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Assessment of ambient dust pollution status at selected point sources (residential and commercial) of Mingaladon area, Yangon region, Myanmar

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Abstract

Purpose – Dust (particulate matters) is very dangerous to our health as it is not visible with our naked eyes. Emissions of dust concentrations in the natural environment can occur mainly by road traffic, constructions and dust generating working environments. The purpose of this paper is to assess the ambient dust pollution status and to find out the association between PM concentrations and other determinant factors such as wind speed, ambient temperature, relative humidity and traffic congestion.

Design/methodology/approach – A cross-sectional study was conducted for two consecutive months (June and July, 2016) at a residential site (Defence Services Liver Hospital, Mingaladon) and a commercial site (Htouk-kyant Junction, Mingaladon) based on WHO Air Quality Reference Guideline Value (24-hour average). Hourly monitoring of PM2.5 and PM10 concentration and determinant factors such as traffic congestion, wind speed, ambient temperature and relative humidity for 24 hours a day was performed in both study sites.

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CW-HAT200 handheld particulate matters monitoring device was used to assess PM concentrations, temperature and humidity while traffic congestion was monitored by CCTV cameras.

Findings – The baseline PM2.5 and PM10 concentrations of Mingaladon area were $(28.50 \pm 11.49)\mu g/m^3$ and $(52.69 \pm 23.53)\mu g/m^3$, means 61.48 percent of PM2.5 concentration and 54.92 percent of PM10 concentration exceeded than the WHO reference value during the study period. PM concentration usually reached a peak during early morning (within 3:00 a.m.-5:00 a.m.) and at night (after 9:00 p.m.). PM2.5 concentration mainly depends on traffic congestion and temperature (adjusted $R^2 = 0.286$), while PM10 concentration depends on traffic congestion and relative humidity (adjusted $R^2 = 0.292$). Wind speed played a negative role in both PM2.5 and PM10 concentration with $r = -0.228$ and $r = -0.266$.

Originality/value – The air quality of the study area did not reach the satisfiable condition. The main cause of increased dust pollution in the whole study area was high traffic congestion ($R^2 = 0.63$ and 0.60 for PM2.5 and PM10 concentration).

Keywords Myanmar, Air quality, Relative humidity, Ambient temperature, Particulate matters, Traffic congestion

Paper type Short report

Introduction

Emissions of dust in the environment can occur in many ways. Above all of that, a large proportion of emissions results from road traffic, constructions and dust generating working environments. In terms of effects, the above causes increase long-term particulate matters, PM2.5 and PM10 concentration, which have negative effects on human health. Exposure to PM10 and PM2.5 concentration has long been associated with a range of health effects. High levels of PM2.5 and PM10 affect pulmonary function and exacerbate respiratory problems in respiratory compromised people, i.e. asthmatics. Dockery and Pope[1] reported that there was a strong association between high concentration of particulate matters in the air and mortality rates in six cities in the USA. On the other hand, smog in London in 1873 killed up to 500 people suffering severe respiratory problems. It is estimated that ambient (outdoor) air pollution in both cities and rural areas caused 3.7 million premature deaths worldwide in 2012. Health effects of particulate matters include acute respiratory diseases like bronchitis, chronic fibrosis, emphysema, bronchopneumonia and higher incidence of cough, shortness of breath, bronchitis, colds of long duration and fatigue. Particulate matters have also affected human health causing variety of problems including premature death in people with lung disease, aggravated asthma, decreased lung function and increased respiratory symptoms, such as irritation of the airways, coughing or difficulty in breathing. In Myanmar, air pollution is far more within the acceptable condition. A previous study[2] suggested that 90 percent of air in Myanmar is polluted. Air pollution is increasing every day and proper measures to control it need to be taken before everybody's health is in danger. The study also found that in Yangon (the economic capital of Myanmar), the dust pollution mainly comes from cars and roads. They emit dust and coarse particles into the air which can cause ambient dust pollution. Yangon region is the most vulnerable area of dust pollution in Myanmar. Considering local situation, 468,000 of total 3,987,962 motor vehicles in Myanmar are being used in Yangon region[3]. According to the Department of Immigration (September 2016), Mingaladon township is the third most crowded area of Yangon region in population density ($3{,}043/km^2$). This study aimed to assess the ambient dust pollution condition in selected point areas (residential, commercial and industrial) of Mingaladon area, Yangon region, Myanmar to find out the association between PM concentration and its determinant factors (traffic congestion, wind speed, ambient temperature and relative humidity).

