Distribution of particulate matter (PM10) concentration in seven townships of Yangon, Myanmar

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Abstract. Particulate matter (PM) plays a crucial role in air quality deterioration in urban areas. Myanmar is a developing country in Southeast Asia and still in an early phase of urbanization. Yangon is the most populated and urbanized region in Myanmar, hosting 15% of the total population. Reports on particulate pollution in Yangon are limited as well as not up to date. Therefore, the present study aimed to assess distribution of PM10 in Seven Townships of Yangon. The result indicates a significant difference (p<0.001) in PM 10 concentrations among the morning (185±85 µg/m³), the afternoon (64±35 µg/m³) and the evening (129±50 µg/m³) respectively. PM10 concentrations at different times of the day except the morning period were within USEPA guideline value for PM10 (150 µg/m³, 24h mean).

1. Introduction
Particulate matter is the term for a mixture of solid particles and liquid droplets found in the air. PM10 are inhalable particles, with a diameter of ≤10µm, equivalent to one fifth of the diameter of a strand of human hair. PM10 is produced mainly from burning coal, oil, wood and fuel in domestic fires, transportation and industrial processes. Natural sources of particles, including PM10, are sea salt, dust, pollens and volcanic activity. Some of the most common health effects of PM10 include irritation of eyes, throat and lungs [1].

According to WHO (2011) data between 2008 and 2009, populations in countries such as China (150 µg/m³, Lanzhou), South Korea (64 µg/m³, Seoul), Nigeria (122 µg/m³, Lagos), Ghana (98 µg/m³, Accra), Madagascar (68 µg/m³, Antananarivo), South Africa (66 µg/m³, Johannesburg) suffer from high PM10 concentration in ambient air [2]. Exposure to high concentrations of PM can also exacerbate lung and heart conditions, significantly affecting quality of life, and increase deaths and hospital admissions. Children, the elderly and those with predisposed respiratory and cardiovascular disease, are known to be more susceptible to the health impacts from air pollution [3,4,5,6]. The growing awareness of PM10 is largely associated with potential damaging effects on human health. Therefore, we conducted this study for the initial assessment of distribution of PM10 concentration in seven Townships of Yangon, Myanmar. We also reported the monitoring PM2.5 concentration of seven Townships in Yangon City,
Myanmar [7]. This study is a collaborative work between University of Medicine 1, Myanmar and National Institute for Environmental Studies (NIES), Tsukuba, Japan.

2. Materials and Method

2.1. Materials
Pocket PM$_{2.5}$ Sensors (Yaguchi Electric Co., Ltd., Miyagi, Japan) were utilized for measurement of concentrations of PM$_{10}$. This pocket Sensor can measure and display both PM$_{2.5}$ and PM$_{10}$ concentrations at the same time. Principle of Pocket Sensor Module was shown in Figure 1a. The sensor has a laser LED (light-emitting diode), a PD (photodiode) sensor, a fan, amplifier, and USB (Universal Serial Bus) encoder. The sensor can generate log data in CSV (comma-separated values) of Google KML (Keyhole Markup Language) format including GPS (Global Positioning System). The portable sensor has to be connected to a smart phone with android system (Figure 1b). The phone displays PM$_{10}$ concentrations in microgram per cubic meter and phone screen color changes from blue, yellow, red, purple to black with increasing values of PM.

Figure 1. (a) Principle of Pocket PM$_{2.5}$ Sensor Module (adapted from Ishigaki et al., Cyber 2, 2017;11-12.) [8] LED-Light Emitting Diode, PD-Photodiode, USB (Universal Serial Bus), (b) Pocket PM$_{2.5}$ Sensor with a smart phone with android system.

2.2. Sampling Method
This study was carried out for 5 consecutive days (from 25th to 29th January 2018) in winter season. Sampling areas (Hlaing, Hlaingthayar, Kamayut, Kyimyindine, Pazundaung, South-Okkalapa and Tamwe Townships) in Yangon were selected randomly. Locations of seven Townships in Yangon are shown in Figure 2. The investigators walked along the roadsides of these areas for three times a day (7:00h, 13:00h, 19:00h) for 15 min.

