Electronic Supplementary Information

Effectiveness of wearing face masks against traffic particles on the streets of Ho Chi Minh City, Vietnam

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ESI 1. Instrumentation

The mass concentrations of fine particles (≤ 2.5 µm in size, $PM_{2.5}$), equivalent black carbon (eBC), and particle-bound polycyclic aromatic hydrocarbons (pPAHs) were measured using a DustTrak Aerosol Monitor (TSI 8534), Micro-Aethalometer (AethLabs AE51), and Photoelectric Aerosol Sensor (EcoChem Analytics PAS-2000CE), respectively. Particle number concentration (PN) and the aerosols' active surface area (ASA) were measured by a Condensation Particle Counter (TSI 3007) and Diffusion Charging Sensor (EcoChem Analytics DC-2000CE), respectively. A portable logger (HOBO ProV2) was used for measuring temperature (*T*) and relative humidity (*RH*). Table 1 in the main text summarizes the characteristics of each instrument.

ESI 1.1 Instruments preparation and corrections applied during data post-processing

DustTrak Aerosol Monitor - $PM_{2.5}$

The DustTrak Aerosol Monitor measures size-segregated mass fraction particle concentrations with a laser photometer, whose readings depend on the ambient humidity and particle properties, such as size distribution, morphology, and refractive index. We follow the approach of Ramachandran et al. to correct for the humidity effect in the monitor using the *RH* data measured simultaneously.[1]

In a previous study, the response to particle properties of Singapore's tropical atmosphere was evaluated through a gravimetric calibration.[2] Similar to Apte et al.,[3] a power-law regression relationship was obtained from comparisons with 24-h $PM_{2.5}$ concentrations determined by gravimetric analysis of 22 co-located filter samples with concentrations ranging from 10 to 80 µg m^{-3}. Aerosol samples were collected on Teflon

filters (47 mm diameter, 2.0 µm thick; Pall Corporation P/N R2PJ047) using a MiniVol Portable Air Sampler (Airmetrics) fitted with a $PM_{2.5}$ impactor and a flow rate of 5 m^3 min^{-1}. Filters were conditioned in a controlled box (T = 22°C and RH = 32%) before weighing (0.001 mg precision Sartorius MC5 Microbalance). Each filter was weighed three times and the mean weight was taken. Samples with erroneous results due to weighing problems or other issues were rejected. The relationships obtained from this inter-comparison exercise were applied to the collected and humidity-corrected $PM_{2.5}$ data ($y = 2.657x^{0.661}$, $r^2 = 0.84$). For a complete description of the intercomparison procedure see Tan.[4]

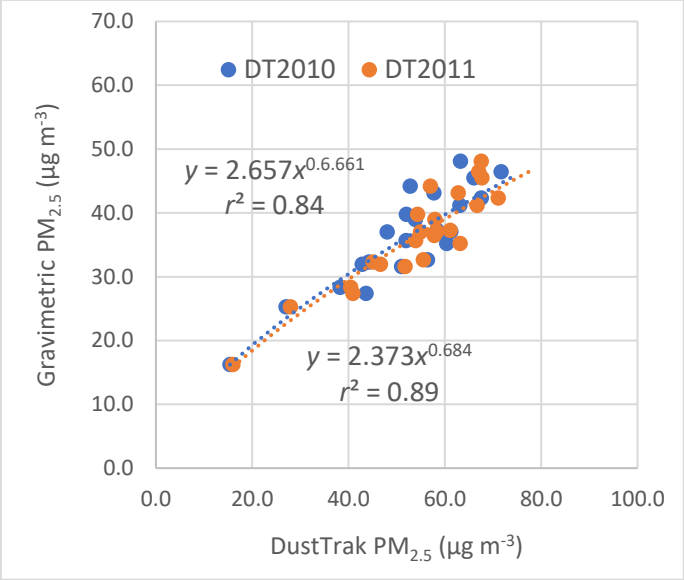

Fig. ESI1. Scatter plot of co-located gravimetric and time-averaged DustTrak $PM_{2.5}$ measurements for the monitor used in this study.