Materials and methods

This cross-sectional descriptive study illustrates information from January to December 2016 in Mingaladon area, Yangon, Myanmar. The ambient particulate matter (PM2.5 and PM10) concentrations were assessed hourly for 24 hours a day for total 61 days during the data collection period (from 1 June, 2016 to 31 July, 2016). PM concentrations were assessed in two representative areas of Mingaladon: residential area (Defence Services Liver Hospital) and the commercial area (Htouk-kyant Junction). The main variables of interest to this study were PM2.5 and PM10 concentrations and the other determinant variables were wind speed, traffic congestion, ambient temperature and relative humidity.

Monitoring PM2.5 and PM10 concentrations

CW-HAT200 handheld particulate matters monitoring device was used to determine PM2.5 and PM10 concentrations, ambient temperature and relative humidity.

Data collection tools for traffic congestion and other determinant factors

Traffic congestion (vehicles/hour) was monitored by CCTV cameras and wind speed data were received from the Department of Meteorology and Hydrology, Yangon.

Data management and analysis

Data management and analysis was performed by using SPSS version 16.0. The relationship between PM concentrations and the determinant factors were calculated by using multiple linear regression based on the multivariate analysis. Then, prediction models for PM2.5 and PM10 concentrations were applied by this study in the following equation:

$$y = a + b_1x_1 + b_2x_2 + b_3x_3$$

Results

PM2.5 concentrations (24-hour mean) for residential and commercial area were $(23.60 \pm 10.13)\mu g/m^3$ and $(33.40 \pm 10.64)\mu g/m^3$, respectively, while PM10 concentrations (24-hour means) were $(42.93 \pm 21.90)\mu g/m^3$ and $(62.46 \pm 20.90)\mu g/m^3$, respectively (Table I). WHO air quality reference guideline for 24-hour means was $25\,\mu g/m^3$ for PM2.5 and $50\,\mu g/m^3$ for PM10.

For accuracy reason, PM2.5 and PM10 concentrations in Mingaladon area during the study period were 61.48 percent and 54.92 percent, respectively, which exceeded the WHO reference guideline value (Figure 1). The main influencing factor for the PM concentration was traffic congestion ($p < 0.001$). Relative humidity was positively correlated with PM10 concentrations with $P < 0.001$ (Table II), but not statistically significant with PM2.5 ($p = 0.342$), (Table III) whereas the ambient temperature and the wind speed were found to be negatively correlated with both PM2.5 ($p < 0.001$) and PM10 concentrations ($p < 0.001$), (Tables II and III).

PM2.5 concentration in the residential area started at $25\,\mu g/m^3$ during the interval of 12-1 a.m., followed by mild fluctuation of $30\,\mu g/m^3$ until 7-8 a.m. Between the period of 8-9 a.m. and 3-4 p.m., PM2.5 concentration was within the value of 10-20 $\mu g/m^3$. After that,

Table I. Overall status of the variables for the whole area

Variables	Means (SD) Residential area	Commercial area	Total average
Wind speed (km/hour)	7.36 (4.01)	7.05 (3.45)	7.21 (3.74)
Traffic congestion (vehicle/hour)	355.23 (171.37)	1,964.40 (1,020.50)	1,159.81 (1,087.56)
Temperature (°C)	27.55 (1.53)	27.20 (1.56)	27.38 (1.56)
Humidity (%)	89.25 (7.71)	87.46 (8.59)	88.35 (8.21)
PM2.5, 24-hour mean ($\mu g/m^3$)	23.60 (10.13)	33.40 (10.64)	28.50 (11.49)
PM10, 24-hour mean ($\mu g/m^3$)	42.93 (21.90)	62.46 (20.90)	52.69 (23.53)

