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Laboratory tests for vehicle in-cabin air quality characterization - their complementarities to on-road tests

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SUMMARY

OBJECTIVE OF THE PRESENT STUDY

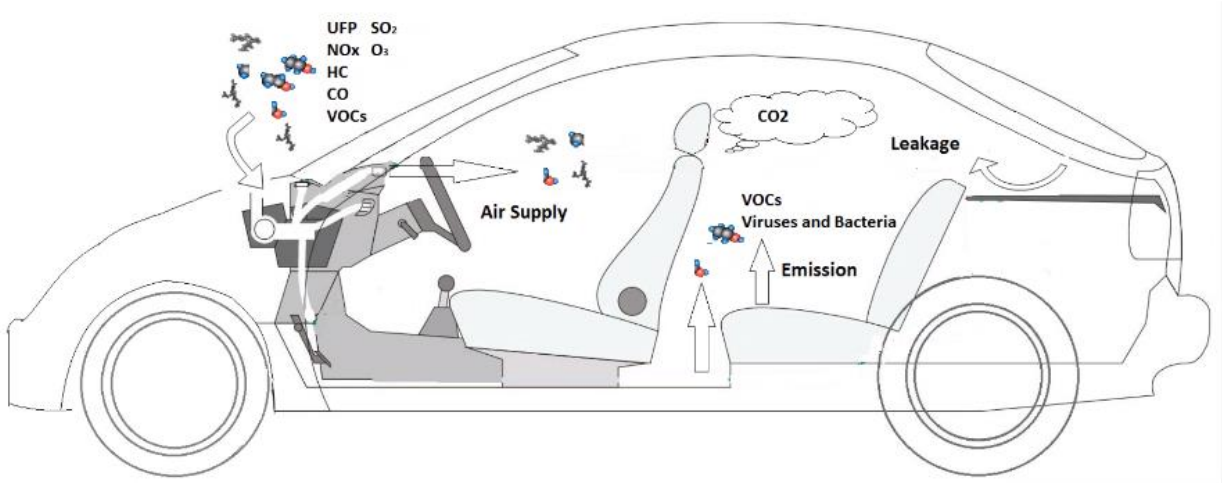


Fig. (1) : Vehicle cabin pollutants sources: interior emission/infiltration from outdoor

- The use of closed chamber for Vehicle Interior Air quality characterization.
- In this presentation we present our preliminary results concerning the investigation of :

→ The impact of tube length on fine and ultrafine particle concentration measurements

→ The influence of outdoor particle concentration level on the vehicle in-cabin concentration measurements and hence on In-cabin to On-road (I/O) concentration ratios.

Test methodology

THE VIAQ MEASUREMENT CHAMBER (THE BUBBLE)

Closed chamber (The bubble)

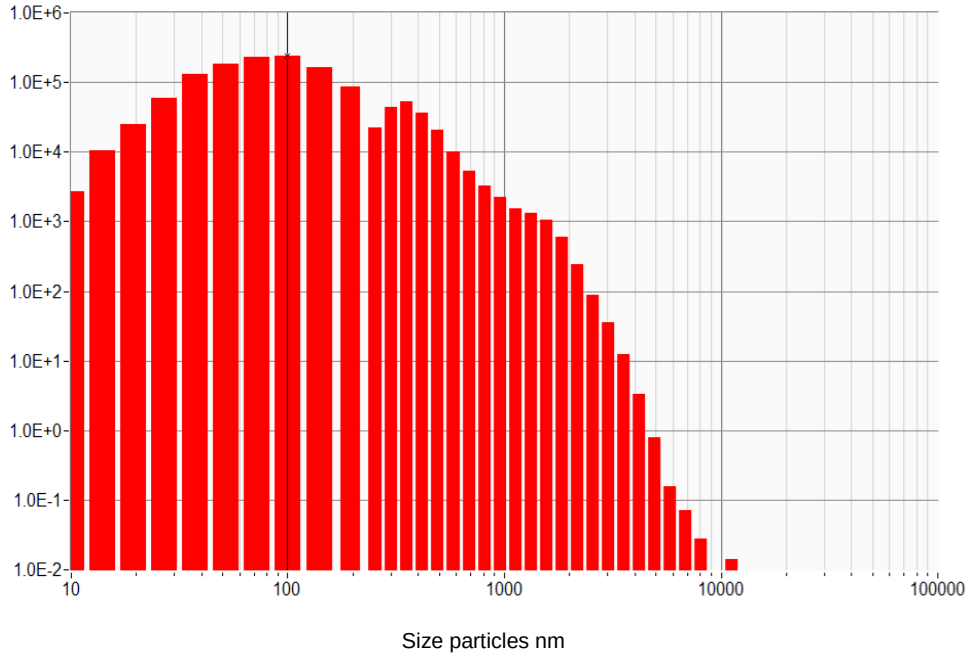
- Closed enclosure allowing to introduce the vehicle
- Air extractor, fan and power supply.
- Generation of a polluted environment with fine and ultrafine particles

Fig. (2) : The measurement plateforme

PARTICLE INJECTION SYSTEM

Fig. (3): Palas AGK 2000

- Particles (NaCl ou KCl)
- Particles size : 0.01µm – 15µm
- Injection concentration : 10^7 particles/cm^3.min



- Numerical and experimental characterization of particles distribution homogeneity in the bubble (more details could be found in the previous VIAQ meetings presentations)

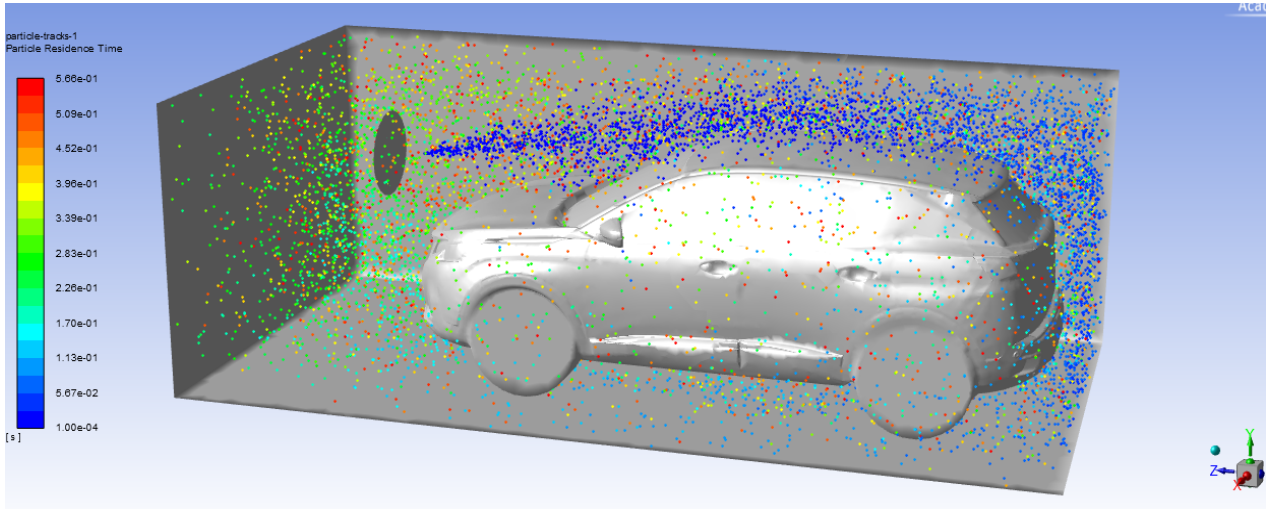


Fig. (4) : Particles distribution (0,1µm<d_p<10µm in the bubble colored by there residence time (t=0,5 s)

