Measurements of Particulates Concentrations inside Vehicle Cabin

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The main objectives of the study presented here were to assess the effects of the ventilation method on air pollution inside the car, and to derive recommendations aimed at reduction of driver and passengers' exposure to air pollution.

In countries with hot climate conditions, almost the entire vehicle fleet is equipped with air conditioning (AC) systems, and the driver usually makes a decision about the desired method of car ventilation: without AC and opened window, with AC and internal recirculation of air, or with AC and introduction of outdoor air into the car. The following car ventilation modes have been tested in the study:

- AC switched on and introduction of outdoor air into the car (vent on), windows closed – "AC out";
- AC switched on, internal air recirculation, windows closed – "AC rec";
- AC switched off, vent on, windows closed;
- AC switched off, vent off, window of the driver fully open – "Window open".

In these experiments PM mass concentrations were measured in the ranges of PM10, PM2.5 and PM1. Volume concentrations of some gaseous pollutants, such as CO, NO and NO2 have been measured too. Significant influence of car ventilation method on the inside air quality was found with relatively high levels of particles concentrations inside a vehicle. The highest values of air pollution for all measured pollutants were found for the ventilation mode with AC switched off, vent off and fully opened driver's window. The lowest internal air pollution levels were found at the ventilation mode with air conditioning switched on, internal air recirculation and windows closed. The differences between these modes were statistically significant and lied in the range 22 – 97%, dependent on pollutant type.

An attempt to reduce air pollution inside a vehicle by using a dedicated nano-particle filter system (Matter Engineering) is described. Special series of road experiments have been performed with passenger cars and shuttle taxis. Air pollution by nano-particles was assessed using a diffusion size classifier (DiSC, Matter Engineering) which allows simultaneous measurement of particle number concentration and particle size. Effects of nano-particle filter on the noise level inside a vehicle cabin were assessed. Air quality inside a passenger car was treated by using a one nano-particle filter and inside a shuttle taxi – by two filters of the same capacity. Air pollution inside a vehicle was measured at different car ventilation methods without nano-particle filter; with AC, internal recirculation of air and nano-particle filter; and compared with the ambient air pollution outside a vehicle at the same driving route.

Filter effects on air quality inside a vehicle were assessed and recommendations on future directions of research and development were derived. Results of experiments demonstrated that dedicated nano-particle filter system allows significant reduction up to 99% of particle number concentrations inside a vehicle. Some minimal time is required, in order to achieve maximal cleaning effect.

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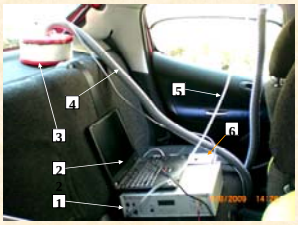
Objectives

- assess effects of the ventilation method on air pollution inside the car
- derive recommendations aimed at reduction of driver and passengers' exposure to air pollution

Methodology

➢ Target pollutants

Concentrations of CO, NO, NO_2, PM10, PM2.5, PM1 and nano-particles were measured. Average size of nano-particles was assessed as well.



➢ Vehicles tested

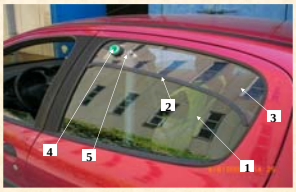
Nine vehicles of different ages were tested: "new" vehicles with mileage accumulated not exceeding 25,000 km and "old" vehicles with mileage of 150,000 km or more

➢ Data collection and analysis

Sampling - in the driver's breathing zone
Experiments - all working days, 7 AM - 7 PM

Particulates mass concentrations - measured by GRIMM 1.107 PM meter

Nano-particles concentrations and their average size - measured by the Matter Engineering diffusion size classifier (DISC)



Nanocleaner installation in a vehicle

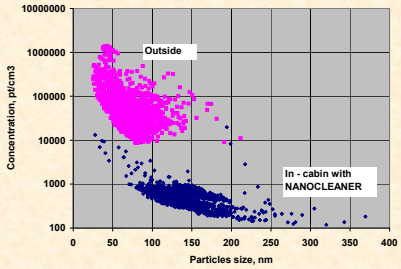
➢ Testing program

Driving routes in Haifa and Tel-Aviv differing by their topography

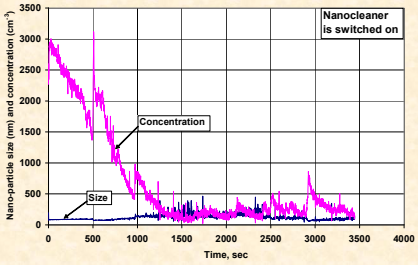
Novel nano-particle filter (Nanocleaner) developed by the Matter Engineering AG was used

Measurements outside vehicle and inside vehicle at different ventilation modes with the Nanocleaner switched on and off

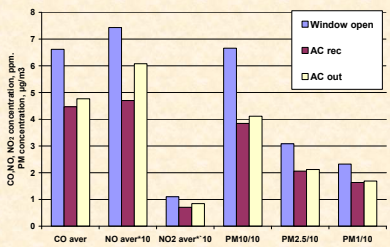
Results and Discussion



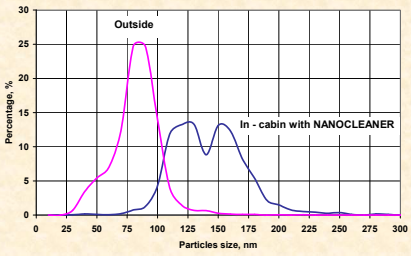
Nano-particle measurements outside and inside a car



Nano-particle measurements inside a car – Tel-Aviv route



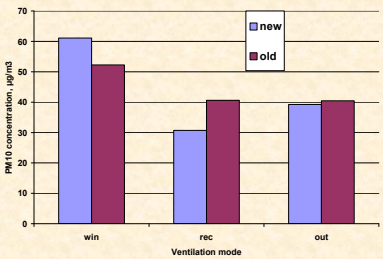
Ventilation mode effects



Distribution of nano-particle size inside and outside a car

Acknowledgement

The financial support of the Israeli Ministry of Environment Protection and Haifa District Association of Municipalities for the Environment is highly appreciated.



Average PM10 concentrations for “new” and “old” cars

Conclusions

✓ The lowest internal air pollution levels were found at the ventilation mode with air conditioning switched on, internal air recirculation and windows closed.

✓ Better sealing of new cars and, probably, higher efficiency of new air filtration systems allow lower PM concentrations inside a car of lower age, if the “AC rec” ventilation mode is used.

✓Dedicated nano-particle filter system allows significant reduction up to 99% of particle number concentrations inside a vehicle.

✓ Minimal PN concentrations inside a car were achieved after about 25 min of filter operation.

✓ Use of nano-particle filter leads to some increase in size of particles measured inside a vehicle compared with ambient air data.