Notes: WHO Air Quality Reference Guideline for 24-hour mean: $25\,\mu g/m^3$ for PM2.5 and $50\,\mu g/m^3$ for PM10 there was a dramatic increase of 24 μg/m^3 during 4-5 p.m. and then PM2.5 concentration fluctuated by 20-30 μg/m^3 during the rest of the day. PM10 started at 44 μg/m^3 during 12-1 a.m. It reached a peak thrice during 2-3 a.m., 5-6 a.m. and 8-9 p.m., respectively. It is noted that PM10 concentrations in the other hours were between 24 and 55 μg/m^3 (Figure 2).

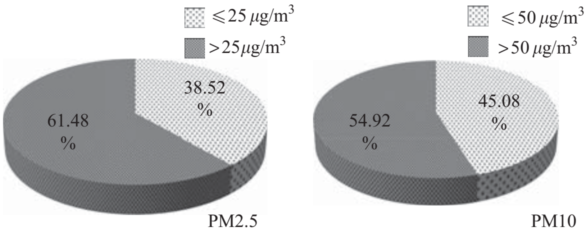

Figure 1. PM2.5 and PM10 concentration compared to WHO reference guideline value for 24-hour mean in the whole study area

Variables	β coefficient	R^2	95% CI Lower bound	95% CI Upper bound	p-value
Wind speed (km/hour)	−1.670	0.071	−1.889	−1.450	< 0.001**
Vehicle/hour (vehicle)	0.008	0.145	0.008	0.009	< 0.001**
Temperature (°C)	−2.100	0.019	−2.643	−1.558	< 0.001**
Humidity (%)	0.280	0.010	0.177	0.384	< 0.001**

Note: **Significant at p-value (0.05)

Table II. Relationship between PM10 concentration and determinant factors

Variables	β coefficient	R^2	95% CI Lower bound	95% CI Upper bound	p-value
Wind speed (km/hour)	−0.701	0.052	−0.808	−0.592	< 0.001**
Vehicle/hour (vehicle)	0.004	0.176	0.004	0.005	< 0.001**
Temperature (°C)	−0.763	0.011	−1.029	−0.497	< 0.001**
Humidity (%)	0.025	0.000	−0.026	0.075	0.342

Note: **Significant at p-value (0.05)

Table III. Relationship between PM2.5 concentration and determinant factors

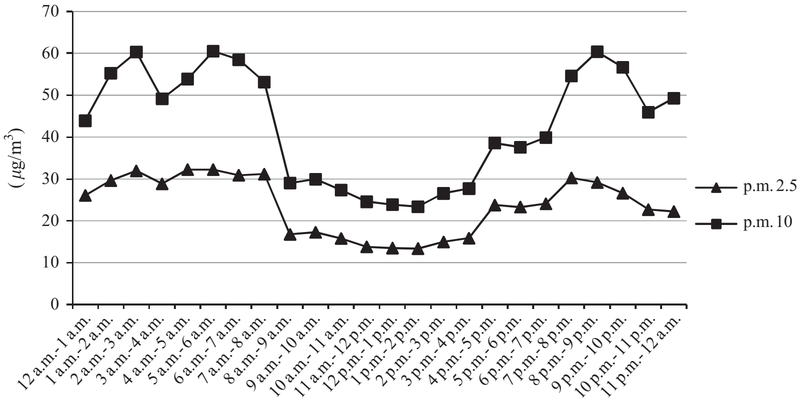

Figure 2. Trend of mean PM2.5 and PM10 concentrations in the residential area (DSLH) during the study period

In case of PM2.5 and PM10 concentrations in the commercial area, PM2.5 concentration was 30 $\mu g/m^3$ from the start of the day till 3-4 p.m. Then, there was a sharp increase during 4-5 p.m. which is followed by a gradual decrease until 30 $\mu g/m^3$ at the end of the day (Figure 3). Overall, the ranges of PM2.5 and PM10 concentrations in the commercial area were 27-45 and 47-80 $\mu g/m^3$, respectively.

