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Variation of PM_{10} from Urban, Sub-Urban and Industrial Areas of Perak, Malaysia

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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.

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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.

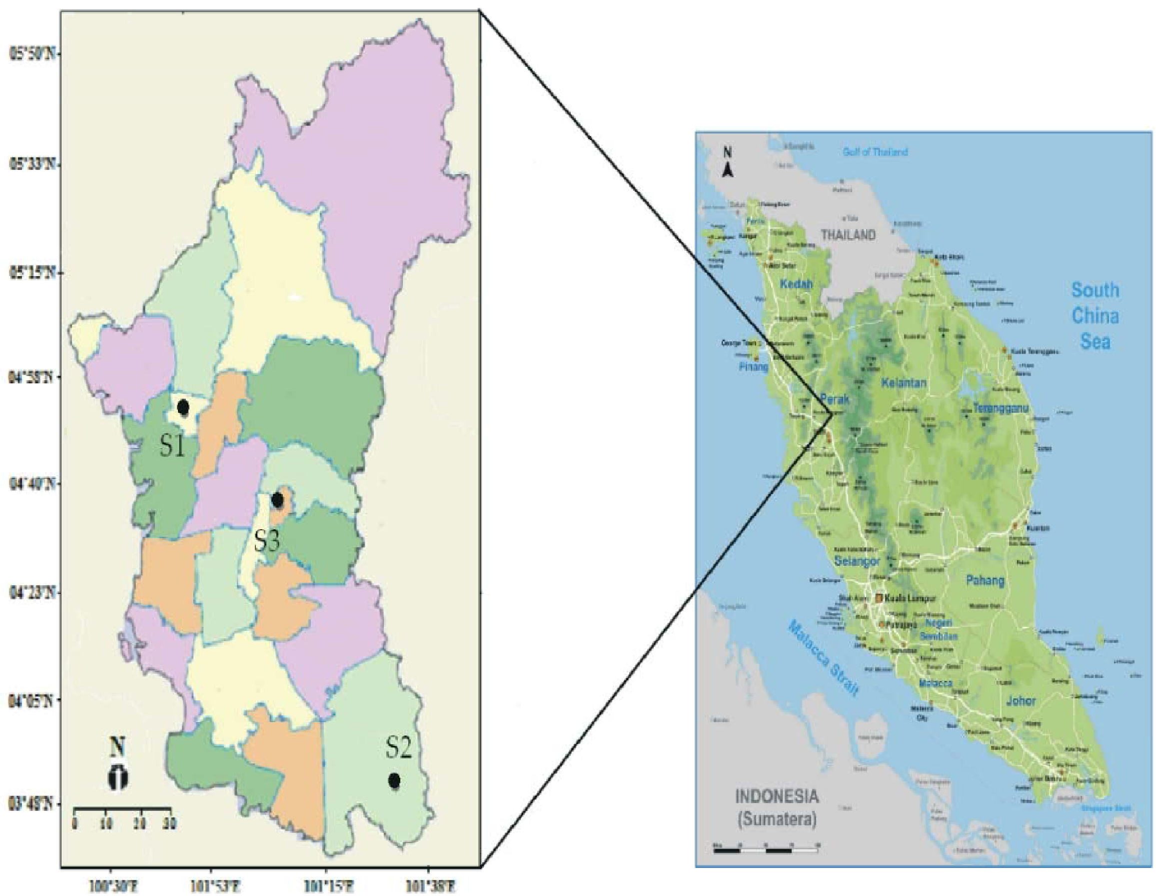

Fig. 1: Locations of air quality monitoring stations in Perak, Malaysia

Table 1: Details of the air quality monitoring stations

Station ID	Station Location	Background Area	Coordinates
S1	Sek. Keb. Air Puteh, Taiping	Industrial	5.9733° N, 100.4592° E
S2	Universiti Pendidikan Sultan Idris (UPSI), Tanjung Malim	Sub-urban	3.6850° N, 101.5241° E
S3	Sek. Keb. Jalan Pegoh, Ipoh	Urban	4.5539° N, 101.0811° E

