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Research paper



Variation of Particulate Matter (PM10) in a Semi-urban Area during 2015 Malaysia Haze

Nurul Bahiyah Abd Wahid*, Helmiah Abdul Razak, Rabieatul Adawiyah Amzah

Department of Biology, Faculty of Science and Mathematics, Universiti Pendidikan Sultan Idris, 35900 Tanjung Malim, Perak, Malaysia
**Corresponding author E-mail: nurul_bahiyah@fsmt.upsi.edu.my*

Abstract

Particulate matter (PM10) is one of the most dangerous air pollutants released during haze phenomena which can disrupt lung function, circulatory system and reduce visibility. The aims of this study were to determine the trend of PM10 in Tanjung Malim, Perak during 2015 haze episode. The four months trend of PM10 was analyzed, along with daily trend for the highest concentration of PM10 recorded during the haze episode. In addition, the correlation between PM10 and meteorological parameters, such as wind speed, temperature, and humidity were also analyzed. Result indicated that, PM10 level during September and October 2015, have mostly exceeded the Recommended Malaysian Air Quality Guidelines (RMAQG) by Malaysian Government (150 µg/m3). From the 72h backward trajectories, it can be stated that most of the pollutants came from biomass burning in neighbouring country, during the southwest monsoon. Changes in PM10 concentration were possibly influenced by meteorological factors which play an important role in haze episode.

Keywords: *Particulate Matter, Transboundary Haze, Southwest Monsoon, Meteorological Factors, Trajectories*

1. Introduction

Over decades, haze event has become a major concern as it has impacts over Malaysia almost every year. In the year of 1997, 2005 and 2013, Malaysia had declared some region with haze emergency according to the data provided by Malaysia Department of Environmental, (DoE) (Show and Chang, 2016). The Malaysia haze episode occurred in 2015 has become one of the worst haze episode on record (Tay et al., 2016). This is because Malaysia had suffered from transboundary haze from biomass burning that occurred in Indonesia, which severely diminished nationwide horizontal visibility as thick smoke blanked Peninsular Malaysia. This air pollution crisis had also affected other neighboring countries in Southeast Asia including Singapore, Thailand, and Brunei (Dotse et al., 2016; Lee et al., 2016).

Problem Statement

Many studies indicated that forest fires are the significant source of haze episode in which it is the cheapest and most convenient method of land clearance preferred by smallholder agriculturists (Lee et al., 2016). Haze resulted from land and forest fires will generate high concentration of particulate matter size range less than 10µm diameter (PM10) which is the dominant air pollutant produced resulting a reduction of air quality at affected areas (Abas et al., 2004; Wahid et al., 2014). Prolong exposure to PM10 can reduce visibility and causing short and long term adverse health effects including eye irritation, coughing, headaches, asthma and acute respiratory infections (Afroz et al., 2003; Tsitouridou et al., 2003; Wen et al., 2016). Previous studies had reported that the formation of PM10 from haze is influenced by monsoonal seasons and meteorological conditions (Abas et al., 2004). Malaysia experiences Southwest (June-September) and Northeast monsoon (November-March) anually. The period of June-September is known as dry season where most of the air masses mainly originated from west or south-west such as Sumatra, Indonesia (Khan et al., 2016). Monsoonal variability of meteorological factors had transport different air pollutants to the affected area including Malaysia.

2. The Aim of Research

PM10 is one of the most important atmospheric pollutant discovered in major cities in Malaysia (Ismail et al., 2011; Juneng et al., 2011; Wahid et al., 2014). In fact, PM10 in smoke from forest fires is the major component in the atmospheric samples collected at most of the Malaysian stations during haze episodes (Abas et al., 2004). Thus, this study aims to determine the trend of PM10 concentration in air quality monitoring station at Tanjung Malim, Perak during 2015 haze episode. Furthermore, the correlation between PM10 and the meteorological factors and other pollutants are also discussed. Backward trajectories have also been analyzed to trace the former path of the air parcel before arriving the study areas.

3. Materials and Methods

Tanjung Malim is a small town situated approximately 75 km north of Kuala Lumpur and it lies on the Perak-Selangor state border. Tanjung Malim is a developing city in the southern region of Perak It surrounded by highland of Banjaran Titiwangsa and deep valley which receive average daily temperature of 28˚C - 32˚C and annual humidity value of 85.2%. The air quality monitoring station for this study was situated at Sultan Abdul Jalil Shah Campus, Universiti Pendidikan Sultan Idris (UPSI) (3.6850° N, 101.5241° E).

The data used in this study were obtained from the air monitoring stations managed by Alam Sekitar Malaysia Sdn. Bhd (ASMA) on behalf of the Malaysia Department of Environment. Other than PM10 concentration, the data for wind speed, temperature, relative

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humidity, and other gaseous pollutants were gathered for the duration of four months between Augusts to November 2015, which was the period of haze episode occurred in Malaysia. The PM10 concentrations were analysed throughout the selected months and the trend was depicted in graph based on daily data. In addition, the hourly trend was analysed for three days that recorded the highest concentration of PM10, within haze. The linear relationship between PM10 concentration and the meteorological factors such as wind speed, temperature and relative humidity was measured by conducted the Pearson Correlation.

To determine the effects of wind during haze episode, the backward trajectories for wind direction as a diagram to determine the path where the air pollutant passed through were developed using the Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT). For this study, 72 h backward trajectories were undertaken for the three selected days with high haze level as to determine the origin of air mass arriving at Tanjung Malim.

