Associations between Ultrafine Particles and Co-Pollutant Concentrations in the Tampa Bay Area

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Abstract

Ultrafine Particles (UFP) are ubiquitous in urban air, and recognized risk to human health. The aim of a study is to measure the relationship between ultrafine particles and other ambient air pollutants and meteorological factors in the Tampa Bay area. We measured continuous Ultrafine Particles (UFP), Particulate Matter (PM_{10}), Nitric Oxide (NO), Nitrogen Dioxide (NO_2), Oxides of Nitrogen, (NO_x), Black Carbon (BC), Ozone (O_3), Sulfur Dioxide (SO_2), Ambient Temperature (AT), Wind Speed (WS) and Relative Humidity (RH) during Jan-Mar 2014. We also compared the relationship between Ultrafine Particles and co-pollutants during morning rush hour periods and daily correlation. We found moderate correlation between UFP and BC, NO, NO_x and NO_2 during hourly continuous measurements and rush hours periods, and low level correlation between O_3, SO_2, CO, PM_{10}, AT, WS, RH. It indicated that we should not use co-pollutants as surrogates to assess the human health risk to ultrafine particles exposure.

Introduction

Ultrafine particles are defined as particles with a diameter less than or equal to 100 nanometers (≤ 100 nm or ≤ 0.1 µm) and a component of atmospheric particulate pollution. They are a part of larger particulate air pollutants (PM_{10} and $PM_{2.5}$). Based on their size, ultrafine particles (UFPs) contribute little to the mass concentration of Particulate Matter (PM) in the ambient air but are a dominant contributor of the Particulate Number. Various experimental animal studies suggest that UFPs at high concentrations have the potential to induce airway inflammation. Several epidemiological studies show that ambient particulate pollution is associated with adverse health effects. Atmospheric Ultrafine particles are generated from numerous sources which include the combustion of fossil fuel in motor vehicles, cooking and other anthropological activities such as burning of wood and other biomass. Major sources of UFPs are from motor vehicle emissions in the urban environment. Increases in urbanization and road traffic is anticipated to increase potential UFP population exposures. In addition to the primary source of UFPs in the environment, secondary sources of UFPs are from the photochemical reaction in the atmosphere. Experimental and epidemiological studies also found that adverse health effects are exacerbated in the presence of other pollutants.

Methods

Julian B Lane MS

Davis Island MS

Air quality monitoring data for this study was collected from two (2) air monitoring stations within the City of Tampa, Florida; the well-established Davis Island station and the new Julian B. Lane Park station. These stations are part of the State of Florida Air Monitoring Network, operated and maintained by the Environmental Protection Commission of Hillsborough County (EPC). The Davis Island station is located in an urbanized residential area along the shipping channel on the west side of Port Tampa Bay. Continuous air quality data is collected for ground-level ozone (O_3), sulfur dioxide (SO_2), and particulate matter having an aerodynamic diameter of ten (10) microns or less (PM_{10}). This site was established in 1973 to represent the population exposure to urban air pollution. The JBL Park station was established in January, 2014 pursuant to the federal requirement (40 CFR Part 58, Appendix D) for air monitoring in the near-road environment. In addition to the meteorological station that collects wind speed and direction, ambient temperature and relative humidity data, the site collects continuous air quality data for nitrogen dioxide (NO_2), carbon monoxide (CO), black carbon (BC), and the number of ultra-fine particles (UFP). In order to sample the representative air pollution proximate to a heavily traveled road segment (I-275) in the Tampa, Florida area, the site is located approximately 20 meters south of the elevated roadway. The annual average daily traffic (AADT) counts for this segment of I-275 is 190,500 vehicles per day for 2011.

Results

Table 1: Hourly Atmospheric pollutants parameters in Tampa Bay Region

	Mean	St Dev	Quartile 1 (25th Percentile)	Quartile 3 (75th Percentile)	IQR	Median
Black Carbon (µg/m^3)	1459.5	1286.656	576.05	1975.86	1399.81	1134.59
UFP Number of Particles (n/cm^3)	8188.15	5978.84	3884.77	11397.63	7512.86	7361.44
NOx (PPB)	26.84	22.95	11	37	26	21
NO_2 (PPB)	14.72	8.85	7	21	14	14
NO (PPB)	12.11	16.6	2	15	13	7
CO (PPM)	0.1738	0.19	0.24	0.397	0.149	0.314
RELHUM (PERCENT)	72.354	22.6	59.75	90.8	31.05	77.8
WS (MPH)	4.7	2.64	3	6	3	4
AMBTEMP (DEGC)	17.27	6.03	13.8	21.6	7.8	18.1
O3 (PPB)	25.29	12.75	16	34	18	25
SO2(PPB)	0.844	1.84	0	1	1	1
PM10 (µg/m3)	17.27	12.89	10	23	13	16

Table 2: Rush hours (5AM-8AM) data for atmospheric pollutants

	Mean	St Dev	Quartile 1 (25th Percentile)	Quartile 3 (75th Percentile)	IQR	Median
UFP Number of Particles (n/cm^3)	10853.00241	8614.659	4591.125	14966.986	10375.86101	9682.611
Black Carbon (µg/m^3)	2339.24	1889.396	872.657	3550.0275	2677.37	1894.26
NOx (PPB)	43.73	35.16	17	60	43	36.5
NO_2 (PPB)	18.1	9.283	11	24	13	18
NO (PPB)	25.6305	28.6358	5	35	30	17.5
CO (PPM)	0.4122	0.178	0.273	0.492	0.21875	0.379
RELHUM (PERCENT)	81	20.36	75.5	94.775	19.275	87.95
WS (MPH)	4.05	2.128	2	5	3	4
AMBTEMP (DEGC)	14.61	5.46	11.125	18.85	7.725	15.3
O3 (PPB)	14.32	11.16	3	23	20	13
SO2(PPB)	0.86	3.2	0	1	1	1
PM10 (µg/m3)	18.352	13.23	9	26	17	17

Table 3: Hourly Pearson Correlation Coefficient r, of Ultrafine Particles (UFP)vs. co-pollutants and meteorological factors for the Tampa Bay Area during Jan-Mar 2014 (p values <0.05,95%CI)

All Hours		During Rush Hours (5-8 AM)	
BC	0.735	BC	0.802
NO_2	0.646	NO_2	0.674
NO	0.621	NO	0.737
NO_X	0.6	NO_X	0.776
O_3	0.092	O_3	0.319
SO_2	0.174	SO_2	0.125
CO	0.686	CO	NS*
AT	0.085	AT	0.142
PM10	0.182	PM10	0.224
WS	0.27	WS	0.296

NS*= Not Significant

Conclusion

Several health studies confirmed health effects from atmospheric Ultrafine Particles. Initial studies considered that these particles are mainly generated from automobile exhaust, thus other co-pollutants such as CO, BC, NO, NO_x can be used as surrogates of UFPs to assess the human health effects. In addition, several other studies confirmed that UFPs generated from secondary processes in the atmosphere, similar to the formation of O_3. To assess the use of a surrogate pollutant for UFPs, we analyze the relationship between UFPs and other co-pollutants and meteorological conditions in Tampa Bay area. The results of this study suggest that there is low to moderate relationship between UFPs and other gaseous co-pollutants and meteorological conditions for the daily and morning rush hour (5AM-8AM) during January-March 2014. Our results suggest that other co-pollutants should not be use for monitoring of UFPs either for compliance purposes or in epidemiological studies for health effects.

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