Table 2: Recommended Malaysian Ambient Air Quality Guidelines

		Malaysian Ambient Air Quality Standard	
Pollutant	Averaging time	ppm	($\mu g/m^3$)
Particulate Matter (PM_{10})	24 Hours	-	150
	12 Months	-	50
Ozone (O_3)	1 Hour	0.10	200
	8 Hours	0.60	120
Carbon Monoxide (CO)	1 Hour	30.0	35
	8 Hours	9.0	10
Nitrogen Dioxide (NO_2)	1 Hour	0.17	320
	24 Hours	0.04	75
Sulphur Dioxide (SO_2)	1 Hour	0.13	350
	24 Hours	0.04	105
Total suspended particulate (TSP)	24 Hours	-	260
	12 Months	-	90
Lead (Pb)	3 Months	-	1.5

Source: Department of Environment (DOE, 2010)

USA to monitor PM_{10} in (μgm^{-3}) based on the Standard Operating Procedures for Continuous Air Quality Monitoring [13]. The data was compared with RMAAQG as presented in Table 2. In this study, four air quality parameters were analysed; particulate matter (PM_{10}), carbon monoxide (CO), nitrogen dioxide (NO_2), sulphur dioxide (SO_2).

Data Analysis: In this study, PM_{10} concentrations were statistically analysed using XLSTAT 2017 software in order to correlate with other selected gaseous (CO, NO_2 and SO_2). 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 PM_{10} based on monthly data for all selected monitoring stations. The results indicated that the highest concentration of PM_{10} 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 PM_{10} 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 PM_{10} concentrations than other areas [1, 4, 15].

Tropical conditions with heavy rain, different temperatures and humidity may affect the level of PM_{10} in the atmosphere. The results demonstrated the peak value of PM_{10} 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 PM_{10} released from biomass burning in the neighboring country to Malaysia [9, 17] may contributes to a highly amount of PM_{10} 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 PM_{10} 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 PM_{10} during October 2015, as October shows the highest level of PM_{10} throughout the year for all monitoring stations studied. Result indicated that the concentration of PM_{10} at all monitoring stations had exceed the Recommended Malaysian Ambient Air Quality Guidelines (RMAAQG) which is 150 μgm^{-3} several times during this month. On 21st October, the PM_{10} 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.

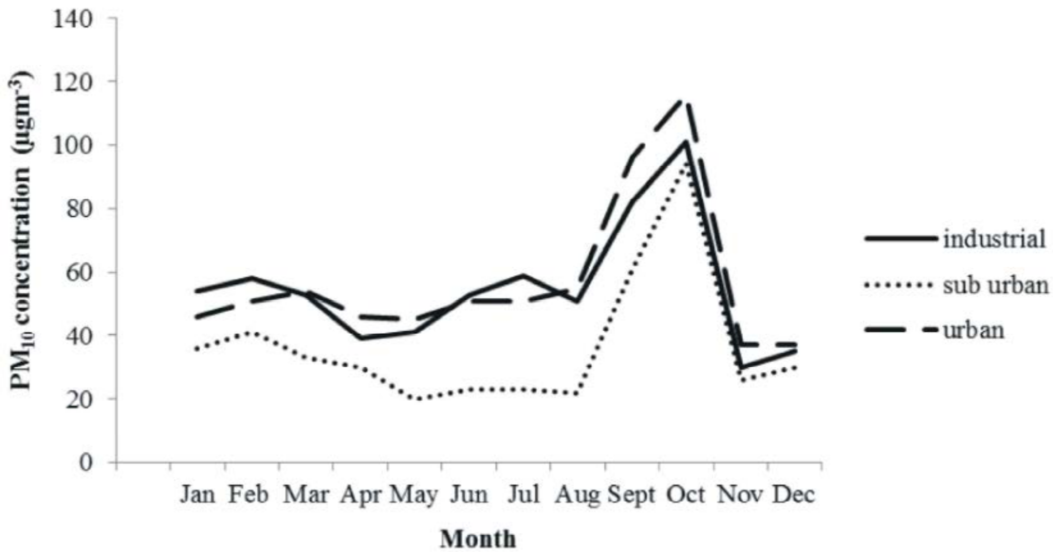

Fig. 2: Monthly trend of PM_{10} (μgm^{-3}) for three different background monitoring stations

