Comparative ratings of vehicles for ultrafine particle exposure in the cabin

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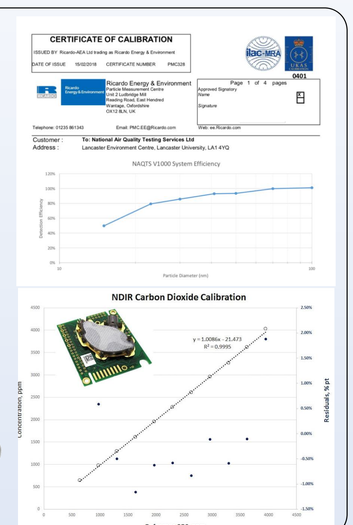
ABSTRACT

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 V2000 Integrated Air Quality Monitors were used to simultaneously monitor inside-outside four vehicles for Particle Number (PN) and Carbon Dioxide (CO_2). The vehicles were analysed to understand *Ingress Ratio* (how much ambient PN is getting into the vehicle cabin) and *Stuffiness* (CO_2).

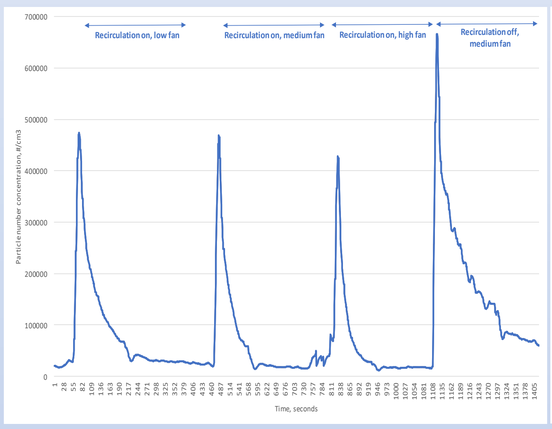
TECHNOLOGY & METROLOGY

PN: CPC with 50:1 pre-dilution (d_{50} 15nm)
CO, NO_2, 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

