Correlation between $PM_{2.5}$ and Particle Number Concentrations in Four Major Cities: Toronto, Los Angeles, Helsinki and London

Alma Lorelei de Jesus[1], Md Mahmudur Rahman[1], Mandana Mazaheri[2], Luke Knibbs[3], Helen Thompson[4] , Greg Evans[5], Cheol Jeong[5] Markku Kulmala[6], Tuukka Petäjä[6], Krista Luoma[6], Hilkka Timonen[7], Jarkko Niemi[8], Roy Harrison[9], David Beddows[10], Constantinos Sioutas[11], Mohammad Hossein Sowlat[11] and Lidia Morawska[1]

[1]International Laboratory for Air Quality and Health, Queensland University of Technology, Brisbane, QLD 4001, Australia
[2]Atmospheric Research Division, Office of Environment and Heritage, Lidcombe, NSW 2141, Australia
[3]School of Public Health, University of Queensland, Herston, QLD 4006, Australia
[4]School of Mathematical Sciences, Queensland University of Technology, Brisbane, QLD 4001, Australia
[5]Southern Ontario Centre for Atmospheric Aerosol Research, University of Toronto, Toronto, ON, M5S 3ES, Canada
[6]Department of Physics, University of Helsinki, FI-00014, Helsinki, Finland
[7]Atmosperic Composition Research, Finnish Meteorological Institute, P.O. Box 503, FI-00101, Helsinki, Finland
[8]Helsinki Region Environmental Services Authority, HSY, FI-00520, Helsinki, Finland
[9]Division of Environmental Health and Risk Management, School of Geography, Earth and Environmental Sciences, University of Birmingham, Edgbaston, Birmingham B15 2TT, United Kingdom
[10]National Centre of Atmospheric Science, School of Geography, Earth and Environmental Sciences, University of Birmingham, Edgbaston, Birmingham B15 2TT, United Kingdom
[11]Department of Civil and Environmental Engineering, University of Southern California, Los Angeles, CA 90089, USA

ABSTRACT

Gaining more knowledge on how different particulate metrics are related would help in successfully controlling particulate matter (PM) concentrations in the ambient air. This study focused on the mass and number concentrations, particularly $PM_{2.5}$ or mass concentration of particles with diameter of <2.5 µm in order to illustrate that mitigating $PM_{2.5}$ would not necessarily reduce the ultrafine particles (UFP) concentration. Particles with diameter <0.1 µm are best quantified by the particle number concentration (PNC). The two parameters, $PM_{2.5}$ and PNC are affected by different drivers, therefore may vary spatially and temporally between cities. $PM_{2.5}$ is relatively more homogenous within an air shed while PNC is more variable depending mainly on the distribution of the combustion emission sources. To better understand these two important metrics and demonstrate their similarities and differences, this study aims to provide quantitative information on the relationship between ambient $PM_{2.5}$ and PNC in four cities: Toronto, Canada; Los Angeles, USA; Helsinki, Finland; and London, UK. All these cities are located in the temperate region though Helsinki and Toronto are classified under Moist Continental Mid-Latitude Climate while London and Los Angeles are classified under Moist Subtropical Mid-Latitude climate based on the Köppen-Geiger system. Urban areas are particularly interesting because high population density implies that considerable amount of anthropogenic pollutants are produced in any city.

One-year hourly averages of $PM_{2.5}$ and PNC were acquired and analysed. Data analysis include: comparing hourly average of $PM_{2.5}$ and PNC using descriptive statistics, statistical models and non-parametric tests; and identifying the factors that drive the relationship. Our results showed that the annual median of $PM_{2.5}$ concentrations for Toronto, Helsinki and London were similar (6.6, 6.9 and

7.8 µg.m^{-3}, respectively) but Los Angeles was a bit higher at 16 µg.m^{-3}. The elevated $PM_{2.5}$ in Los Angeles was due to formation of secondary aerosols influenced by the area's meteorological characteristics according to Hasheminassab et al. (2014). London and Los Angeles had almost the same annual median of PNC (7.2 and 7.3 x 10^3 #.cm^{-3}, respectively) compared to Toronto and Helsinki that were high (1.5 and 1.1 x 10^4 #.cm^{-3}, respectively). This can be attributed to the monitoring site category since it was an urban background station for London and Los Angeles and a roadside station for Helsinki and Toronto; therefore, traffic was directly affecting PNC. The annual medians of both $PM_{2.5}$ and PNC were compared and statistical tests were carried out to assess significant differences between cities. The results indicate significant differences in $PM_{2.5}$ and PNC between cities.

Regardless of the difference in climate, all cities showed similar patterns in the diurnal and seasonal variations. The diurnal trend of the PNC in all cities showed traffic peaks in the morning and evening, which was not the case for $PM_{2.5}$. On the other hand, a seasonal trend was observed for both $PM_{2.5}$ and PNC where concentrations were high during cold months and lower during the warm months. Establishing the relationship between these two parameters is important to determine the more reliable parameter to be used in exposure and epidemiological studies as well as identifying the effective regulatory control measures. There were weak to moderate correlations between $PM_{2.5}$ and PNC across all cities. Therefore, both parameters must be considered in implementing regulatory control measures for ambient PM.

Reference:

Hasheminassab, S., Daher, N., Saffari, A., Wang, D., Ostro, B. D., & Sioutas, C. (2014). Spatial and temporal variability of sources of ambient fine particulate matter (PM2.5) in California. *Atmospheric Chemistry and Physics, 14*(22), 12085. doi:http://dx.doi.org/10.5194/acp-14-12085-2014