Regression model for PM2.5 concentration

$$y = a + b_1x_1 + b_2x_2 + b_3x_3$$

where y = PM2.5 concentration; a (constant) = 45.040; $b_1 = -0.917$; x_1 = wind speed; $b_2 = 0.005$; x_2 = vehicle/hour; and $b_3 = -0.587$; x_3 = temperature.

(Note: relative humidity is not statistically significant for PM2.5 with $p = 0.342$ (Table II) and, therefore, not considered as one of the determinant factors for PM2.5 concentration in the construction of a regression model), see Table IV.

Regression model for PM10 concentration

$$y = a + b_1x_1 + b_2x_2 + b_3x_3$$

where y = PM10 concentration; a (constant) = -18.378; $b_1 = -1.972$; x_1 = wind speed; $b_2 = 0.011$; x_2 = vehicle/hour; $b_3 = 0.587$; x_3 = relative humidity.

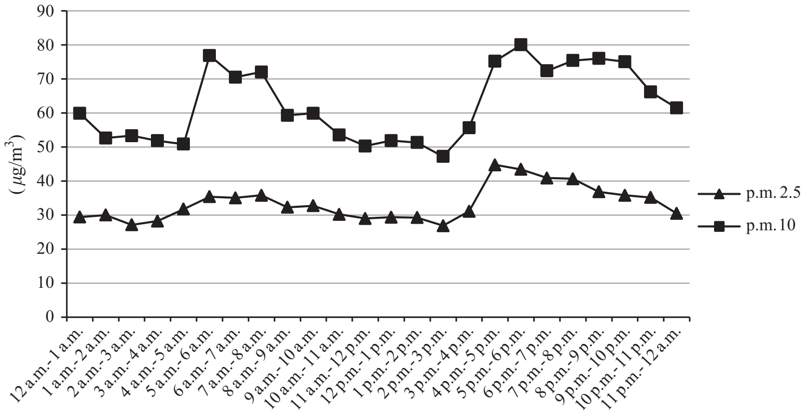

Figure 3.
Trend of mean PM2.5 and PM10 concentrations in commercial area (Htouk-kyant Junction) during the study period

Table IV.
Relationship between PM2.5 concentration and determinant factors based on multivariate analysis using multiple linear regressions

				95% CI		
Variables (unit)	β coefficient	Constant	Adjusted R^2	Lower bound	Upper bound	p-value
Wind speed (km/hour)	−0.917	45.040	0.286	−1.023	−0.810	< 0.001**
Traffic congestion (vehicle/hour)	0.005			0.005	0.006	< 0.001**
Temperature (°C)	−0.587			−0.844	−0.330	< 0.001**

Note: **Significant at p-value (0.05)

(Note: temperature is not statistically significant for PM10 with $p = 0.059$ and, therefore, not considered as one of the determinant factors for PM2.5 concentration in the construction of a regression model, see Table V).

Therefore, x_3 is presented as relative humidity in the regression model for PM10 but temperature for PM2.5.

Discussion

Concerning the assessment of PM concentration, the meteorological factors such as wind speed, traffic congestion, ambient temperature and humidity are the most important considerable determinant factors[4-13].