Micro-Aethalometer - eBC

Similarly, the micro-aethalometer eBC readings are sensitive to mechanical shock or vibrations of the instrument. The eBC data were corrected using software based on the Optimized Noise-Reduction on Averaging method available on the manufacturer's website (www.aethlabs.com). This software removes irregular peaks and negative values caused by optical and electronic noise when sampling at a high time resolution (i.e., 1 s) or at low eBC concentration.[5] A second correction was needed to account for the instrument's sensitivity associated with the filter load. Briefly, because eBC concentration is measured by changes in the light attenuation on a disposable filter through which sample air is drawn at 100 cm^3 min^{-1}, concentrations were adjusted using the empirical relationship of Kirchstetter and Novakov based on the attenuation coefficient reported by the instrument along each reading.[6] The micro-aethalometer response was tested against the response of an Aethalometer (Magee Scientific AE33) used as a reference monitor by the Environmental Analysis Laboratory of Mexico City's Secretariat for the Environment since no reference monitor was available in Vietnam.[7] This intercomparison ran during 19 hours, collected data

every minute, and yielded the following relationships for each sensor used in this study: $y = 0.6585x + 0.1402$, $r^2 = 0.97$).

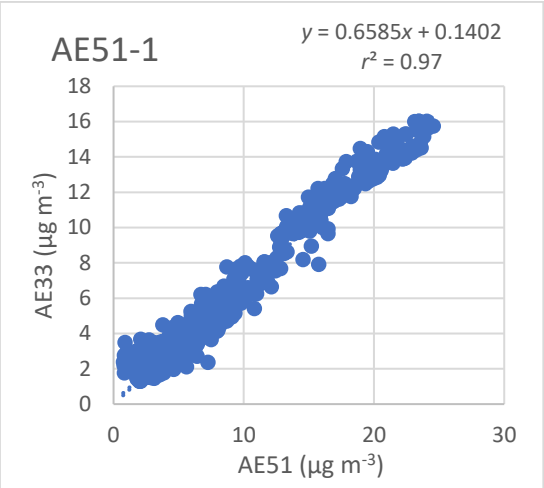

Fig. ESI2. Scatter plot of co-located eBC measurements from an aethalometer AE33 and the micro-aethalometer AE51 used in this study.

Other particle instruments – PN, pPAHs and ASA

Readings of PN, pPAHs and ASA did not require additional corrections. They only passed through a quality data assurance in which suspicious data were removed based on notes taken during sampling (e.g., if the alcohol cartridge inside the Condensation Particle Counter gets dirty or the alcohol level gets low, the internal optical sensor returns erroneous readings). Only concentrations of PN > 100,000 # cm^{-3} were corrected to compensate for particle coincidence effects following the correction proposed by Westerdahl et al.[8]

Similar to the micro-aethalometer response, the response of the Condensation Particle Counter was also evaluated in a previous study in Mexico City.[7] The response of the monitor was tested against the response of an UFP monitor (TSI 3031) whose size threshold was 20 nm, and not 10 nm as for our sensor. A consistent difference of 14-18% was observed, suggesting that it was the fraction of particle counts within the 10-20 nm range during the afternoon period in which the comparison was conducted. No correction relationship was obtained for this monitor.

Instruments preparation

Instruments with removable parts were dismantled and reassembled for each day of sampling in the laboratory, while all instruments were synchronized to a computer clock prior to the measurements. Data post-processing included a second synchronization. The lag time of each instrument was computed through cross-correlations against the DustTrak Aerosol Monitor and adjusted to improve synchronization across all instruments. Lag times ranged from 2 to 20 s. Zero calibration procedures for the Condensation Particle

Counter and DustTrak Aerosol Monitor were carried out before starting each set of measurements.

References

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Table ESI1. Arithmetic mean ± one standard deviation, and median for all variables measured for each individual set of measurements. The PC/DC ratios were obtained from the slopes of the linear-least-square fits to the measurements of pPAHs and ASA, with the *y*-intercept of the line forced through zero. The numbers in parenthesis at the right of the slopes indicate the strength of the relationships through the coefficients of determination (r^2).

