Variation of PM$_{10}$ from Urban, Sub-Urban and Industrial Areas of Perak, Malaysia

Helmiah Abdul Razak and Nurul Bahiyah Abd Wahid

Department of Biology, Faculty of Science and Mathematics, Universiti Pendidikan Sultan Idris, 35900 Tanjung Malim, Perak, Malaysia

Abstract: PM$_{10}$ is the most common air pollutant emitted into the atmosphere that contributes to poor air quality in most of the big cities in Malaysia. Objective: This study aimed to analyse the trends of PM$_{10}$ concentration in urban, sub-urban and industrial areas of Perak, Malaysia. Materials and Methods: Data collected were obtained from the Malaysian Department of Environment (DOE) on a 24 h basis and were statistically analysed using XLSTAT software. Results: Result indicated that the highest concentration of PM$_{10}$ was detected from urban areas, followed by industrial and sub-urban areas. The level of PM$_{10}$ increased sharply during October for all monitoring stations studied. Strong winds had transported the PM$_{10}$ from biomass burning, possibly contributed to higher amounts of PM$_{10}$ in Perak during the southwest monsoon. Analyses of daily average data indicated that PM$_{10}$ concentrations had exceeded the RMAAQG (150 µgm$^{-3}$) for all monitoring stations during the haze episode, with Ipoh showing the maximum value (296 µgm$^{-3}$). Conclusion: In conclusion, the distribution of PM$_{10}$ concentration is crucial for creation of effective mitigation strategies to maintain a good air quality in Perak.

Key words: Air quality Particulate matter PM$_{10}$ Haze Meteorological factors

INTRODUCTION

Air pollution is one of the most pressing global environmental problems that threaten the well-being of living organisms, human health and the environment. It has been a serious issue that needs immediate and serious attention by all relevant authorities since it has been widely recognized problems over the last 50 years [1, 2]. Particulate matter (PM) is one of the most common air pollutants found in the atmosphere appear as black soot, dust clouds or grey hazes. Previous study [1, 3, 4] shows that PM contribute to severe air quality problems in the atmosphere and used to monitor the level of environmental pollution. Recent finding on human health impacts by the exposure to PM with aerodynamic diameter of 10 µm or less (PM$_{10}$) include pulmonary and systemic inflammation, oxidative stress, heart disease and premature death along with a rise in mortality [5, 6, 7, 8].

In Malaysia, the Department of Environment (DOE) is responsible to monitor the quality of air through several air monitoring station. Rapid urbanization due to economic development, might change the physical environment of the city. In Perak, Malaysia, urbanization has led to the increased of population which resulted to the increased of vehicles and thus, causes heavy traffic. Severe air quality problems has exist in highly urbanized areas particularly attributed to motor vehicles emission as the major source of air pollution in urban areas in most of the cities in Malaysia including Ipoh [1, 2, 9, 10]. Stationary sources including power plants, industrial waste incinerators, cement and quarry industries and large emission of road dust along with open burning are also contribute to the level of PM$_{10}$ in Malaysia [1, 5, 11].

This study aims to explore the trend of PM$_{10}$ within the three selected air quality monitoring stations with difference background in Perak, Malaysia. The trend was assessed based on one year database. The air quality database was compared to the Recommended Malaysian Ambient Air Quality Guidelines (RMAAQG) and its correlation with other air quality parameter was also assessed. In addition, this study interpolates the influence of wind on the PM$_{10}$ concentrations, particularly during the haze episode.
MATERIALS AND METHODS

**Sampling Site:** Three continuous air quality monitoring stations in Perak were selected. These stations were selected based on their different background and data availability throughout the year. Taiping (S1) lays in the areas with heavy industrial and quarry activities. Meanwhile, Tanjung Malim (S2) is located in sub-urban areas surrounded by natural forest and agricultural activities. The third location, Ipoh (S3) is an urban area, located in the northern region of the Malaysian Peninsular. This station is also surrounded by residential area with heavy traffic as well as industrial and commercial activities. Based on DOE report, most of the time the overall status of air quality in Malaysia are within good and moderate levels [4]. There are no major natural disasters such as typhoon, volcanic eruption and earthquake happened in this study areas. Fig. 1 illustrates the locations of the sampling stations, while the details of the air quality monitoring stations are tabulated in Table 1.

**Data Collection:** A one-year data was used in this study. Data were gathered from the continuous air quality monitoring stations managed by a company, Alam Sekitar Sdn. Bhd. (ASMA) for Malaysian Department of Environment (DOE). ASMA used BAM-1020 Beta Attenuation Mas Monitor from Met One Instrument, Inc.

Fig. 1: Locations of air quality monitoring stations in Perak, Malaysia

<table>
<thead>
<tr>
<th>Station ID</th>
<th>Station Location</th>
<th>Background Area</th>
<th>Coordinates</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Sek. Keb. Air Puteh, Taiping</td>
<td>Industrial</td>
<td>5.9733° N, 100.4592° E</td>
</tr>
<tr>
<td>S2</td>
<td>Universiti Pendidikan Sultan Idris (UPSI), Tanjung Malim</td>
<td>Sub-urban</td>
<td>3.6850° N, 101.5241° E</td>
</tr>
</tbody>
</table>
Table 2: Recommended Malaysian Ambient Air Quality Guidelines

