Exhaust and Non-Exhaust Particle Emission Measurements using a Road Tunnel Environment in Tokyo

Hiroyuki HAGINO, Japan Automobile Research Institute (JARI)

Summary

- Typically, Exhaust and Non-Exhaust Particles are measured in Laboratory, whereas in This Study Emission Factors are observed from Point of View of Tunnel Observation under Actual Vehicle Traffic.
- Slightly Higher Correlation between PM_{10} and SPN (10 nm – 100 nm) than TPN (10 nm – 100 nm).
- Deployment of Positive Matrix Factorization for Separation of Exhaust and Non-Exhaust Particle Emission.

Road Tunnel Measurements

- Observation Period: November 2022.
- Simultaneous Measurement for Entrance/Exit (Distance: 1.37 km).
- Particle Number Size Distributions: 10 nm - 10 μm for Total PN (TPN)/ Solid (350 °C) PN (SPN) (SMPS 3938, OPS 3330 (TSI)).
- Particle Mass: PM_{10} and $PM_{2.5}$ (Beta Attenuation Monitor, PM712, Kimoto).
- Gaseous Species: NO_X and NH_3 (Chemiluminescence, Model 17i, Thermo Scientific), CO (NDIR, APMA-370 HORIBA), CO_2 (NDIR, LI-820, Li-Cor).

Road Tunnel **Exit**

$PM_{2.5}$ Filter Samples

Exit **Entrance** Blank

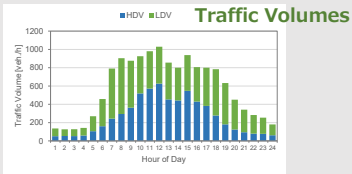
Road Tunnel **Entrance**

Emission Factor

- Emission Factor (EF) Calculated from following Parameters:
  - Concentration Difference at Tunnel Entrance/Exit. *C* [e.g. mg/m³ for PM]
  - Ventilation Speed, *WS* [m/h]
  - Tunnel Cross Section, *A* [m²]
  - Driving Distance, *D* [km]
  - Traffic Volume, *V* [veh./h]

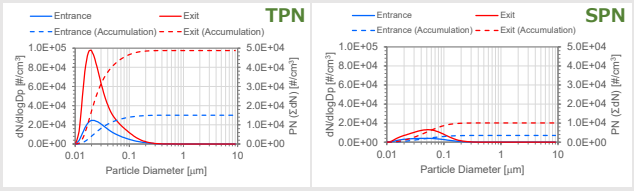
$$EF = \frac{[C_{Exit} - C_{Entrance}] \times A \times WS}{D \times V}$$

Traffic Volumes



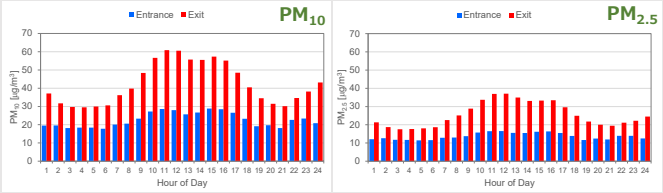
Particle Number Size Distributions

- Similar particle size distribution for Exit and Entrance.
- Large contribution of Sub-20nm particles for TPN in the Road Tunnel (53 % of TPN (10 nm – 10 μm).
- Small contribution of Sub-20nm particles for SPN in the Road Tunnel (14 % of SPN (10 nm – 10 μm).



PM_{10} and $PM_{2.5}$

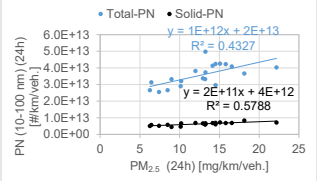
- Higher Concentration of PM_{10} than $PM_{2.5}$.
- Diurnal profile is roughly similar for PM_{10} and $PM_{2.5}$.
- PM_{10} and $PM_{2.5}$ are Slightly Higher at Night with Higher Humidity and Lower Traffic.



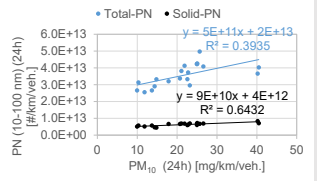
PN vs PM Emissions

- Correlations between SPN, TPN, $PM_{2.5}$ and PM_{10} Emission Factors for each Particle Size Range (10 nm - 100 nm, 10 nm - 2.5 μm, 10 nm - 10 μm), averaged over 24 hours.
- Slightly Higher Correlations between PM_{10} and SPN rather than TPN.
- Few Differences in Correlation to SPN / TPN between $PM_{2.5}$ and PM_{10}.

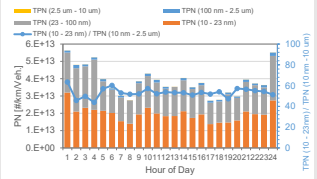
$PM_{2.5}$ vs PN (10 nm - 100 nm)



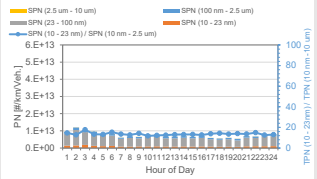
PM_{10} vs PN (10 nm - 100 nm)



Diurnal Profile (TPN)

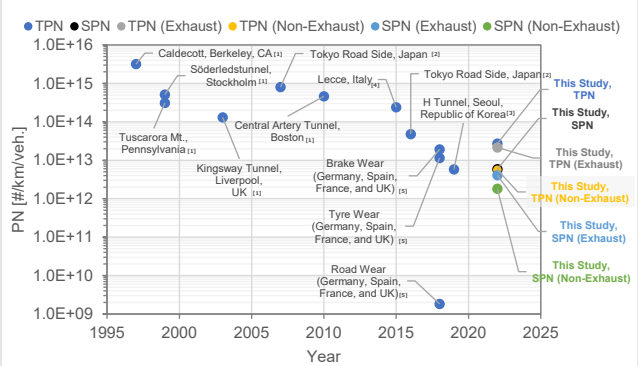


Diurnal Profile (SPN)



Exhaust and Non-Exhaust Emissions

- SPN (10 nm – 100 nm) and TPN (10 nm – 100 nm) analyzed as an Example.
- Positive Matrix Factorization (PMF) separated SPN (10 nm - 100 nm) into 2 Factors,
  4.1 x 10^{12} #/km/veh. for Exhaust and
  1.8 x 10^{12} #/km/veh. for Non-Exhaust (included Brake Wear, Tyre Wear, and Road Wear).
- Decreasing Trends over Year with several Literatures.



[References]
e.g. [1] Conte and Contini, Environ. Pollut., 251, 830-838 (2019); [2] Fujitani et al., Atmos. Environ. X, 5, 100055 (2020); [3] Parket al., Appl. Sci., 11, 794 (2021); [4] Perkins et al., Atmos. Environ., 74, 326-337 (2013); [5] Lin et al., SSRN (2023)

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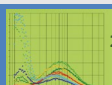

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