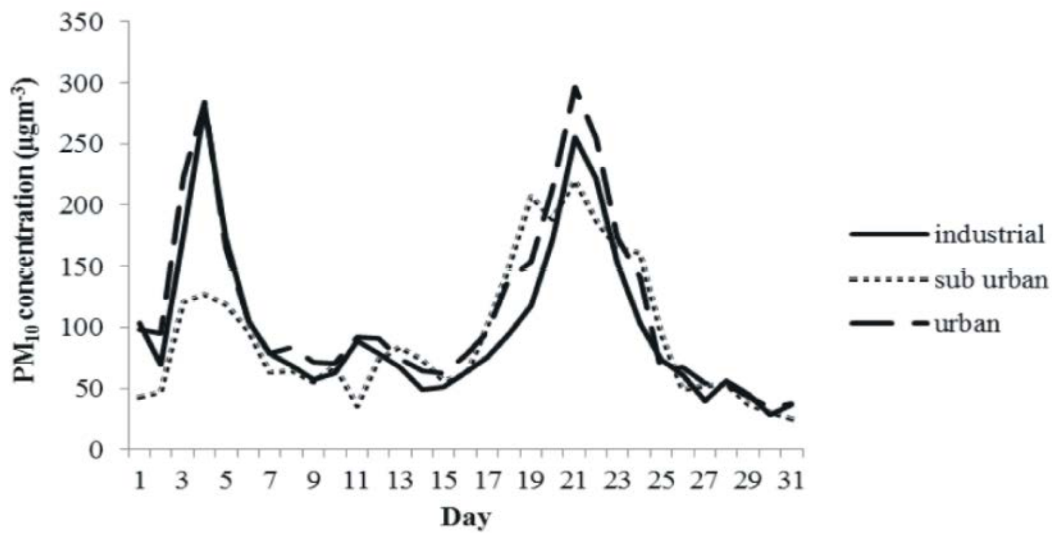

Fig. 3: Daily trend of PM_{10} (μgm^{-3}) during October 2015 (haze episode)

Table 3: Correlation between PM_{10} and other gaseous pollutants

Variables	PM_{10}	CO	NO_2	SO_2
PM_{10}	1	0.603*	0.384*	0.404*
CO	0.603*	1	0.425*	0.211
NO_2	0.384*	0.425*	1	0.269
SO_2	0.404*	0.211	0.269	1

$p < 0.05$

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.

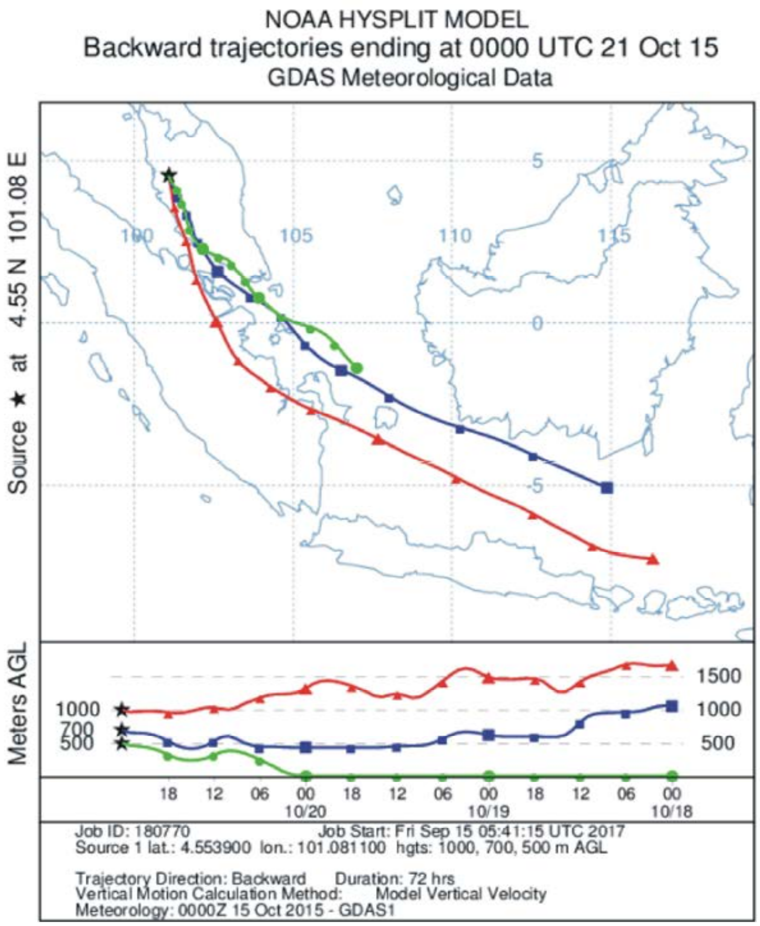

Fig. 4: The 72 h backward trajectories for S1 (urban area) using HYSPLIT on the 21st October 2015

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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