Figure 2. Locations of Seven Townships in Yangon.
2.3. Statistical analysis

Data analysis was done by using Statistical Package for Social Science (SPSS) software version 22. Results were expressed as mean ± SD. For comparison of morning, afternoon and evening PM\textsubscript{10} concentrations in each Township, one-way analysis of variance (ANOVA) and post hoc Bonferroni test were used. Statistical significant level was set up at p < 0.05.

3. Results and discussion

The mean PM\textsubscript{10} concentrations of the morning, afternoon and evening of seven Townships were 185±85 µg/m\textsuperscript{3}, 64±35 µg/m\textsuperscript{3} and 129±50 µg/m\textsuperscript{3} respectively. There was a significant difference (p<0.001) in PM\textsubscript{10} concentrations among the morning, afternoon and evening of all studied Townships. The morning period of mean PM\textsubscript{10} concentrations only found exceeded the USEPA guideline value (150 µg/m\textsuperscript{3}, 24h mean) Figure 3.

In each Township, PM\textsubscript{10} concentrations at different times of the day except the morning period of all Townships and Hlaingtharyar evening value were within USEPA guideline value (Figure 4). The maximum value of PM\textsubscript{10} in the morning could be due to the presence of smoke from burning dried leaves and smog in the winter season. Winter is also the time of year when weather conditions that worsen PM\textsubscript{10} concentrations occur – such as settled conditions and temperature inversions (layers of hot air sitting above cooler air near ground level) which restrict the dispersion of pollutants. Conversely, particularly windy and unsettled weather can quickly disperse pollutants, having a beneficial effect on air quality [9].

The mean PM\textsubscript{10} concentrations, minimum, maximum and population density (people/km\textsuperscript{2}) of each seven Townships are shown in Table 1. Among seven Townships, the highest PM\textsubscript{10} concentration in the morning and afternoon was found in Tamwe (288 ± 202 µg/m\textsuperscript{3}, 112 ± 76 µg/m\textsuperscript{3} respectively). This high PM levels might be attributed to unpaved road and construction works around sampling sites. In addition, PM\textsubscript{10} concentrations of both morning and evening were found to be higher than that of afternoon because heavy traffic in sampling area especially during rush hours in the morning and in the evening. Therefore, emissions from increased traffic volumes and roadside mobile food shops opened at the evening may contribute to the evening rise in PM concentrations. Hlaingtharyar had the highest evening concentration (191 ± 70 µg/m\textsuperscript{3}) in which traffic and industry were considered as the main source in the region.
Table 1. PM$_{10}$ concentrations ($\mu$g/m$^3$) of seven Townships of Yangon.

| Township   | Morning(7:00 h) Mean ± SD (Min~Maxi) | Afternoon(13:00 h) Mean ± SD (Min~Maxi) | Evening(19:00 h) Mean ± SD (Min~Maxi) | Population Density (people/km$^2$) | Remark               |
|------------|--------------------------------------|------------------------------------------|---------------------------------------|------------------------------------|----------------------|
| Hlaing     | 136 ± 46$^\Delta$ (76~508)           | 44 ± 12$^*$ (20~79)                      | 103 ± 37$^*$ (49~259)                 | 9,100                              | Residential area     |
| Hlaingtharyar | 257 ± 81$^\Delta$ (150~961)      | 51 ± 23$^*$ (7~114)                     | 191 ± 70$^*$ (70~344)                 | 10,385                             | Industrial area      |
| Kyimyindine | 139 ± 101$^\Delta$ (54~952)         | 46 ± 19$^*$ (13~139)                    | 99 ± 28$^*$ (51~330)                  | 8,955                              | Semi-residential area|
| Kamayut    | 156 ± 51$^\Delta$ (60~337)          | 62 ± 32$^*$ (11~309)                    | 121 ± 50$^*$ (60~917)                 | 12,000                             | Semi-residential area|
| Pazundaung | 140 ± 46$^\Delta$ (50~398)          | 70 ± 38$^*$ (16~453)                    | 135 ± 75$^*$ (46~713)                 | 31,000                             | Residential area     |
| South Okkalapa | 181 ± 71$^\Delta$ (64~649)   | 65 ± 43$^*$ (21~632)                    | 108 ± 39$^*$ (54~642)                 | 19,635                             | Commercial area      |
| Tamwe      | 288 ± 202$^\Delta$ (89~1408)        | 112 ± 76$^*$ (26~835)                   | 149 ± 53$^*$ (67~621)                 | 3,200                              | Residential area     |