Measuring the mass and number concentrations of fine and ultra-fine particles :

Particle mass (µg/m3) and number (Nbr/cm3) concentration granulometry

Particle size from 0.01 to 35µm

Acquisition rate (1 measurement/min)

Fig (5): Grimm Mini Wras

Particle mass concentration measurements (mg/m3)

Size of the particles to be measured 0.1 to 15µm

Acquisition rate (1 measurement/s)

Fig (6): TSI Dust Track

Particle number concentration measurements (0-500,000 particles/cm3)

Size of particles measured 0.02 to 2 µm

Acquisition rate (1 measurement/s)

Fig (7): PTrack

Probe positions

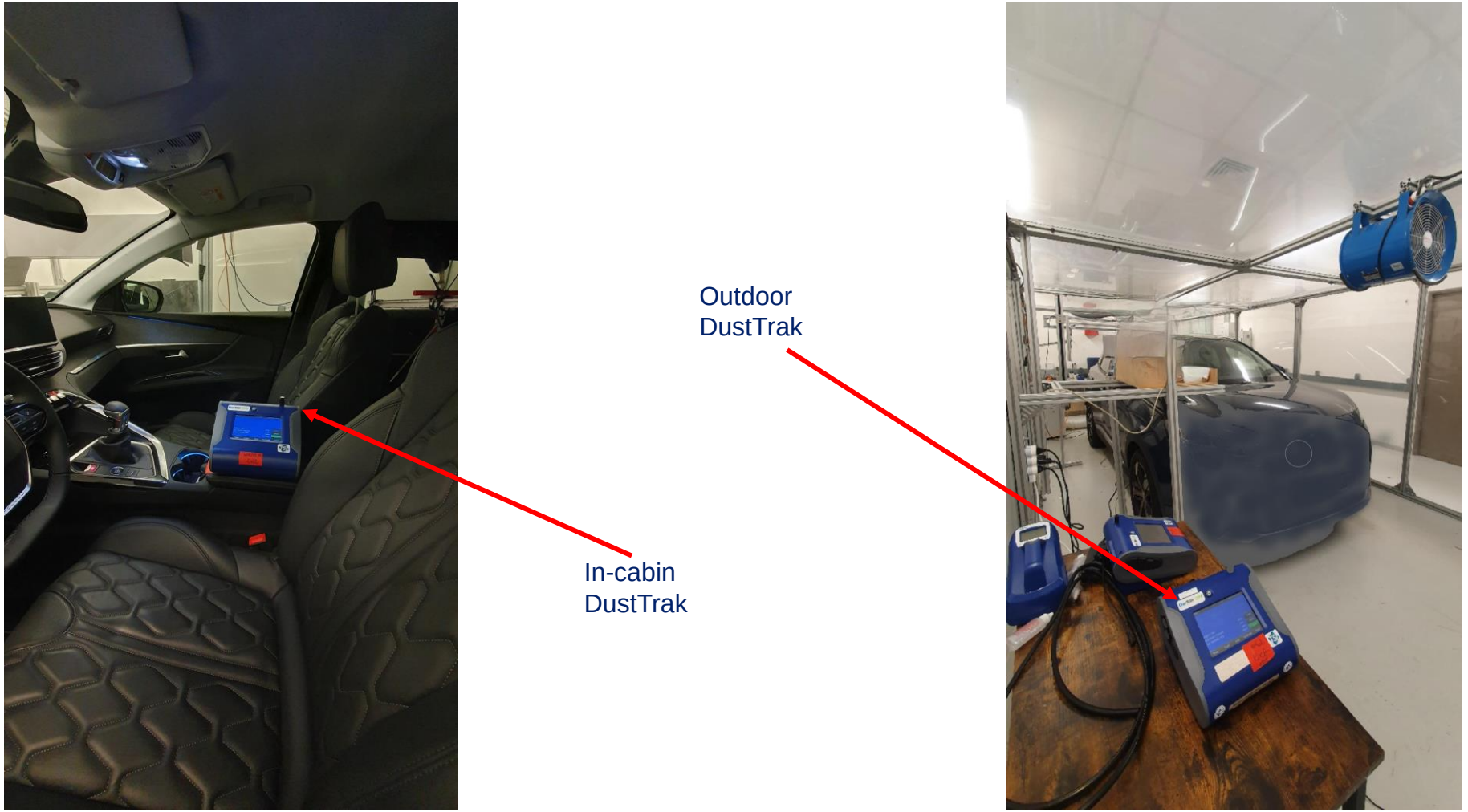


Fig. 5 : In-cabin and outdoor measurements positions

Vehicle/ filter types

- Suv type vehicle: combustion engine, mileage 2800 km
- Cabin filter: OEM HE type, new 0 km
- Activated carbon filter
- Length [mm]: 290, width [mm]: 95, thickness [mm]: 30