	PN (# cm^{-3})	$PM_{2.5}$ (µg m^{-3})	eBC (µg m^{-3})	eBC/$PM_{2.5}$	pPAHs (ng m^{-3})	ASA (mm^2 m^{-3})	PC/DC (ng mm^{-2})	$D_{Aver,S}$ (nm)	CO (ppm)	T (°C)	RH (%)
Site 1 - University gate (10.73346°N, 106.69976°E) - 24/Feb/2016, 7:37 – 9:15 h											
Mean ± SD (median)	96986 ± 30861 (98288)	65.2 ± 12.3 (64.0)	12.1 ± 6.2 (11.2)	0.19 ± 0.09 (0.17)	74 ± 93 (40)	451 ± 260 (367)	0.20 (0.56)	39.5 ± 11.6 (36.9)	24.1 ± 6.3 (22.7)	32.0 ± 1.5 (32.5)	41.0 ± 4.6 (39.5)
25th - 75th	70233 - 124220	56.7 - 71.0	8.0 - 14.6	0.13 - 0.23	21 - 92	276 - 559		32.0 - 43.2	19.3 - 28.8	31.7 - 32.9	37.9 - 42.3
Readings	5148	5940	5673	5673	594	594		515	5940	5940	5940
Site 2 - Nguyen Van Linh and Nguyen Tuu Tho intersection (10.72907°N, 106.70008°E) - 24/Feb/2016, 17:00 – 18:30 h											
Mean ± SD (median)	101763 ± 23988 (104979)	38.1 ± 20.8 (35.0)	18.5 ± 11.3 (15.4)	0.49 ± 0.22 (0.46)	310 ± 191 (258)	540 ± 226 (508)	058 (0.86)	40.9 ± 8.4 (39.6)	21.2 ± 6.6 (20.8)	31.6 ± 0.4 (31.7)	49.1 ± 1.2 (49.0)
25th - 75th	86905 - 120263	25.0 - 46.4	10.4 - 24.0	0.32 - 0.65	179 - 386	386 - 653		35.6 - 44.2	16.6 - 25.4	31.6 - 31.8	48.3 - 49.7
Readings	5350	5449	4520	4509	546	546		535	5460	5460	5460
Site 3 – University's underground motorbike parking lot - 25/Feb/2016, 17:25 – 18:00 h (rush hour)											
Mean ± SD (median)	107601 ±21483 (115064)	108.0 ± 29.6 (103.4)	41.3 ± 28.9 (31.6)	0.38 ± 0.20 (0.31)	1104 ± 1038 (661)	1105 ± 603 (940)	1.14 (0.91)	57.4 ± 21.5 (50.1)	75.6 ± 41.9 (69.0)	31.7 ± 0.2 (31.8)	49.3 ± 1.1 (49.0)
25th - 75th	94809 - 122521	86.5 - 121.9	22.2 - 47.7	0.23 - 0.47	366 - 1474	663 - 1322		42.3 - 64.2	33.7 - 107.3	31.6 - 31.9	48.4 - 50.1
Readings	2100	2100	2034	2034	210	210		210	2100	2100	2100
Site 4 - Le Van Luang Av. (in front of a petrol station) (10.73997°N, 106.70361°E) - 26/Feb/2016, 7:05 – 9:20											
Mean ± SD (median)	108747 ± 24006 (113988)	54.7 ± 17.9 (51.4)	16.2 ± 9.9 (13.8)	0.30 ± 0.17 (0.27)	308 ± 204 (266)	517 ± 187 (495)	0.63 (0.87)	37.8 ± 6.1 (36.8)	22.0 ± 6.5 (21.5)	28.4 ± 1.5 (28.5)	54.8 ± 5.7 (53.7)
25th - 75th	93062 - 129264	44.7 - 60.1	9.6 - 20.2	0.18 - 0.39	171 - 391	391 - 613		33.9 - 40.4	17.5 - 26.0	26.8 - 29.8	49.1 - 60.9
