Electronic Supplementary Material (ESI) for Environmental Science: Atmospheres.

Supporting Information

Investigation of Indoor Air Quality in University Residences Using Low-Cost Sensors.

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Section S1. The choice of the Low-cost sensor (LCS).

The LCS choice was made considering the United State Environmental Protection Agency (US EPA) requirements. A sensor is considered useful when it can detect the target pollutants over the full range of concentrations generally present in the environment of interest, for instance, particular matter, $PM_{2.5}$ (0-40 µg/m^3) and carbon dioxide, CO_2 (350-600 ppm). However, the US EPA recommended some criteria for selecting LCS mainly for measuring the outdoor pollutants, with no particular parameters set up yet for the indoor environment The choice of our LCS was determined by the target pollutants (i.e., particulate matter ($PM_{2.5}$), and carbon dioxide (CO_2)), their detection range, and the price of the sensor unit.

Table S1: The specification of the design of the LCS.

Parameter	**Regulatory exposure limit**	**US EPA recommendation**[1]	**Our LCS specification**
$PM_{2.5}$	[a]35 µg/m^3 (24-hour average)	[c]5 µg/m^3	[d]0-999.9 µg/m^3 [e]0.6 µg/m^3
CO_2	[b]1000 ppm (24-hour average)	[c]100 ppm	[d]0-40000 ppm [e] Not measured
Response time	-	Less than 1 minute	1 Sec
Cost	-	$100 to $2500	$150

[a] Recommended by US EPA,[2] [b]Recommended by Health Canada.,[3 4] This recommended CO_2 exposure limit is in line with standards from other countries (i.e., South Korea, Japan, France, Norway, Portugal, and Germany) and organizations (i.e., The American Society of Heating, Refrigerating and Air-Conditioning Engineers).[4]
[c]Useful detection limit recommended by US EPA, [c]Detection range, and [e]Detection limit of LCS

Section S2. Comparison of Sensirion SCD30 CO_2 data.

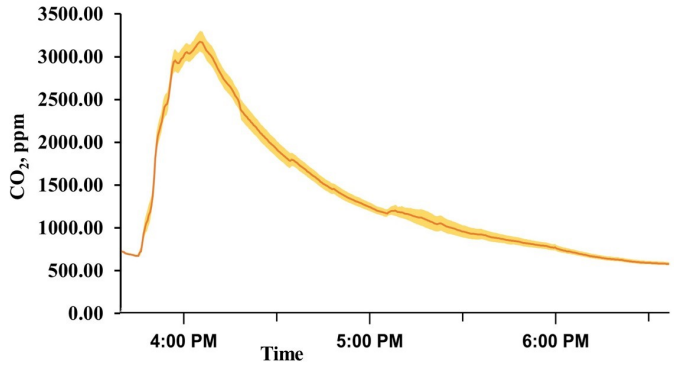

Figure S1: Inter-comparison of SCD30 sensors using dry ice. The solid line is the average value, and the shaded area covers the range of CO_2 concentrations monitored by all the sensors used in this work.

Section S3. Application of correction factor.

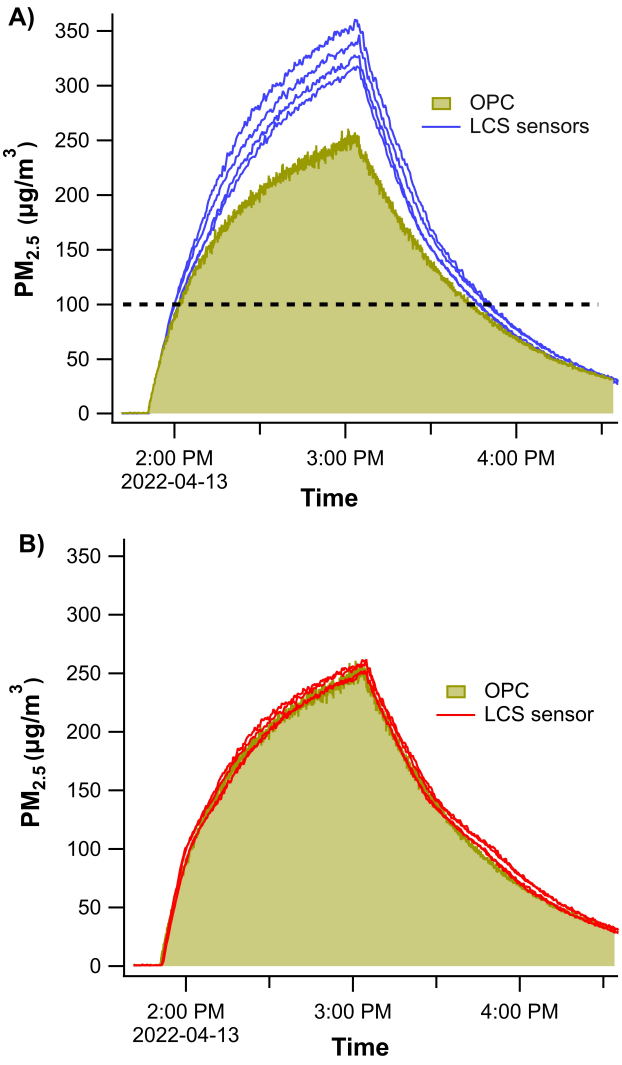

Figure S2: Application of sensor-specific correction factor obtained from the post-calibration data, when the $PM_{2.5}$ was >100µg/m^3, (a) before applying the correction factor and (b) after applying the correction factor.