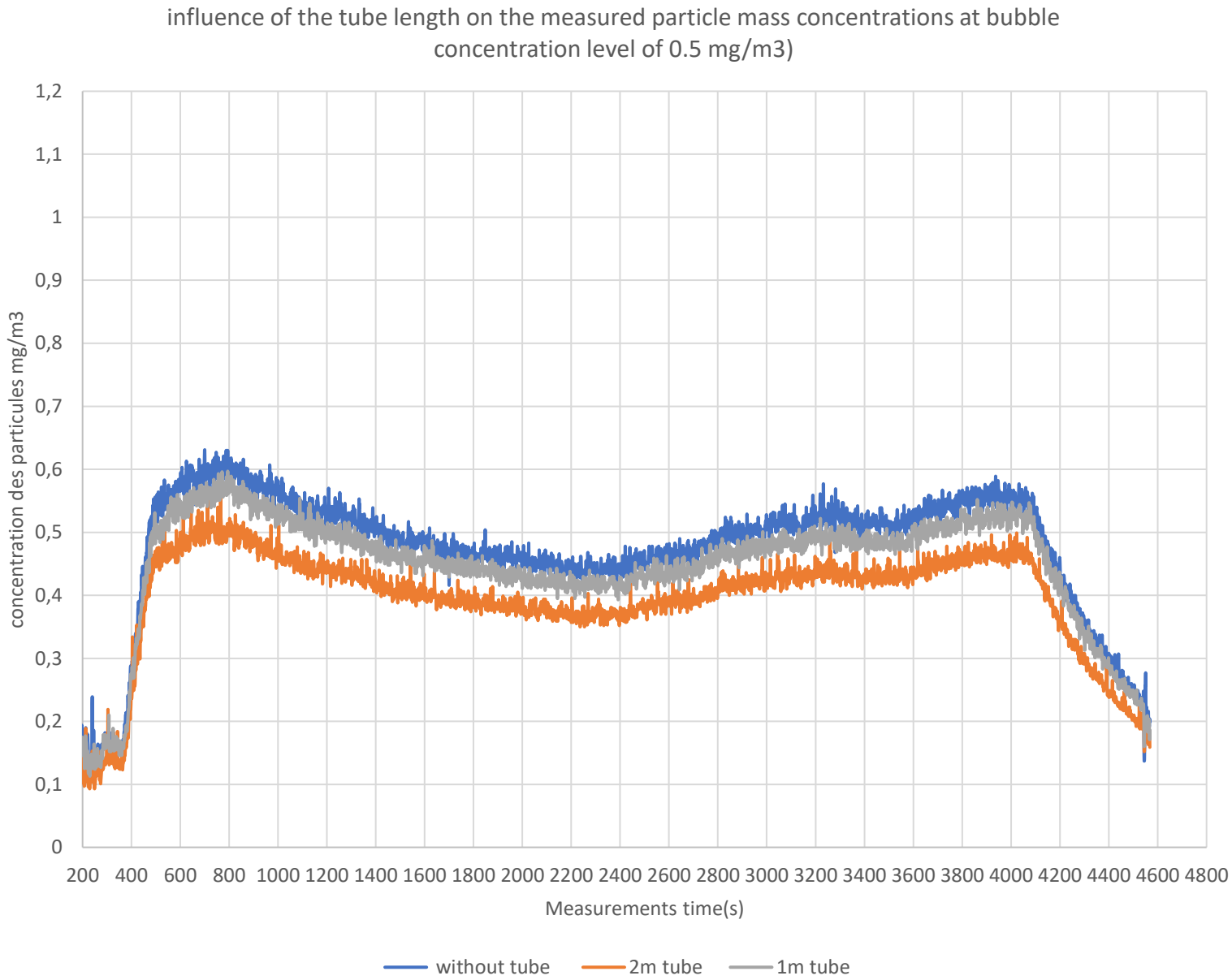
Fig. 6 : Filter type

Results and analysis

INFLUENCE OF TUBE LENGTH

- Influence of the tube length on the measurement of particle mass concentration in a polluted environment with a concentration level of 0.5mg/m^3 at T= 17°±2°, RH=25% ±5%

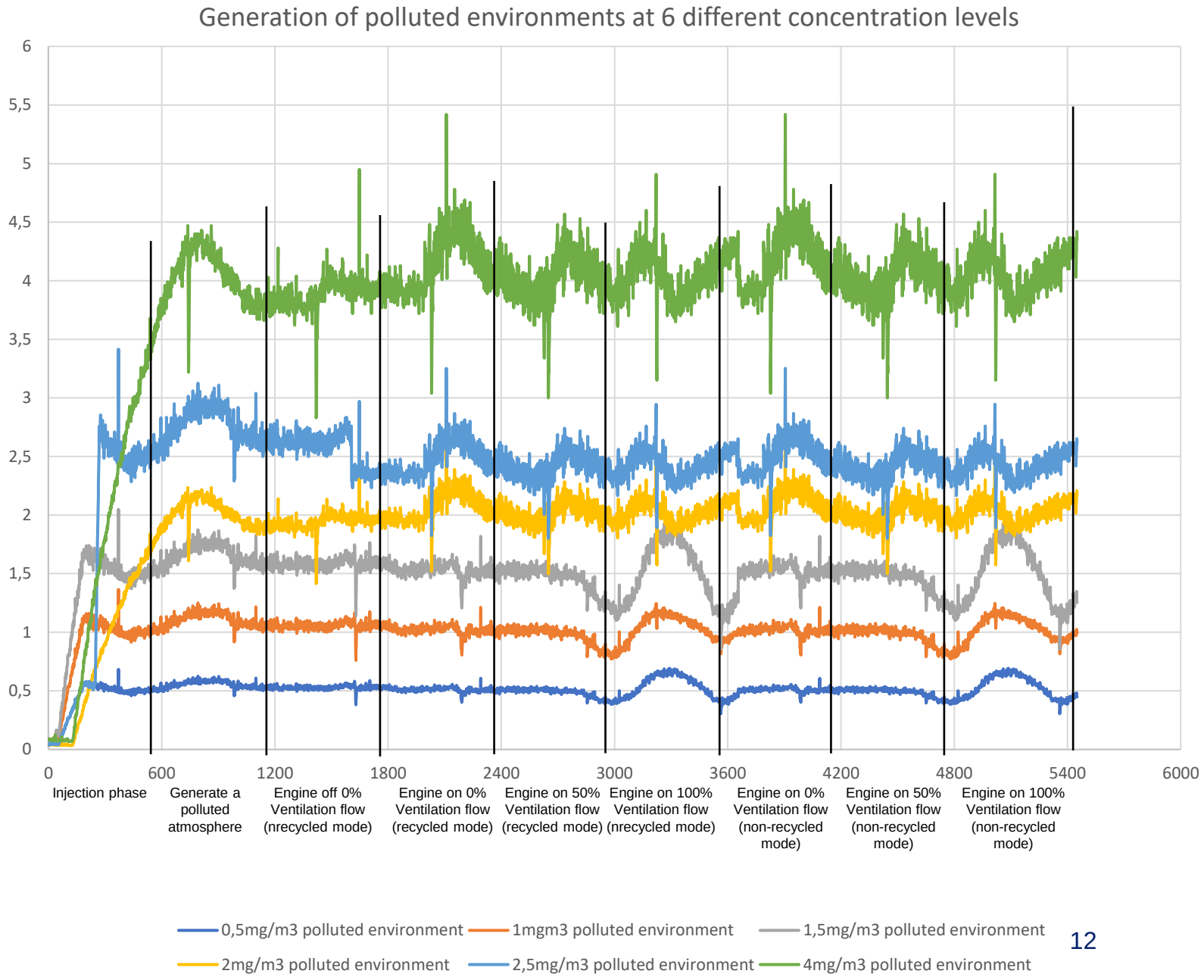
	Comparison between without tube and with tube of 1m length	Comparison between 1m length tube and 2m length tube
Relative difference of mass concentration	**6%**	**12%**