PM2.5 and PM10 concentrations

The total 24-hour mean concentrations of PM2.5 and PM10 for the whole study area during the study period were $(28.50 \pm 11.49)\mu g/m^3$ and $(52.69 \pm 23.53)\mu g/m^3$, respectively (see Table I). Both exceeded WHO reference guideline value for PM concentrations ($25\,\mu g/m^3$ for PM2.5 and $50\,\mu g/m^3$ for PM10 concentration). In other way round, more than 60 percent of PM2.5 concentrations in 24-hour means was found to be beyond the WHO reference guideline value, while PM10 concentration was 54.92 percent (see Figure 3).

Wind speed and particulate matter (PM2.5 and PM10) concentrations

Charron and Harrison[14] showed that lower wind speeds favor high PM2.5 concentrations and stronger wind speeds favor high PM10 concentrations. In addition, Tahir and Yousif[15] found that high wind speed (⩾15 km/hour) made a definite trend between PM concentration and relative humidity. In this study, stronger wind speed (⩾15 km/hour) made a decreasing trend in PM10 concentration, whereas lower wind speed (⩽14 km/hour) made an increase trend in PM2.5 concentration.

This may be due to the fact that particulate matters are easily carried by the wind to other places outside the environment of study areas as they have a very tiny particulate mass. Therefore, it can be concluded that if there is more wind speed, the less PM concentration would be assessed in this study.

Traffic congestion and particulate matters

The total mean number of traffic congestion (vehicle per hour) in this study area during the study period was 1,160 (Table I) which consisted of 355 and 1,964 vehicles per hour for residential and commercial area, respectively. Generally, residential area had low traffic flow compared to commercial area. Traffic congestion was lowest during 3-4 a.m., and then peaked during the rush hours. The total volume of the two areas (both residential and commercial) peaked thrice during 9-10 a.m., 5-6 p.m. and 8-9 p.m. Ghandehari's study[10] also reported that the above-mentioned times were also the times of peak traffic congestion, which are identical to the times within this study. It is because Mingaladon township is

Variables (unit)	β coefficient	Constant	Adjusted R^2	95% CI Lower bound	95% CI Upper bound	p-value
Wind speed (km/hour)	−1.972	−18.378	0.292	−2.190	−1.755	< 0.001**
Traffic congestion (vehicle/hour)	0.011			0.010	0.012	< 0.001**
Temperature (°C)	0.750			−0.029	1.529	0.059
Humidity (%)	0.587			0.435	0.738	< 0.001**

Note: **Significant at p-value (0.05)

Table V. Relationship between PM10 concentration and determinant factors based on multivariate analysis using multiple linear regressions situated between downtown area of Yangon city and other townships such as Hmaw-bi, Taik-kyi, Hle-gu, Inn-da-gaw and In-dine, from where people come to Yangon through the Mingaladon township (the study area) for various purposes. Furthermore, semi-urban areas such as Shwe-pyi-thar and Hlaing-thar-yar township are in vicinity with Mingaladon. As Yangon has a lot of work opportunities, many people and many vehicles (mainly buses) from the above areas pass through the Mingaladon area to attend their daily chores. This is the reason why there was huge traffic congestion during the rush hours.

In this study, the mean PM2.5 and PM10 concentrations for the whole study area (both residential and commercial area) during 9-10 a.m., 5-6 p.m. and 8-9 p.m. were 25 and 45 $\mu g/m^3$, 33 and 59 $\mu g/m^3$, and 33 and 68 $\mu g/m^3$, respectively, which might be recognized as a high PM concentration level for PM2.5 and PM10 concentrations. In addition, R^2 value of traffic congestion (vehicle per hour) for PM2.5 and PM10 is 0.18 and 0.15, respectively; thus, the traffic congestion was the most determinant factor than other factors for PM concentrations.

Ambient temperature, relative humidity and PM concentration

The ambient temperature during the study period ranged from 24-33°C. The highest magnitudes of temperature were usually seen during 12-1 p.m. in the afternoon and 4 p.m.-5 p.m. in the evening in this study. In addition, the traffic congestion during these times was also the highest.

