Vehicle Interior Air Quality: Ultrafine Particles

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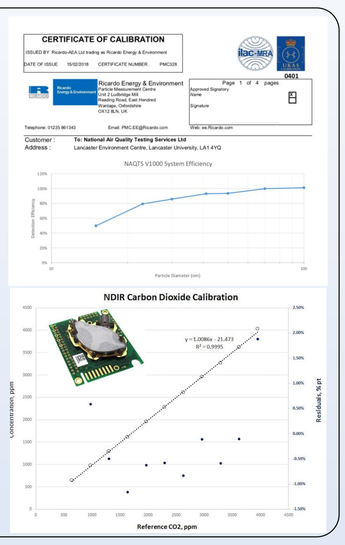
ABSTRACT

Many studies have addressed Ambient Air Pollution (AAP) that arises from traffic, and its associated negative impacts on public health. However, less has been done to understand Indoor Air Quality (IAQ) despite the average person now spending more than 90% of their time indoors (Klepeis et al. 2001). Around one hour of this indoor exposure is spent inside vehicles (Müller et al. 2011), and is referred to as Vehicle Interior Air Quality (VIAQ). This exposure is important to understand given the immediate proximity to significant pollutant sources (other vehicles), plus, in urban areas, high AAP concentrations compared to other micro-environments.

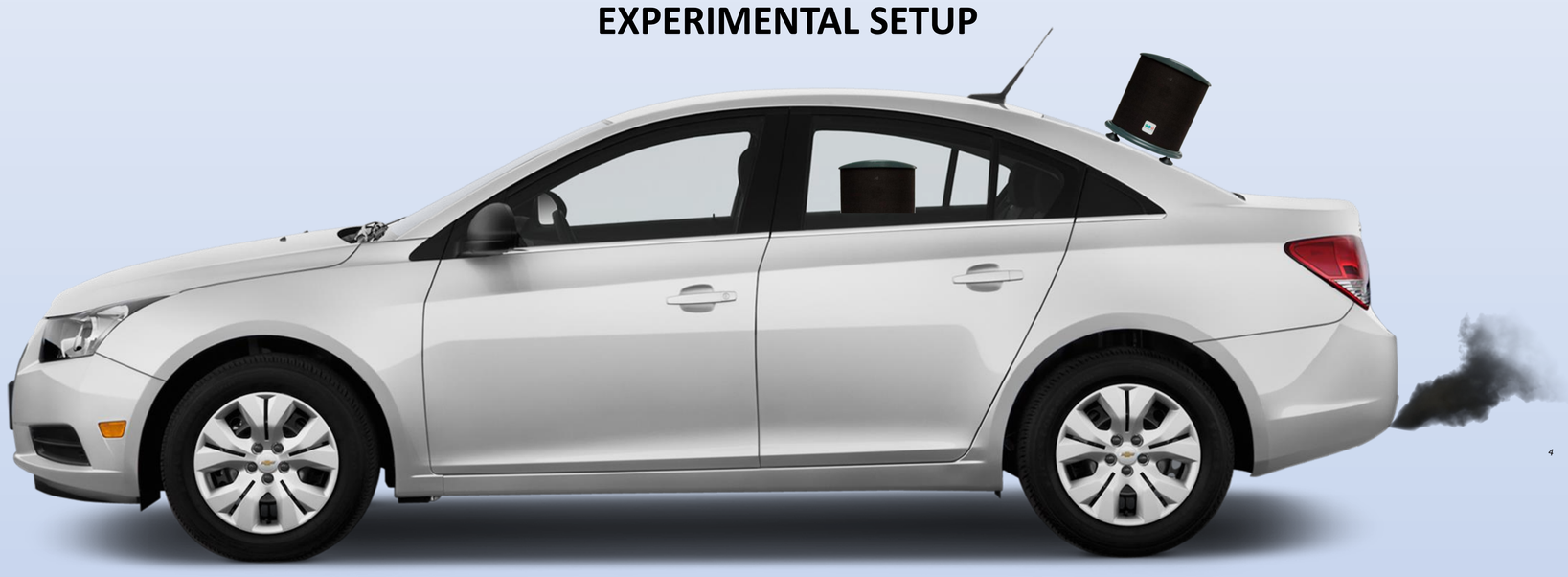
To address this knowledge gap, two NAQTS V1000 Integrated Air Quality Monitors were used to simultaneously monitor inside-outside four vehicles for Particle Number (PN) and Carbon Dioxide (CO2). The vehicles were analysed to understand *Ingress Ratio* (how much ambient PN is getting into the vehicle cabin) and *Stuffiness* (how well the vehicle is ventilating CO2).