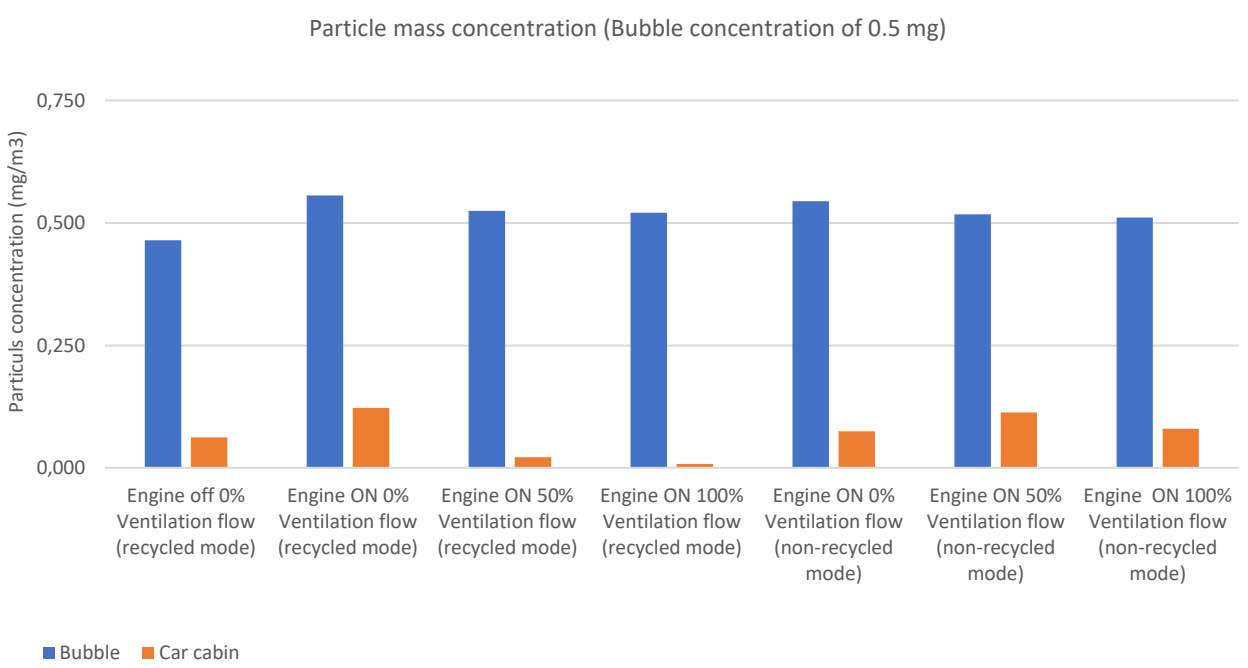
Particle deposition

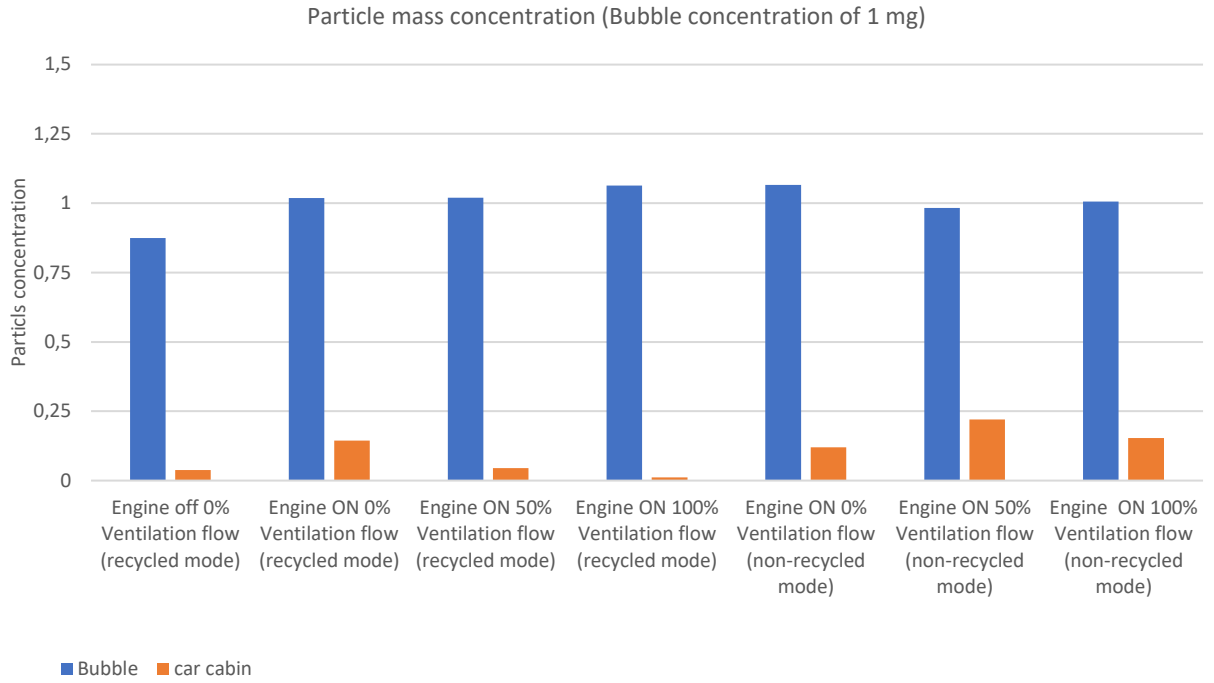
INFLUENCE OF OUTDOOR PARTICLE CONCENTRATION LEVELS

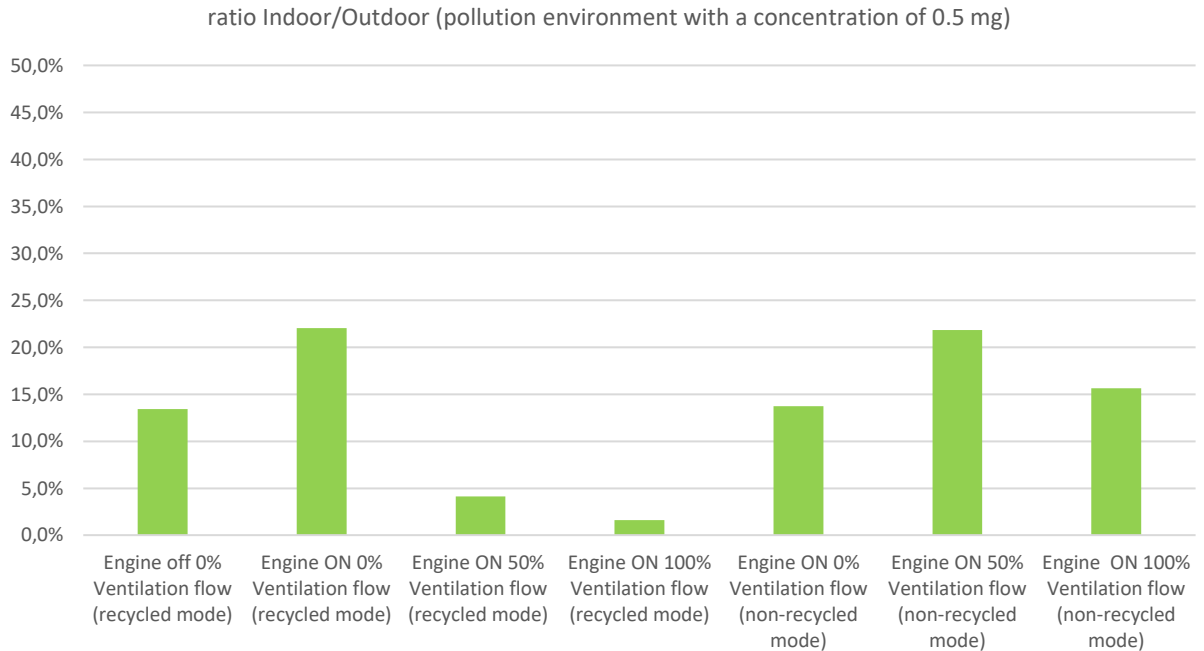
- Generation of polluted environments with different levels of particle mass concentrations : 0.5mg/m^3, 1mg/m^3, 1.5mg/m^3, 2mg/m^3, 2.5mg/m^3 and 4mg/m^3.

