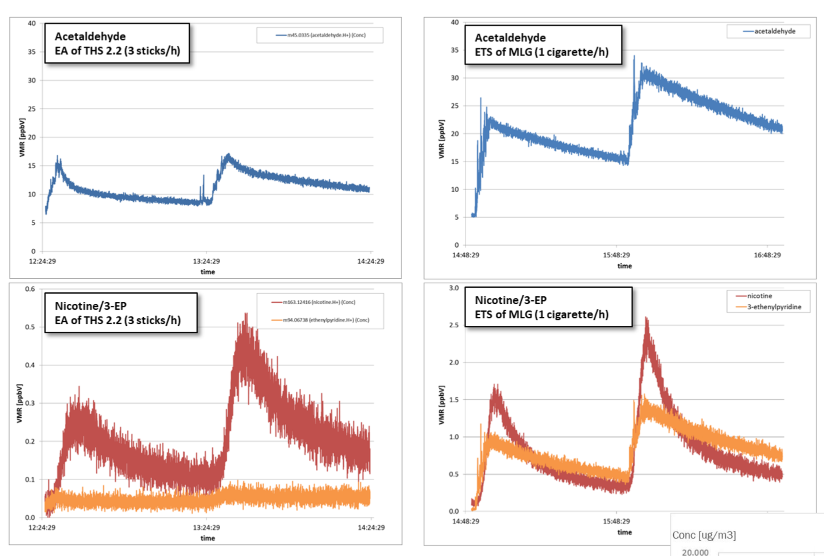
Left: Comparison of real-time PM2.5 particle profiles acquired with the two-sensor solution for a low-pollution environment (EA of THS 2.2). Right: comparison of average results.

\+ Good repeatability of two real-time PM2.5 sensors, with similar results in a low-pollution environment and good alignment with the reference findings

\+ Sensor A showed good alignment with the reference methodology in a polluted environment

\- Sensor B showed bias relative to the reference methodology in a highly polluted environment

PTR-MS chemical release profiles



PTR-MS profiles of selected targets for the EA of THS 2.2 and ETS of MLG.

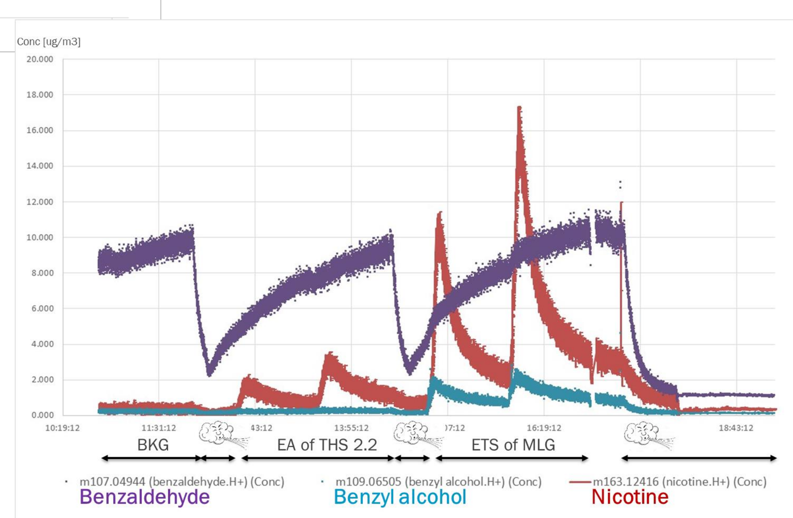
\+ Allows emission profiling of a broad range of volatiles of different nature (usually requires analysis by of different analytical techniques)

\+ (-) Although the quantification results showed differences from the reference results, the technique allows a good estimation of the concentration ranges of pollutants present in air.

\+ The PTR-TOF MS system offers outcompeting features, enabling verification of emission/contamination events for a broad range of airborne pollutants as well as evaluation of decay profiles.

\- Transportable solution rather than portable

\- Expensive equipment



PTR-MS profiles for selected chemicals for room air (BKG), EA of THS 2.2, and ETS of MLG.

5. Conclusion

Online or near-real-time quantitative analysis of pollutants at low levels in indoor air remains a challenge. However, as this technological field evolves rapidly, the limitations observed today might be resolved tomorrow.

The approach used in this study enabled selection and characterization of (trans)portable solutions and can now be used to complement the current analytical capability for IAQ assessment.

\+ A portable solution was identified for CO analysis.

\+ The portable GC-MS instrument offered an opportunity to monitor the presence and abundance of volatiles, even at low concentrations, and enabled their identification.

\+ PTR-MS allowed the monitoring of a wide range of chemicals, including highly volatile compounds such as formaldehyde.

References

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