TECHNOLOGY & METROLOGY

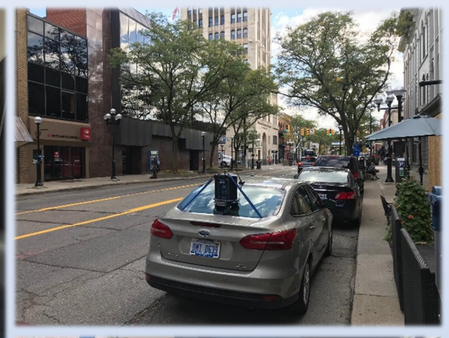
PN: CPC with 50:1 pre-dilution (d_{50} 15nm)
CO, NO2, NO, VOCs: Metal Oxide & Electrochemical
VOCs - 4 event-driven thermal desorption tubes
CO2: NDIR
T, P, RH: BME280
Noise: dBA
Location: GPS
Vibration: 3D-accelerometer & -gyro
Data Storage: SQL database
GUI: WIFI HTML interface



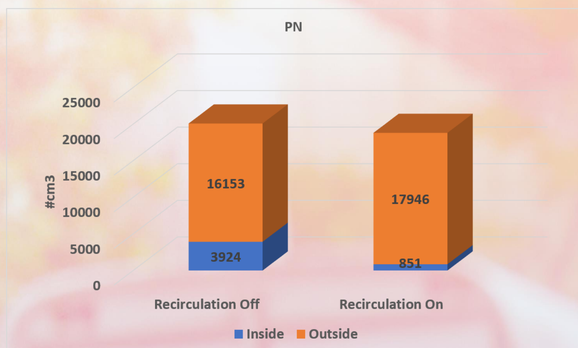
EXPERIMENTAL SETUP



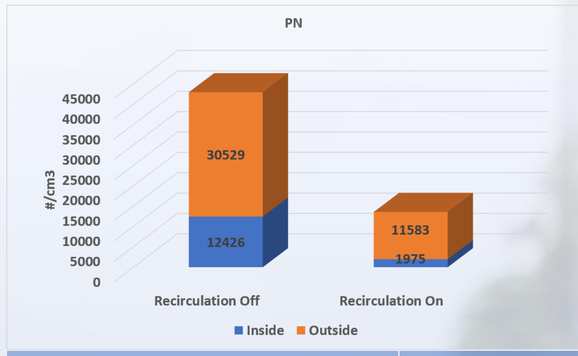
SIMULATENOUS INDOOR AND OUTDOOR AIR QUALITY MEASUREMENTS

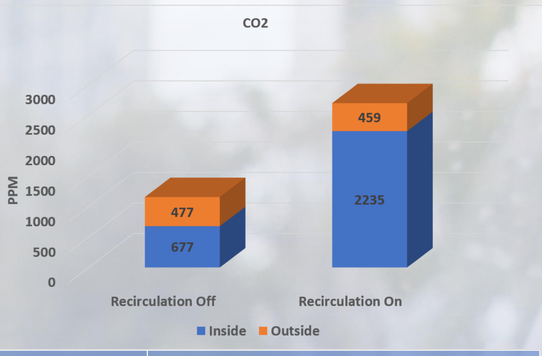


HOW MUCH AMBIENT AIR POLLUTION PENETRATES INTO THE CABIN?

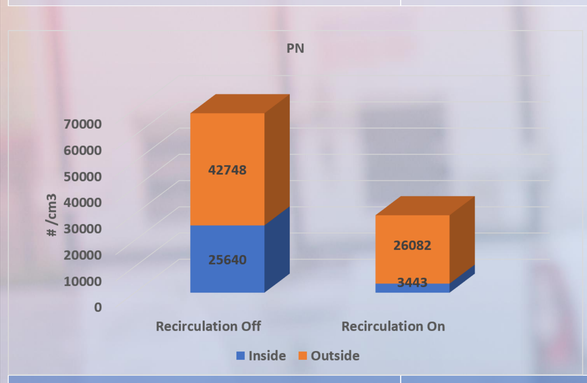


	INGRESS RATIO	STUFFINESS FACTOR
Recirculation Off	24%	1.4
Recirculation On	5%	3.6