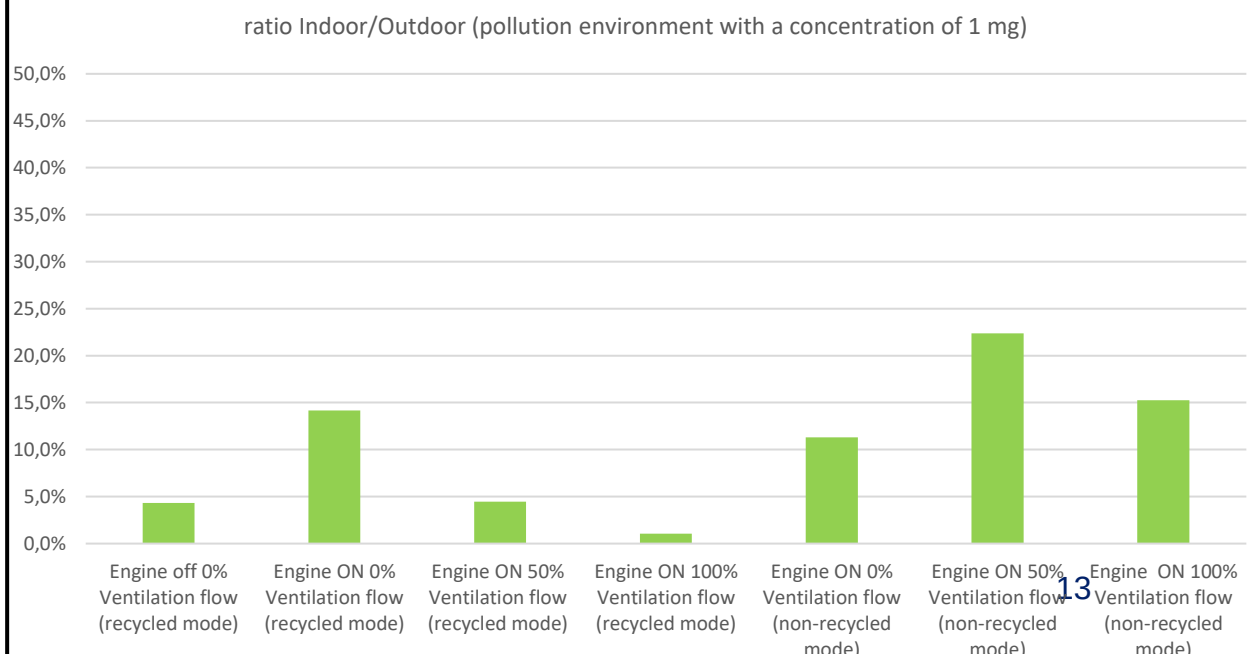


CHARACTERIZATION OF THE CAR-CABIN IN A POLLUTED ENVIRONMENT WITH A CONCENTRATION OF 0.5 AND 1 mg/m³

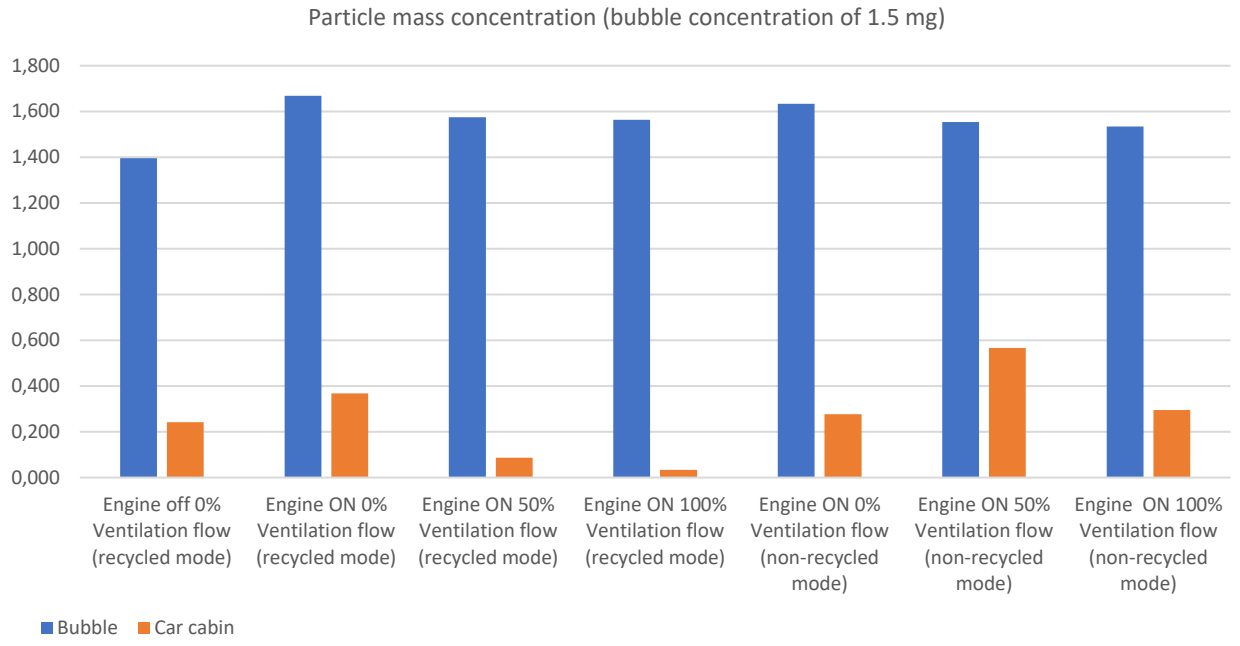


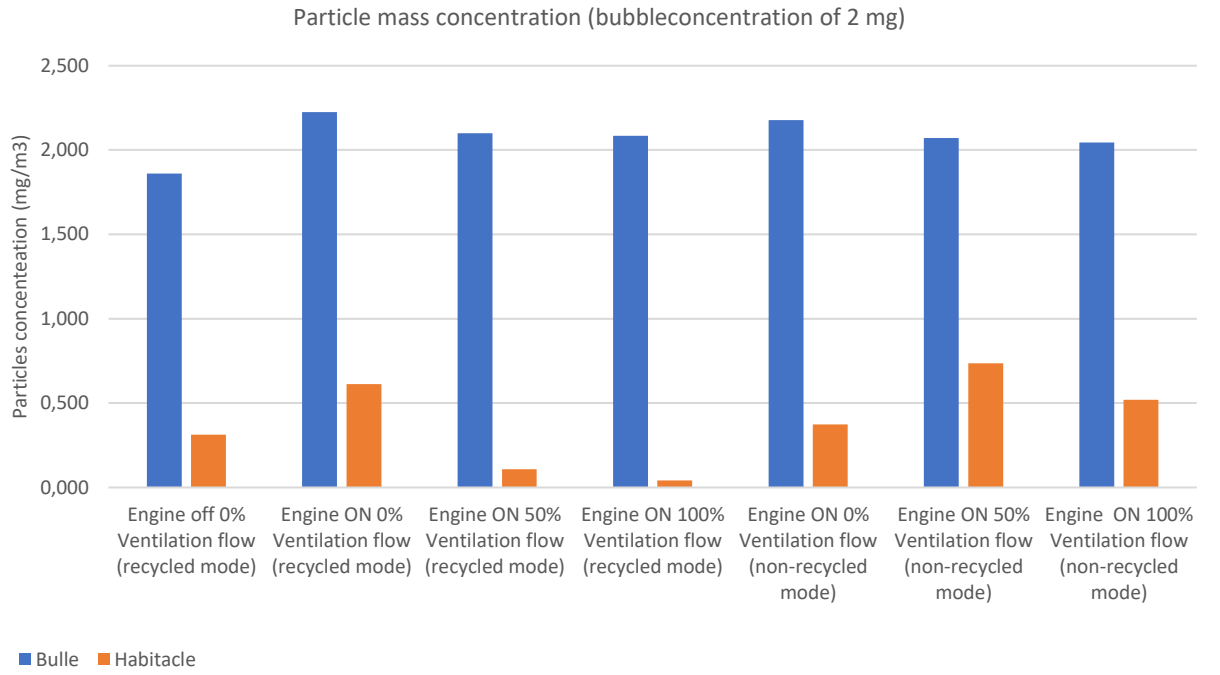


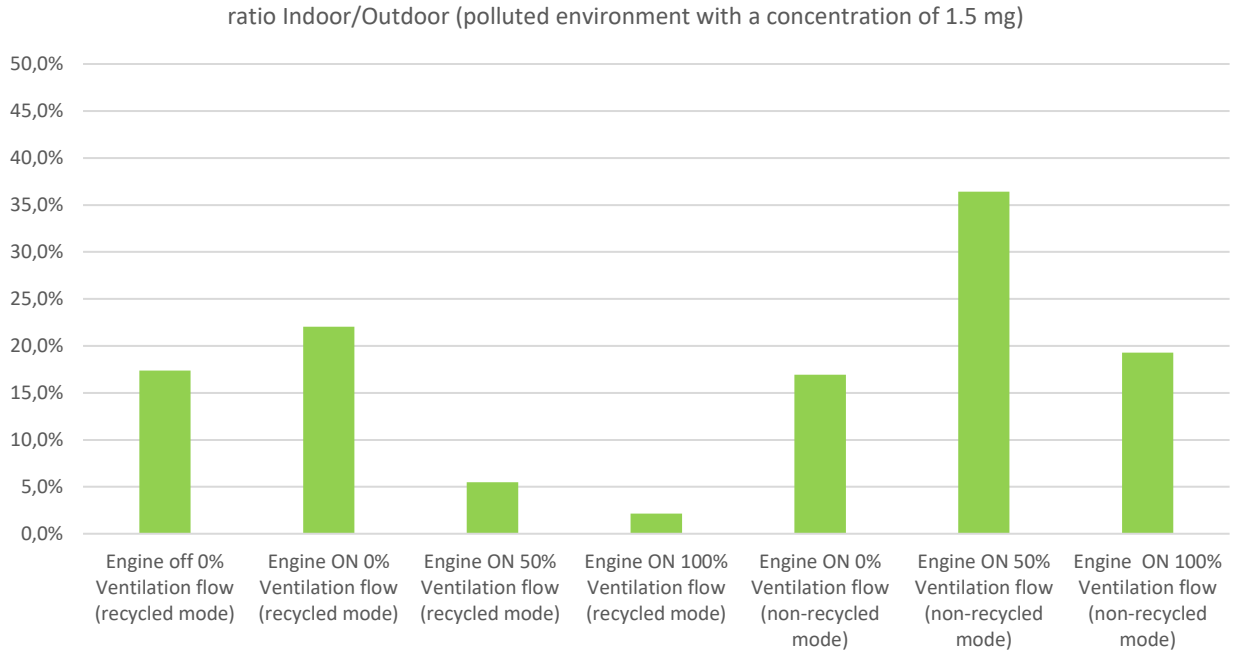


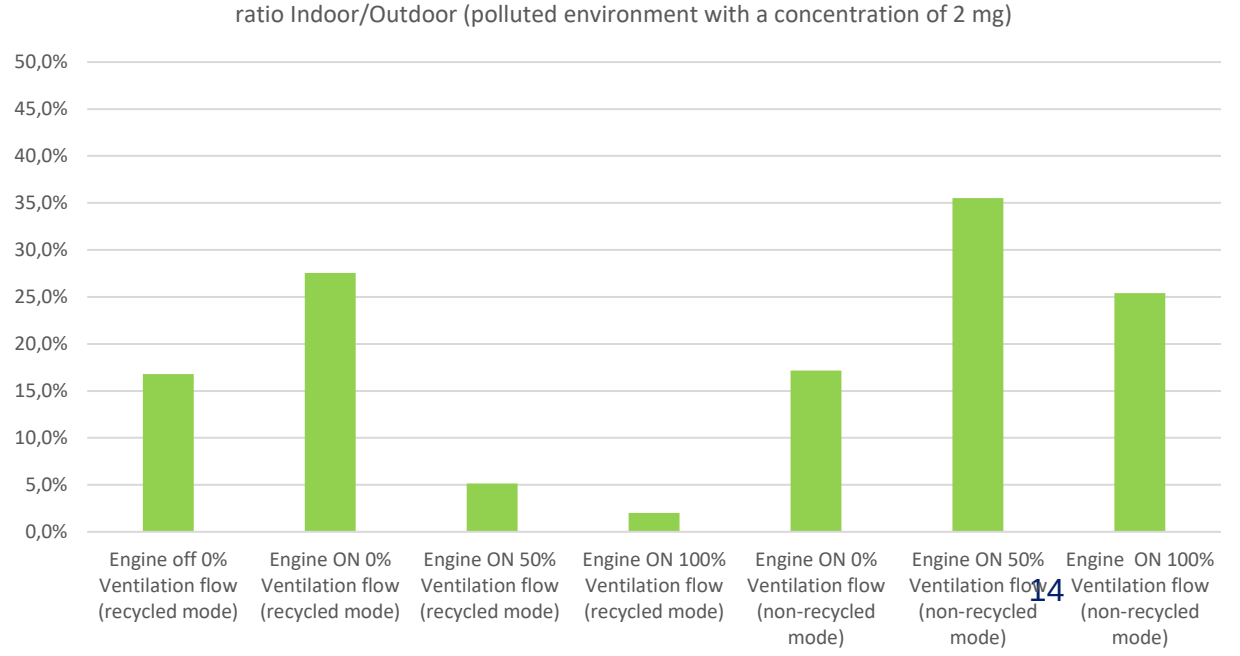


CHARACTERIZATION OF THE CAR-CABIN IN A POLLUTED ENVIRONMENT WITH A CONCENTRATION OF 1.5 AND 2 mg/m³

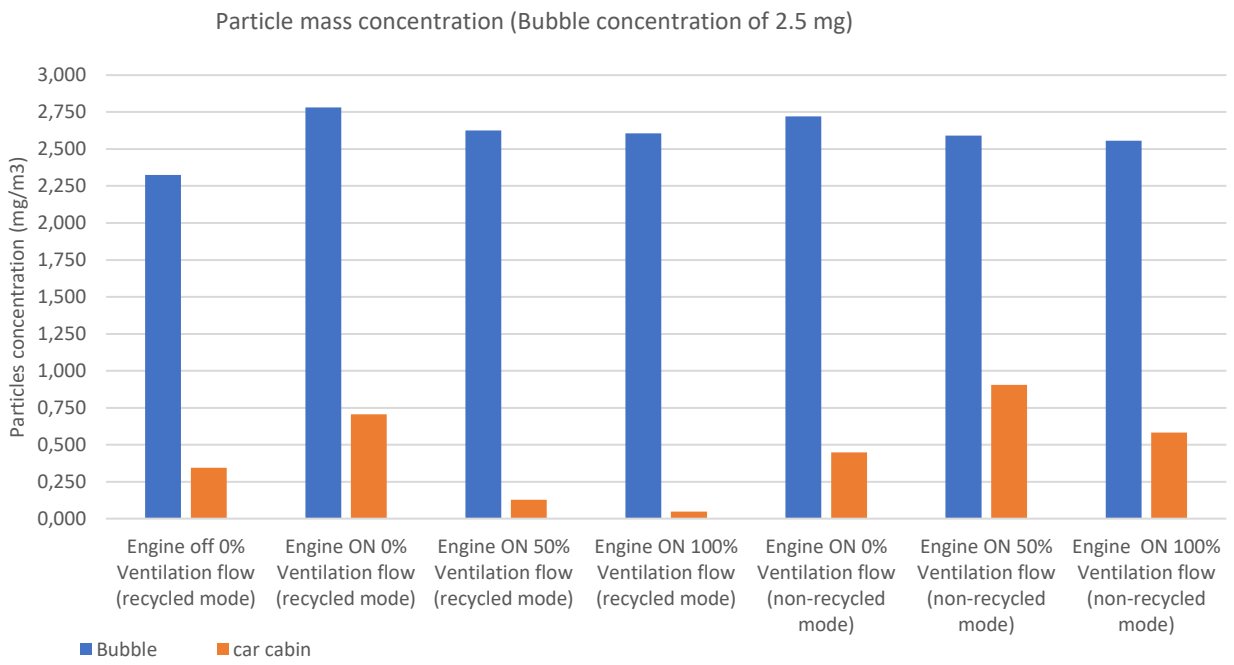


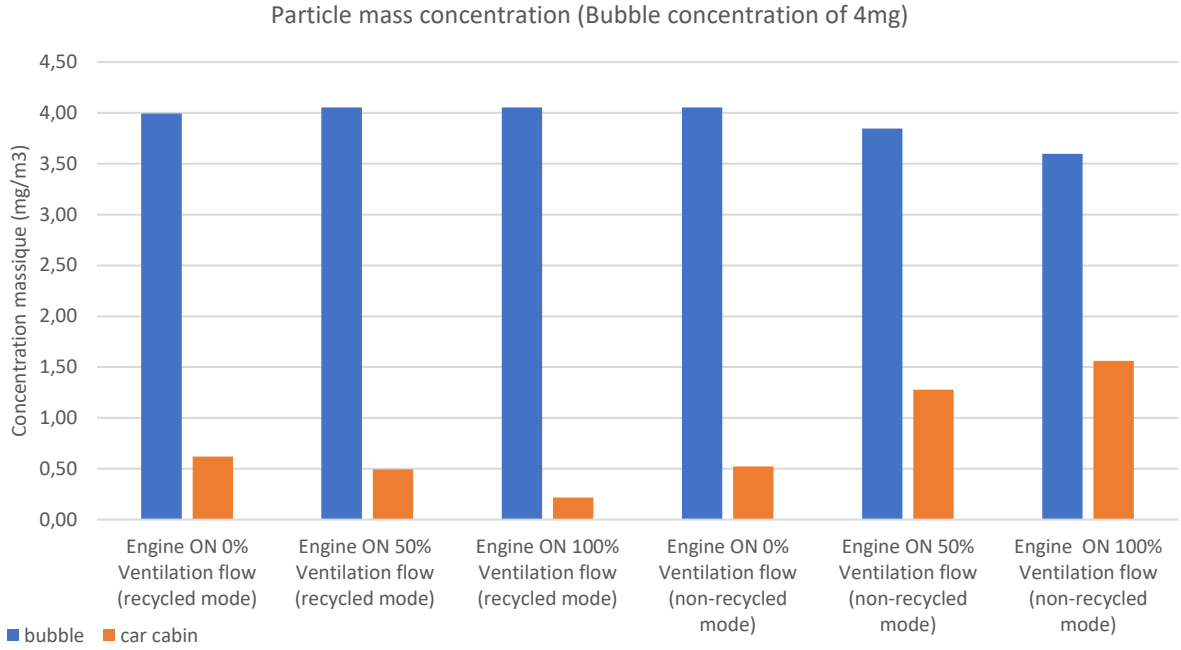


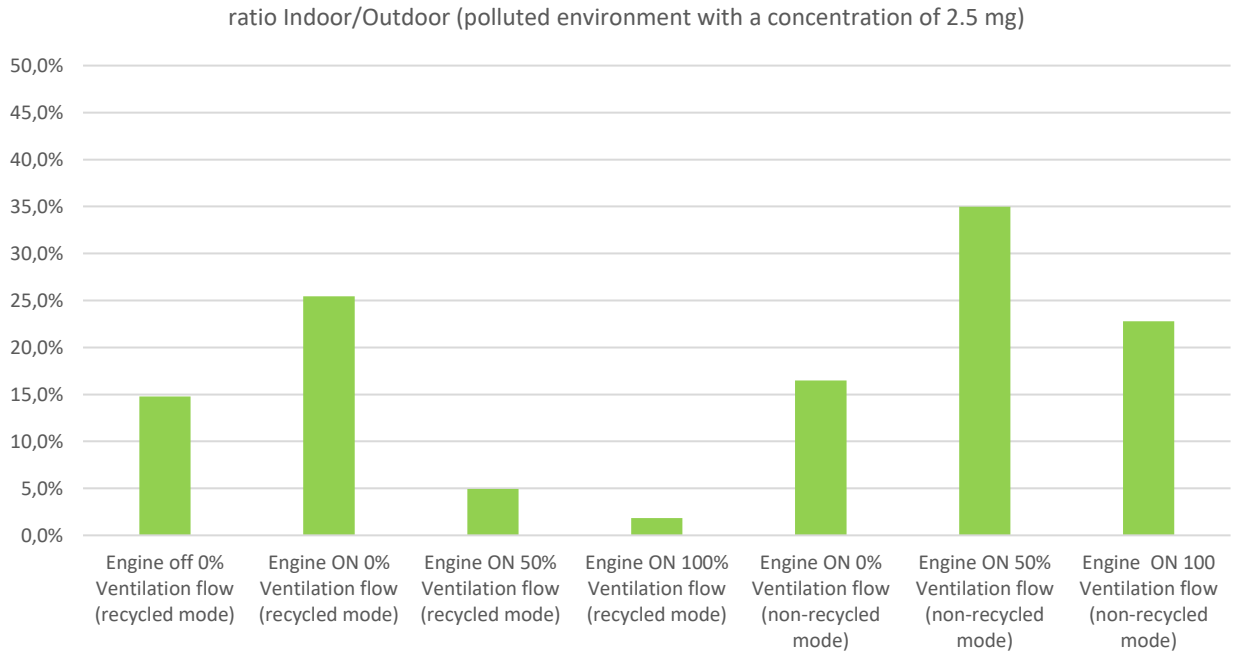


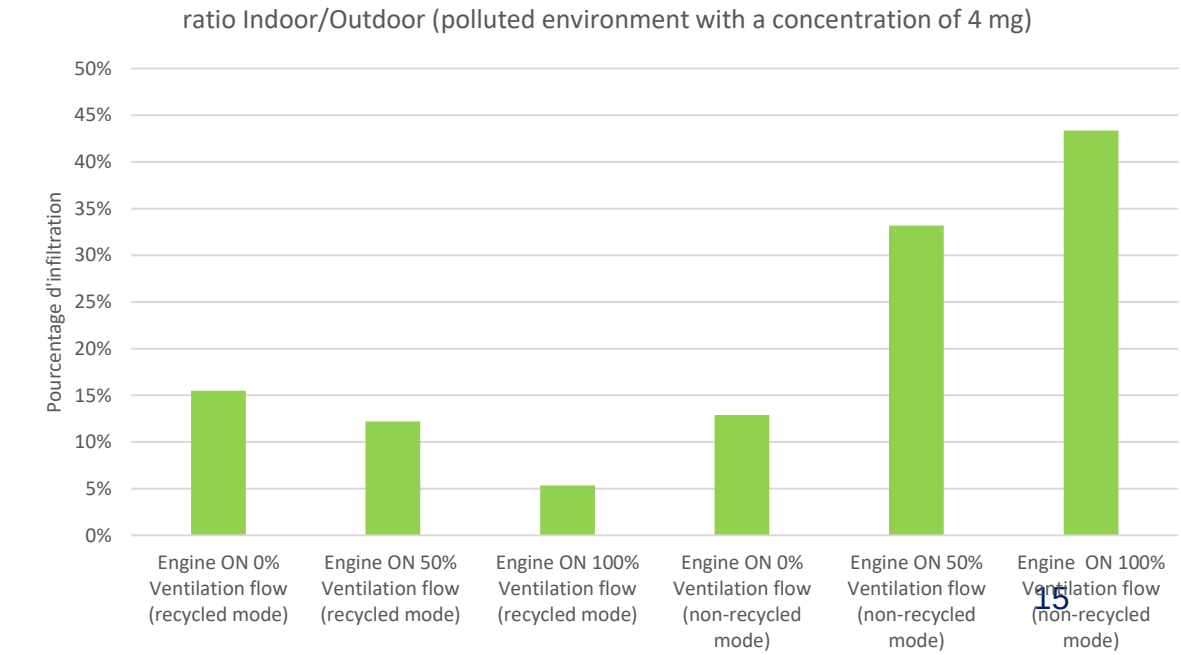


CHARACTERIZATION OF THE CAR-CABIN IN A POLLUTED ENVIRONMENT WITH A CONCENTRATION OF 2.5 AND 4 mg/m³



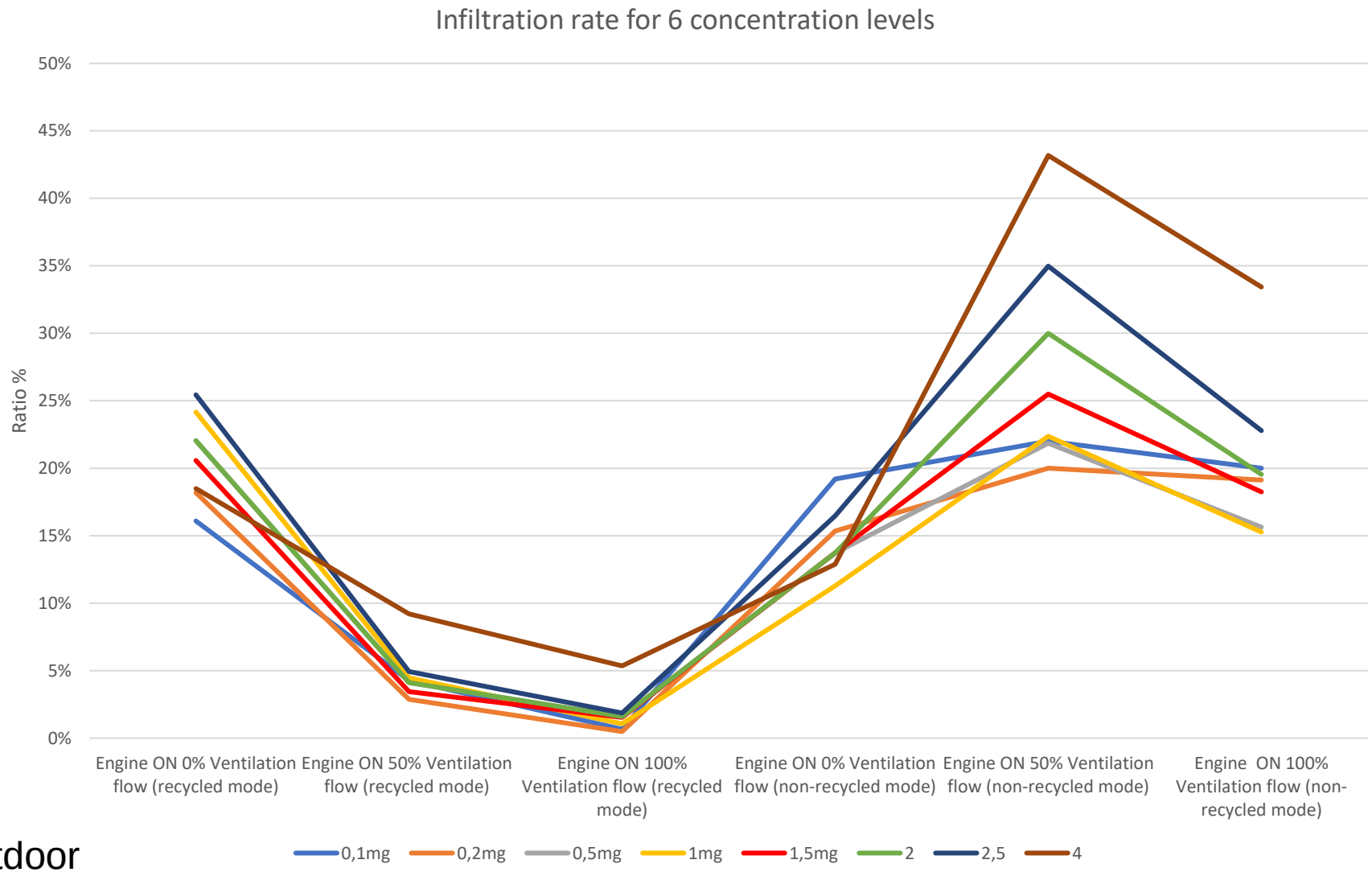






COMPARISON OF THE INFILTRATION RATE FOR 8 LEVELS OF POLLUTION