Section S4. Sensor data quality.

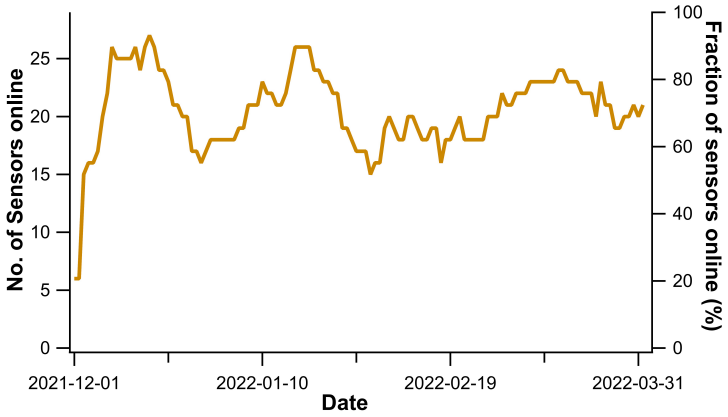

Figure S3: Numbers and Percentages of data availability for the entire study period. Sensors deployed in buildings A to D are included. A sensor is considered online on a day when at least 10 hours of data are available.

Section S5. Buildings information and questionnaires.

Table S2: Buildings information.

Residences	**Year built**	**Full renovation**	**MERV rating of MV**	**No. of floors**	**No. of Beds**
Residence A	2003	-	M8	11	417
Residence B	1958	2020	M8 and M13[a]	11	769
Residence C	2018	-	M8	4	300
Residence D	1972	-	M8 and M14[b]	7	849
Residence E	2004	-	Not applicable	6	157

Table S3: Questionnaires

No	Types of questions.
1	How often did you cook inside your residence?
2	On average per day, how long did you keep the window open? Please answer in hours.
3	Did any of the following activities happen inside your residence? For example: (i) Cleaning with a vacuum machine. (ii) Using a humidifier, candle, diffuser, incense, and dry ice. (iii) Smoking (including cigarettes and cannabis). (iv) E-cigarette smoking or vaping. (v) Gathering or Party (4 people or more)
4	We appreciate any information on incidents or activities that may have affected IAQ. i.e., how often certain activities take place, any changes in your routine, etc.
5	Would you let us know the date you left the residence? And when returned to the residence?
6	Were you in the residence during the Christmas (winter) break? (i) I was there for the entire time. (ii) I left for the break and have not returned since. (iii) I left the residence during the break.

Section S6. The P value for statistically measuring the effect of occupancy, and ventilation affects the indoor pollutants.

Table S4: The P value for the comparison between occupied and unoccupied conditions for residence A-D.

	P Value	
Name of the residence	$PM_{2.5}$	CO_2
Residence A	0.1391	0.0013
Residence B	0.0421	6.216 E-07
Residence C	0.0071	0.0071
Residence D	0.0411	0.0411

Table S5: The P value for the comparison of ventilation effect for residence A-D with residences E.

	P Value	
Name of the residence	$PM_{2.5}$	CO_2
Residence A vs E	0.0257	0.0149
Residence B vs E	0.0358	0.0199
Residence C vs E	0.2483	0.0005
Residence D vs E	0.1829	0.0021

References

(1) Guidebook - Final - Epa - Epa/600/R-14/159 June 2014 Epa/Ord Air Sensor Guidebook Ron Williams and - Studocu. https://www.studocu.com/en-us/document/universal-technical-institute/pile-design/guidebook-final-epa/18013270, Accessed December 1, 2022.

(2) USEPA Quality assurance guideline. https://www3.epa.gov/ttnamti1/files/ambient/pm25/qa/m212.pdf, Accessed August 22, 2022.

(3) Canada H. Consultation: Proposed Residential Indoor Air Quality Guidelines for Carbon Dioxide. October 29, 2020. https://www.canada.ca/en/health-canada/programs/consultation-residential-indoor-air-quality-guidelines-carbon-dioxide/document.html., Accessed August 15, 2022.

(4) Canada H. Carbon dioxide in your home. https://www.canada.ca/en/health-canada/services/publications/healthy-living/carbon-dioxide-home.html., Accessed December 10, 2022.