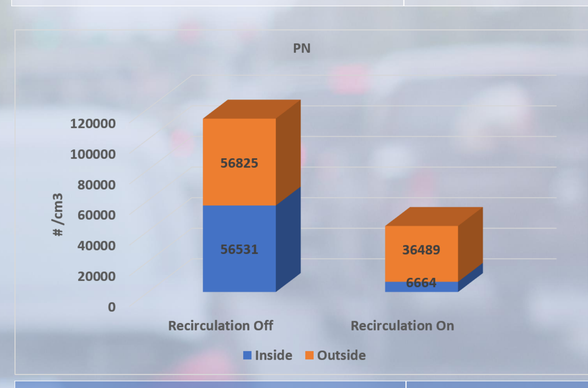


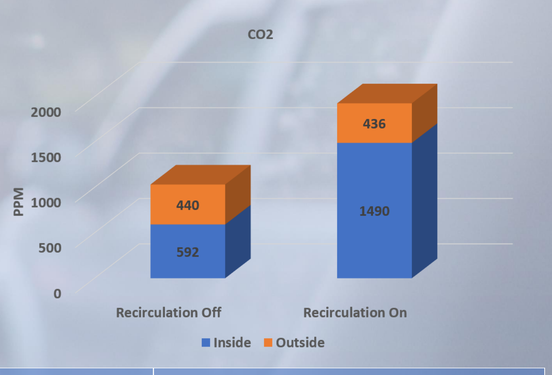


	INGRESS RATIO	STUFFINESS FACTOR
Recirculation Off	41%	1.4
Recirculation On	17%	4.97



	INGRESS RATIO	STUFFINESS FACTOR
Recirculation Off	60%	1.2
Recirculation On	13%	3.3



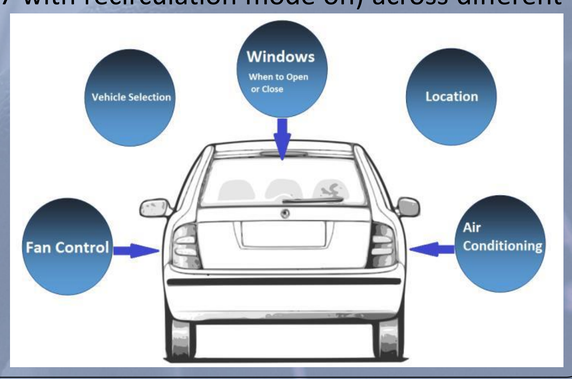


	INGRESS RATIO	STUFFINESS FACTOR
Recirculation Off	99%	1.3
Recirculation On	18%	3.4

CONCLUSIONS

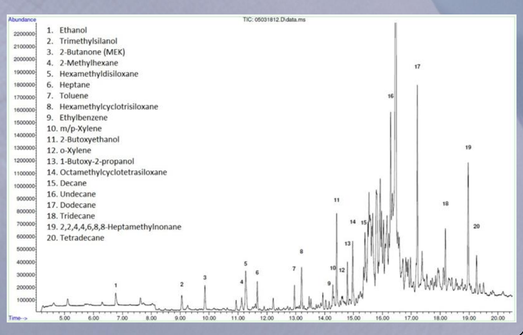
The data from these four vehicles shows the heterogeneity of Ingress Ratios (ranging from 24% to 99% with recirculation mode off, and 5-17% with recirculation mode on) and Stuffiness Factors (1.2 – 1.4 with recirculation mode off, and 3.3 – 4.97 with recirculation mode on) across different manufacturers and vehicle types.

The results raise an inherent tradeoff between protecting passengers from ambient PN ingress, and adequate ventilation to prevent Stuffiness. This demonstrates the huge influence of passenger habit on dose of CO2 and PN. By driver education, and/or automation of HVAC controls, exposure to PN can be reduced significantly.



FUTURE RESEARCH

This study represents a small data set, however, Emissions Analytics are using NAQTS' air quality monitoring technology to gather data on Ingress & Stuffiness for 100s of vehicles per year. Moreover, this will be extended to include other pollutants (NO2, NO, CO, VOCs). This analysis of the dynamics between indoor-outdoor will be supplemented with full VOC speciation using TD GC-MS to characterize both the "new car smell" as well as dynamic VOCs. The combination of these measurements will give a holistic, "real-world" understanding of VIAQ, for the consumer, regulators, and industry.



REFERENCES

D. Müller, D. Klingelhöfer, S. Uibel and D.A. Groneberg. Car indoor air pollution - analysis of potential sources. *Journal of Occupational Medicine and Toxicology* 6, no. 33 (2011): 1-7.

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