- Beyond an outdoor concentration of 1mg/m^3 the infiltration rate increases by an average of **5%** for two successive concentration level when outdoor air ventilation mode (OA) is set to on. (the maximum difference being 11%) .
- While the average difference is around 1.5% for lower concentration (below 1 mg/m$^{3)}$) (the maximum is 4%)



(I/O) influenced by outdoor (on-road) concentration level

STATIC VIAQ MEASUREMENTS VS ON-ROAD MEASUREMENTS

	On-road			static		
	Indoor concentration (mg/m3)	Outdoor concentration (mg/m3)	Infiltration rate (I/O)	Indoor concentration (mg/m3)	Outdoor concentration (mg/m3)	Infiltration rate (I/O)
PM_{10}	0,009	0,010	92%	1,447	4,433	33%
$PM_{2.5}$	0,008	0,008	96%	1,439	4,256	34%
PM_{1}	0,008	0,008	96%	1,436	4,039	36%

If the outdoor pollutant concentration is weak, i.e., of the same order of magnitude than the in-cabin background (reference) concentration, then:

- the I/O ratios approaches 1 and hence, the on-road measurements are not reliable

The outdoor particulate concentration should be:

→ More important than the background in-cabin concentration (minimum threshold to be defined)

→ Not exceeding 1 mg/m^3 for PM

Purpose of approval/certification

The static measurements could help for the following reasons:

- The influence of on-road (outdoor) pollution concentration levels on the infiltration rate (I/O)
- The unpredictability of outdoor air pollution concentration levels making it difficult on-road measurements scheduling

→ Even if we could have pollutants concentrations peaks, related to traffic or road infrastructure type encountered (e.g., tunnels), if the average on-road concentration is low, the I/O ratio could be not representative

- The on-road measurements make it difficult to control external conditions: weather, inter-vehicle distances, road infrastructure types, pollution level

- On the other hand, static laboratory measurements are less representative of realistic conditions during driving: influence of vehicle speed or the airflow.

Purpose of improving understanding/knowledge

- Complete and accurate characterization of the impact of different parameters, independently of each other, on vehicle in-cabin air quality
- Laboratory tests not impacted by, for example, the airflow of moving vehicle, the vehicle inter-spacing distances, road type,)
- Comparable and reproducible outdoor pollution conditions
- Simulating different pollution conditions, for example, what is the air pollution level in the car cabin of a vehicle spending the night outdoor during peaks of pollution