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Averaging time</th>
<th>Malaysian Ambient Air Quality Standard</th>
<th>ppm</th>
<th>(µg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particulate Matter (PM₁₀)</td>
<td>24 Hours</td>
<td>-</td>
<td>-</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td>12 Months</td>
<td>-</td>
<td>-</td>
<td>50</td>
</tr>
<tr>
<td>Ozone (O₃)</td>
<td>1 Hour</td>
<td>0.10</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8 Hours</td>
<td>0.60</td>
<td>120</td>
<td></td>
</tr>
<tr>
<td>Carbon Monoxide (CO)</td>
<td>1 Hour</td>
<td>30.0</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8 Hours</td>
<td>9.0</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Nitrogen Dioxide (NO₂)</td>
<td>1 Hour</td>
<td>0.17</td>
<td>320</td>
<td></td>
</tr>
<tr>
<td></td>
<td>24 Hours</td>
<td>0.04</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>Sulphur Dioxide (SO₂)</td>
<td>1 Hour</td>
<td>0.13</td>
<td>350</td>
<td></td>
</tr>
<tr>
<td></td>
<td>24 Hours</td>
<td>0.04</td>
<td>105</td>
<td></td>
</tr>
<tr>
<td>Total suspended particulate (TSP)</td>
<td>24 Hours</td>
<td>-</td>
<td>260</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12 Months</td>
<td>-</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>Lead (Pb)</td>
<td>3 Months</td>
<td>-</td>
<td>1.5</td>
<td></td>
</tr>
</tbody>
</table>

Source: Department of Environment (DOE, 2010)

USA to monitor PM₁₀ in (µgm⁻³) based on the Standard Operating Procedures for Continuous Air Quality Monitoring [13]. The data was compared with RMMAAQG as presented in Table 2. In this study, four air quality parameters were analysed; particulate matter (PM₁₀), carbon monoxide (CO), nitrogen dioxide (NO₂), sulphur dioxide (SO₂).

Data Analysis: In this study, PM₁₀ concentrations were statistically analysed using XLSTAT 2017 software in order to correlate with other selected gaseous (CO, NO₂ and SO₂). In addition, backward trajectory analysis was performed using the Hybrid-Single Particle Lagrangian Integrated Trajectory (HYSPLIT) model, to determine the origin of wind to selected monitoring stations. This model was used to calculate the 72 h backward trajectories for each sampling sites during the highest amount of air pollutants recorded (haze episode).

RESULTS AND DISCUSSION

The profile of the air particulate can be measured continuously over a period of times. Fig. 2 illustrates the trend of PM₁₀ based on monthly data for all selected monitoring stations. The results indicated that the highest concentration of PM₁₀ was recorded in the urban areas, with value of 116 µgm-3 followed by industrial (101 µgm⁻³), while the lowest concentration was recorded at sub-urban areas (94 µgm⁻³). High concentrations of PM₁₀ in urban areas might be due to Ipoh as the capital city of Perak and the hub of many administrative and businesses activities. Moreover, Ipoh also indicates a high population which possibly contributes to the heavy traffic congestion from the residential area [14]. This finding is coincident with other previous studies in which urban areas have higher PM₁₀ concentrations than other areas [1, 4, 15].

Tropical conditions with heavy rain, different temperatures and humidity may affect the level of PM₁₀ in the atmosphere. The results demonstrated the peak value of PM₁₀ concentration towards the end of the year mainly in September and October for all monitoring stations. The wind from dry southern monsoon season during June to October [16] possibly transported the PM₁₀ released from biomass burning in the neighboring country to Malaysia [9, 17] may contributes to a highly amount of PM₁₀ in Perak. It is likely that the distribution of air pollutant was influenced by this monsoon as suggested by other studies [16, 18]. Besides that, during November, the amounts of PM₁₀ in all stations were decreased sharply due to heavy rainfall. This might be due to the rain water carried away most of the amount of air particulates from the atmosphere [19].

Fig. 3 shows the daily average trend of PM₁₀ during October 2015, as October shows the highest level of PM₁₀ throughout the year for all monitoring stations studied. Result indicated that the concentration of PM₁₀ at all monitoring stations had exceed the Recommended Malaysian Ambient Air Quality Guidelines (RMMAAQG) which is 150 µgm⁻³ several times during this month. On 21st October, the PM₁₀ reach the peak with highest reading (296 µgm⁻³) in urban station (S3).

Backward trajectories using HYSPLIT was performed for S3, clearly showed that most of the wind comes from Sumatra as shown in Fig. 4. This finding is similar with other previous studies [5, 16, 20] where most of the wind flow from haze phenomena at neighboring country during southwest monsoon had transported huge amount of air pollutant to Malaysia.
Correlation Between PM$_{10}$ and Other Gaseous Pollutants: The correlation between PM$_{10}$ concentration and selected pollutants were calculated for the entire data sets and presented in Table 3. Result showed that there was a positive correlation between PM$_{10}$ and other pollutants. It turns out that the CO value recorded the strongest relation with the concentration of PM$_{10}$ with $0.603$ followed by NO$_2$ and SO$_2$. This was expected due to combustion processes, particularly originating from motor vehicles as also discussed by [15, 17, 21, 22] in which mobile emission are characterized by high concentration of CO and NO$_2$. In addition, haze phenomena from neighboring country were also contributed to high amount of air pollutants in the study area.
CONCLUSION

This study indicated that the highest concentration of PM$_{10}$ was detected from urban area, followed by industrial and sub-urban areas. October 2015 showed the highest peak of PM$_{10}$ for all monitoring stations. HYSPLIT analysis illustrated that the wind flows from other country during transboundary haze. This study suggests that anthropogenic sources have contributed to high amount of PM$_{10}$ in the atmosphere. Due to the potential of PM$_{10}$ in influencing health risk, the level of PM$_{10}$ should be monitored regularly in order to maintain a healthy environment of Perak.

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