Data are presented as mean ± SD, (Minimum ~ Maximum), ANOVA with post hoc: $^\Delta$ morning vs afternoon, $^*$ morning vs evening, $^\Delta$ afternoon vs evening, significant level (p < 0.001). Population density data were obtained from Yangon City Development Committee (http://www.ycdc.gov.mm/).

4. Conclusion

The recognizable ambient particulate pollution of Yangon could be contributed to both man-made and natural sources. In Yangon, air pollution is mainly due to high traffic congestion, unpaved roads, construction, factories, burning of waste and dried leaves and roadside mobile food shops. Yangon should be a starting point to monitor air quality, improve practices and enact air quality management policies. Therefore, routine particulate matter monitoring and control are essential for improving environmental air quality in Yangon. Pocket PM$_{2.5}$ Sensor is found able to record the real time PM concentrations and thus, it should be used for evaluation of distribution of PM in local or specific areas easily and effectively.

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References

[1] World Health Organization 2006 Air Quality Guidelines: Global Update 2005. Copenhagen, Denmark: World Health Organization. Retrieved from [https://www.who.int/phe/health_topics/outdoorair/outdoorair_aqg/en/]
Accessed 12 February 2019

[2] World Health Organization 2011 WHO, Urban outdoor air pollution database.
[http://apps.who.int/gho/data/node.main.154?lang=en]
Accessed 12 February 2019

[3] Zhou M, Liu Y, Wang L, Kuang X, Xu X and Kan H 2014 Particulate air pollution and mortality in a cohort of Chinese men Environ Pollut. 186 1-6

[4] Makri A and Stilianakis NI 2008 Vulnerability to air pollution health effects Int J Hyg Environ Health. 211 326-336

[5] Tam WW, Wong TW, Wong AH, Hui DS 2012 Effect of dust storm events on daily emergency admissions for respiratory diseases Respir. 17 143-148

[6] Valavanidis A, Vlachogianni T, Fiotakis K and Loridas S 2013 Pulmonary oxidative stress, inflammation and cancer: Respirable particulate matter, fibrous dusts and ozone as major causes of lung carcinogenesis through reactive oxygen species mechanisms Int J Environ Res Public Health. 10 3886-3907.

[7] Yi EEPN, Nway NC, Aung WY, Thant Z, Wai TH, Hlaing KK, Maung C, Yagishita M, Ishigaki Y, Win-Shwe T-T, Nakajima D, Mar O 2018 Preliminary monitoring of concentration of particulate matter (PM$_{2.5}$) in seven townships of Yangon City, Myanmar Environ Health Prev Med. 23:53 1-8

[8] Ishigaki Y, Tanaka K, Matsumoto Y, Maruo YY and Pradana HA 2017 Citizen sensing for environmental risk communication, action research on PM$_{2.5}$ air quality monitoring in East Asia Cyber, The 2nd Int. Conference on Cyber-Technologies and Cyber-Systems, Barcelona, Spain. Wilmington: IARIA; 2017. 11-12

[9] Kuschel G, Metcalfe J, Wilton E, Guria J, Hales S, Rolfe K and Woodward A 2012 Updated Health and Air Pollution in New Zealand Study Summary Report Wellington vol 1