Readings	7188	8160	7956	7956	816	816		719	8160	8160	8160
Site 5 - Tan Quy Ward, Dist. 7 (residential neighborhood) - 26/Feb/2016, 17:15 – 19:19											
Mean ± SD (median)	67644 ± 18565 (66496)	23.4 ± 12.1 (21.6)	4.6 ± 3.5 (4.0)	0.21 ± 0.11	66 ± 89 (46)	206 ± 80 (192)	0.35 (0.51)	31.2 ± 4.7 (30.6)	8.9 ± 1.9 (8.7)	30.5 ± 0.7 (30.8)	57.7 ± 3.2 (56.2)
25th - 75th	53816 - 78482	16.8 - 27.3	3.2 - 5.3	0.14 - 0.26	30 - 66	160 - 231		28.2 - 33.1	7.6 - 10.0	30.4 - 30.9	55.8 - 58.9
Readings	7303	7431	7384	7384	743	743		731	7431	7431	7431
Site 6 - Road 9 - Trung Son, Dist. Binh Chanh boundary with Dist. 7 (modern boulevard) (10.73483°N, 106.68945°E) - 29/Feb/2016, 7:11 – 10:20											
Mean ± SD (median)	72066 ± 28120 (71014)	61.3 ± 12.6 (58.7)	13.2 ± 8.5 (10.8)	0.21 ± 0.11 (0.18)	69 ± 93 (43)	---	---	---	7.4 ± 1.8 (7.1)	28.1 ± 1.5 (27.9)	64.2 ± 5.4 (65.5)
25th - 75th	49931 - 92191	53.4 - 66.3	8.8 - 14.2	0.15 - 0.24	25 - 76	---	---	---	5.9 - 8.5	26.4 - 29.6	59.2 - 69.6
Readings	11209	11270	11132	11121	1115	0	0	0	11281	11281	11281
Site 7 - 23 September Park bus station &Phan Ngu Lao Street (10.76744°N, 106.68990°E) - 29/Feb/2016, 18:15 – 19:15											
Mean ± SD (median)	98129 ± 15580 (96340)	51.7 ± 15.7 (49.5)	20.4 ± 12.3 (17.6)	0.39 ± 0.17	204 ± 102 (183)	385 ± 114 (363)	0.54 (0.89)	35.2 ± 4.5 (34.8)	14.6 ± 2.7 (14.2)	30.0 ± 0.1 (30.0)	56.0 ± 2.5 (56.2)
25th - 75th	86263 - 110891	41.6 - 57.7	12.1 - 25.3	0.27 - 0.48	123 - 263	308 - 434		32.5 - 37.2	12.8 - 16.3	29.9 - 30.1	53.5 - 58.3
Readings	3601	3503	3659	3465	366	366		360	3660	3660	3660
Site #8 - Outside TDU Campus (No masks, only the head with the inlets passing through its nose) – 2/Mar/2016, 16:37 – 18:30											
Mean ± SD (median)	93633 ± 23747 (95429)	56.8 ± 22.5 (52.9)	12.4 ± 8.2 (10.0)	0.23 ± 0.16 (0.18)	201 ± 164 (149)	450 ± 224 (400)	0.46 (0.80)	39.0 ± 10.3 (36.7)	18.3 ± 8.1 (16.6)	30.6 ± 0.7 (30.9)	51.5 ± 3.3 (50.0)
25th - 75th	78626 - 110844	43.6 - 64.8	7.1 - 14.7	0.13 - 0.29	97 - 239	310 - 515		33.0 - 41.9	13.0 - 20.9	30.0 - 31.1	48.8 - 54.4
Readings	6780	6780	6628	6628	678	678		678	6780	6780	6780