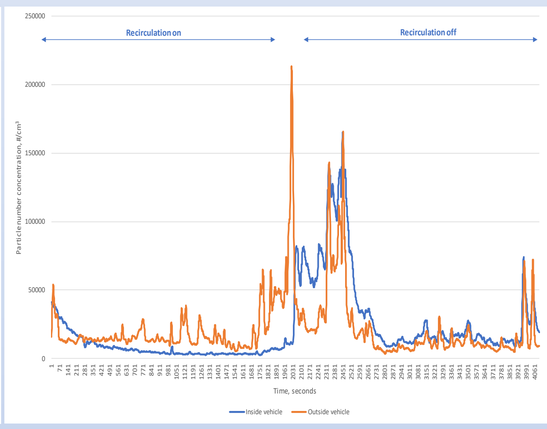


DATA COLLECTION: SIMULTANEOUS INTERIOR AND EXTERIOR

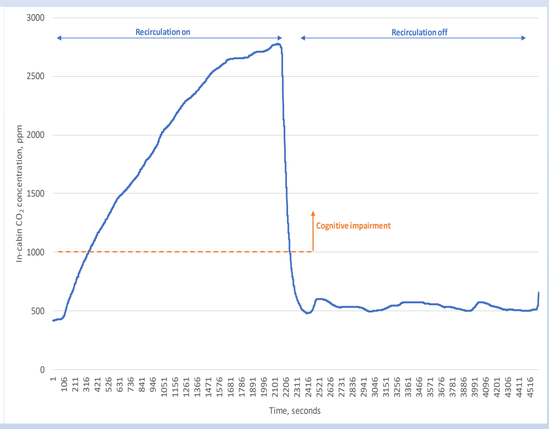
Air exchange rate, pollution clean-up



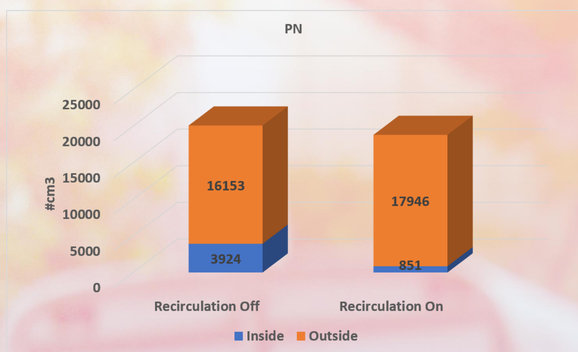
PN filtration

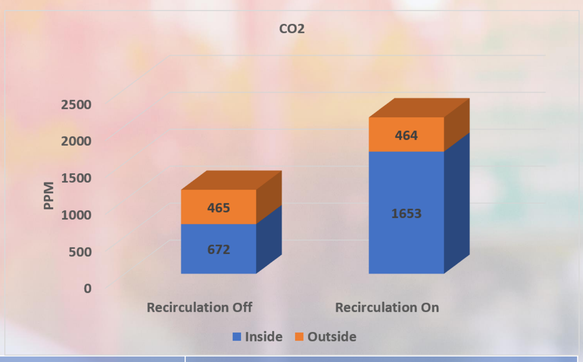


In-cabin CO_2 build-up

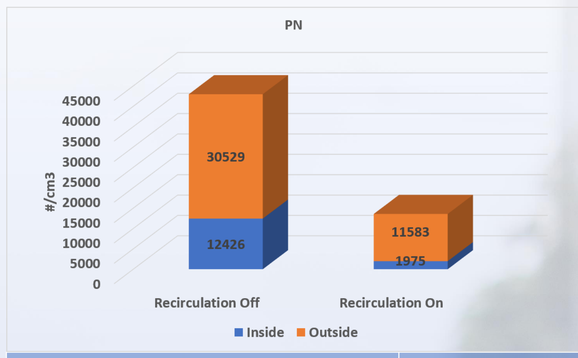


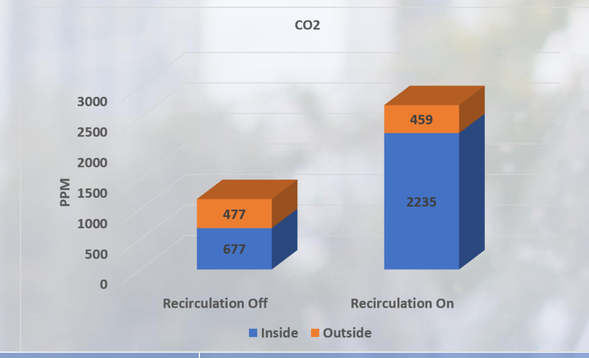
DATA ANALYSIS: HOW MUCH AMBIENT AIR POLLUTION PENETRATES INTO THE CABIN?



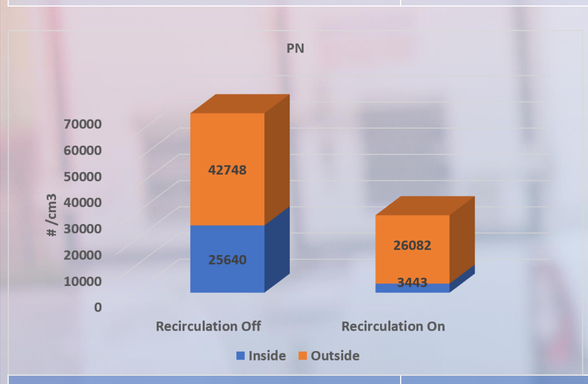


	INGRESS RATIO	STUFFINESS FACTOR
Recirculation Off	24%	1.4
Recirculation On	5%	3.6

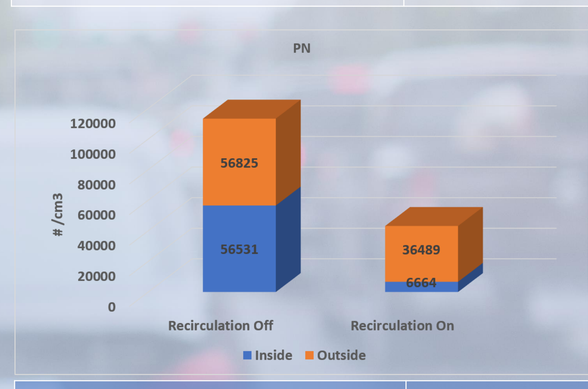




	INGRESS RATIO	STUFFINESS FACTOR
Recirculation Off	41%	1.4
Recirculation On	17%	4.97



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



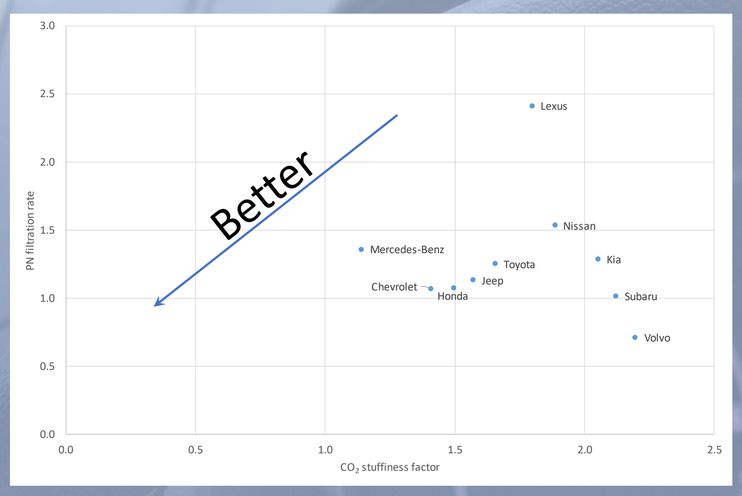
	INGRESS RATIO	STUFFINESS FACTOR
Recirculation Off	99%	1.3
Recirculation On	18%	3.4

VEHICLE BENCHMARKING

As vehicle manufacturers begin to differentiate themselves based on VIAQ, we need more independent research to inform the consumer.

Informed consumer choice can limit emissions and exposure

EQUA CABIN AIR QUALITY



CONCLUSIONS & FUTURE RESEARCH

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 CO_2 and PN. By driver education, and/or automation of HVAC controls, exposure to PN can be reduced significantly.

Emissions Analytics is using the NAQTS PIMS to gather data on Ingress & Stuffiness for hundreds of vehicles per year. The information from different vehicles will be indexed to create a benchmark for vehicles on VIAQ. This will inform the general public on behavioural changes that can mitigate exposure, as well as inform manufacturers on how to best develop models/hardware to automate HVAC systems to reduce occupants air pollution exposure.

Notwithstanding air pollution ingress, VOCs responsible for the "new car smell", can be emitted from an array of interior parts and components. Within the confined space of a vehicle, VOCs emitted from these components may reach levels that are potentially harmful to human occupants. Beyond affecting drivers' and passengers' well-being and comfort, such symptoms may have also consequences on safe driving. The combination of these measurements will give a holistic, "real-world" understanding of VIAQ, for the consumer, regulators, and industry.

In collaboration with
University of California Riverside

UCR

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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.

Klepeis, N. E. et al. The National Human Activity Pattern Survey (NHAPS): a resource for assessing exposure to environmental pollutants. *J. Expo. Anal.* Environ. Epidemiol. 11, 231–252 (2001).

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