Air Quality Inside and Outside Vehicles: Complex Patterns of Exposure in Space and Time

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INTRODUCTION

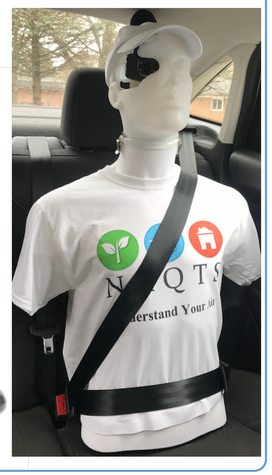
Many studies have addressed Ambient Air Pollution (AAP) and its associated health impacts. However, less has been done to understand Indoor Air Quality (IAQ) despite the average person spending more than 90% of their time indoors (Klepeis et al. 2001). Around one hour of this indoor exposure is spent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

AIMS & OBJECTIVES

To address this knowledge gap, two NAQTS Pollution In-Cabin Measurement Systems (PIMS) were used to simultaneously monitor inside-outside 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 Factor*** (how well the vehicle is ventilating CO_2). Prior to on-road monitoring, the air exchange rates (AC/H) for each vehicle were characterised under a wide range of HVAC operating conditions using the CO_2 concentration decay method.

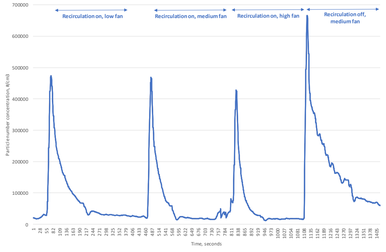
NAQTS PIMS

PN: CPC (d50 15nm)
CO, NO_2, VOCs: Metal Oxide & Electrochemical
VOCs: real-time and thermal desorption tubes
CO_2: NDIR
T, P, RH: BME280
Noise: dBA
Location: GPS
Vibration: 3D-accelerometer & -gyro
OBD
GSM

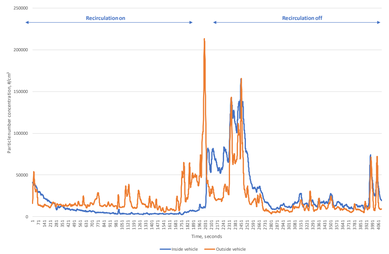


1) DATA COLLECTION

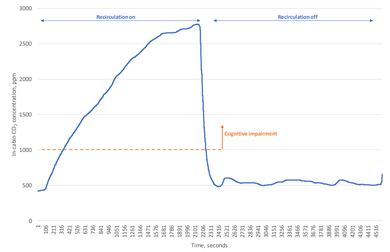
Calculating AC/H



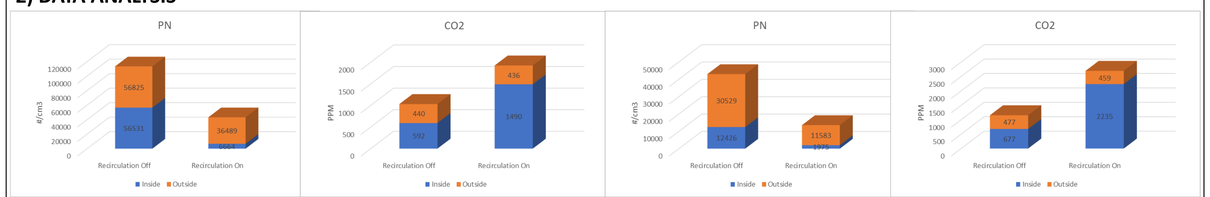
Effect of HVAC on PN



Effect of HVAC on CO_2



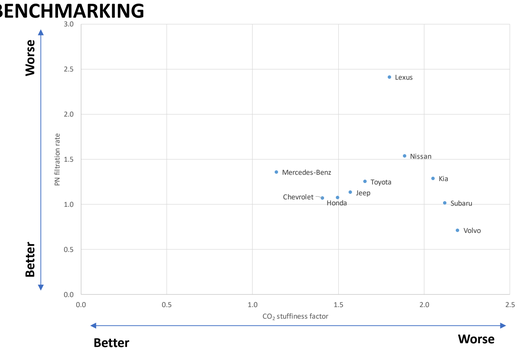
2) DATA ANALYSIS



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

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

3) BENCHMARKING



EQUA CABIN AIR QUALITY

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

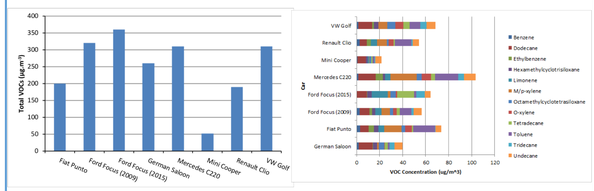
CONCLUSIONS

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 are using the NAQTS PIMS to gather data on Ingress & Stuffiness for 100s 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.

FUTURE RESEARCH

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.



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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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