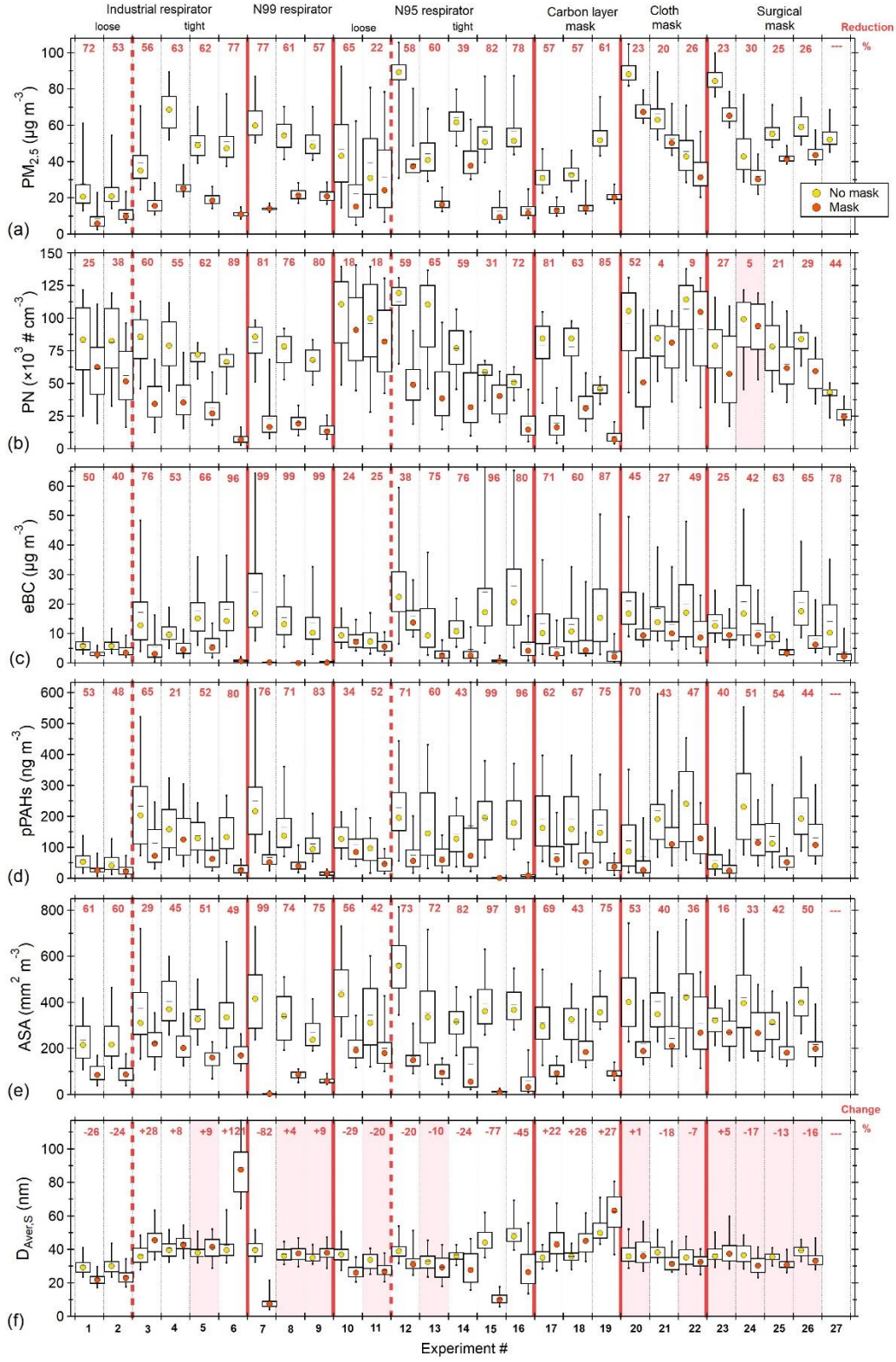

Figure ESI3. Pairs of box plots comparing the particle metrics during the experiments to evaluate the effectiveness of wearing different types of masks. In total 6 types of masks were tested through 27 sets of measurements. Each set included a 10-min test period in which the manikin wore a mask, and two periods of the same length before and after without wearing a mask. The data collected during the latter two periods were combined for the analysis. In each box the thick middle line, top and bottom are arithmetic mean, upper and lower quartile (75th and 25th percentile), respectively, whiskers extend to the 95th and 5th percentiles, and colored dots are medians. Figures in red fonts at the top of each set of measurements for each variable indicate the percentage reduction when wearing masks. For the case of $D_{Aver,S}$, these figures indicate the percentage change for the average size of the particles. Pink shades indicate that no reduction or change statistically significant was observed.