Relative humidity was positively correlated with both PM2.5 and PM10 concentration in the residential area but not in the commercial area. It may be due to the differences between the topography of each area. In the residential area, the percentage of trees was constituted nearly half of the total area, favoring higher humidity. Tahir and Yousif[15] reported that the relative humidity under the trees was significantly higher than relative humidity in the bare land as well. For the corresponding place, the commercial area, it was totally plateau in nature with free airflow way. Therefore, humidity in the commercial area was relatively lower than in the residential area. This means that the variable, relative humidity, served as one of the main determinant factors for PM concentration in the residential area but not in the commercial area.

PM concentration and meteorological factors in residential and commercial area

Comparing residential and commercial area, the determinant variables such as wind speed, ambient temperature and relative humidity were nearly the same, while traffic congestion in commercial area was five times more than the residential area. This is why traffic congestion was the variable of the highest correlation to PM concentration in the commercial area ($r = 0.43$ and 0.42 for PM2.5 and PM10 concentrations, respectively). Künzli *et al.*[16] reported that traffic congestion is the main cause of air pollution which is bad peoples' health.

Conclusion

According to the Air Quality Guidelines-Global Update 2005, the highest concentrations of PM10 were reported from developing countries of Asia[17]. This region also experiences relatively high background concentrations owing to forest fires and local emissions of particles from the use of poor-quality fuels. Actually, particulate matters are too small to be noted because of its tiny size in aerodynamic diameter. At present, in Myanmar, one of the developing countries, the National Air Quality Guideline has not been developed yet.

This study was intended to assess the dust pollution status of the residential and commercial areas of Mingaladon Township, Yangon region. It was found that both PM2.5 and PM10 concentrations in these two areas exceeded the WHO reference guideline value. The main cause of these results was mostly due to high traffic congestion ($R^2 = 0.63$ and

0.60 for PM2.5 and PM10 concentration, respectively). According to the study, about 1,160 vehicles which consisted of 355 and 1,964 vehicles per hour, respectively, for residential and commercial area passed through every hour in the study area during the study period. It cannot be denied that an increase in traffic congestion increases PM concentration level and thus exacerbate the risks of various diseases to human health. In addition, there was just a small amount of natural conditions (trees, ponds and green areas) which prevent the dust pollution.

Another important factor was that lack of green environment intensifies higher ambient temperature. Based on the analysis, the PM concentration in the Mingaladon area will increase when there is high traffic congestion and relative humidity. But, if there is high wind speed, the PM concentrations in Mingaladon will be decreased and vice versa.

Weakness of the study

Many recent studies worldwide for the air quality assessment were performed by using the most reliable and appropriate instruments such as Environmental Perimeter Air Monitoring Station which is very expensive. This study was an individual thesis and, thus, there was no organization for financial support and no readily accessible appropriate instrument. Therefore, CW-HAT200 handheld monitoring devices had been used for the assessment of the PM concentration in this study according to the feasibility.

Data collection period was between May and July which was the period of monsoon in Myanmar. So, the studied results will represent only the data during monsoon. It does not cover condition of the whole year as well as seasonal variations.

The last thing is that there is no guideline value for the air quality standard yet in Myanmar. Therefore, the results were compared with WHO reference guideline value. Actually, it would be more appropriate if the resulted values were being compared and contrasted with Regional Air Quality Reference Guideline Value.

Strength of the study

The monitored results of particulate matters obtained from the study area were mostly valid and reliable compared to the results from the similar study by using sophisticated air quality monitoring stations.

Moreover, there had been no study on dust pollution assessment performed continuously for two consecutive months in Mingaladon like this study. Therefore, at the time of publishing the findings of this study, government’s awareness on the ambient dust pollution will be expected to increase so that further research works and environmental sanitation programs can be explored.

Limitation of the study

Actually, the study area we selected first was another place which comprises with the places of really congested commercial area and really silent residential area. However, because of unfavorable circumstances and unavoidable conditions, this study had to be done in Mingaladon area.

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