4. Results and Discussion

The PM10 concentration was measured based on data from August until November 2015 as illustrated in Figure 1. These four months were selected due to high amount of air pollutants detected in accordance to transboundary haze during this period. The highest PM10 recorded in this sampling station was in October. The peak reached the highest reading with 221 µg/m3 concentration where it had exceeded the permissible data limit recommended by Malaysia air quality guideline (150 µg/m3). At the peak of this episode, many schools were closed and serious environmental and health problems were detected (Lee et al., 2016).
Figure 1 also showed the increasing of PM10 value from around 13 µg/m3 in early August to 221 µg/m3 in mid-October. High amount of PM10 is suspected to come from the transboundary smoke of biomass burning in neighbour country as also being found by Othman et al., (2014) and Lee et al., (2016). In contrast, the trend decreases sharply during November 2015 with average PM10 value were recorded within the permissible value of RMAAQG. This might be due to strong northeast winds dominating over Peninsular Malaysia which bring heavy rainfall at the end of the year (Wen et al., 2016). Rainfall might wash out the trapped pollutants in which have reducing the concentration of PM10 during November.

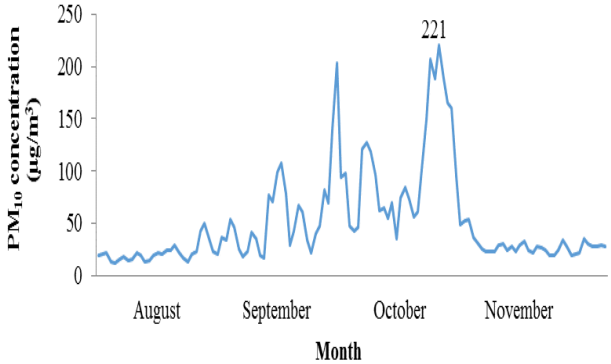


Figure 1. Trend of particulate matter (PM10) concentration for four months in Tanjung Malim

From the average of hourly trend, there are three days that show the PM10 reaching the highest level as illustrated in Figure 2. The highest concentration of PM10 recorded in the study area was during 19th October with the value of 382 µg/m3 followed by 27th September and 21st October with 321 µg/m3 concentration. Selected days in this study showed increasing concentrations of PM10 from around noon to late evening. The peak of PM10 concentrations was found to occur between 14.00 until 15.00 during 19th October. This might be due to the sampling station only experienced a high volume of traffic during peak hours.

In addition, high PM10 detected among those days is expected to be affected by the wind. The concentration of PM10 was found to be higher during the southwest monsoon. The 72 h backward trajectories developed for the sampling station is shown in Figure 2. During the southwest monsoon, the air mass movement tends to originated from Sumatra, Indonesia, This usually contributes to the amount of biomass burning residue, which contains greater quantity of PM10 in the atmosphere. This condition has also been shown by other studies which indicated that the wind blows from fires episode in Sumatra can transport large amount of air pollutants to Malaysia (Abas et al., 2004; Afroz et al., 2003; Wen et al., 2016).

Table 1 demonstrates the correlation between the PM10 concentration and meteorological factors. Results indicated that humidity have a negative significant correlation with PM10 ($p < 0.05$), which showed the high PM10 concentration occurred on less humid day. This is due to lower number of rainfall that resulted to higher concentrations of air pollutants as also presented by Juneng et al. (2011). During southwest monsoon, most of the atmospheric pollutants are suspended and transported from fires episodes in neighbouring country (Khan et al., 2016), in which resulted to poor air quality in this monitoring station. In this study, temperature indicated positive correlation with PM10. This might be due to high temperature in tropical countries leads to hot weather which in turn promotes regional biomass burning.

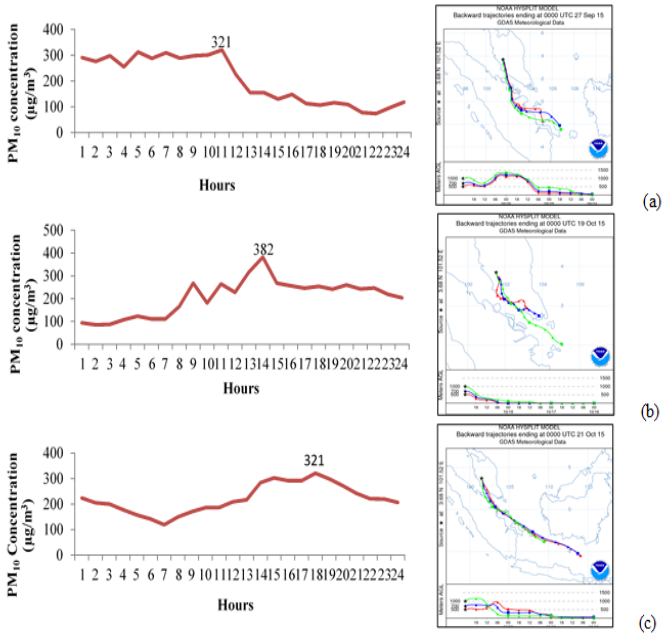


Figure 2. Hourly trend of PM10 and wind direction from backward trajectory analysis on a) 27th September 2015, b) 19th October 2015 and c) 21st October 2015

Table 1: Correlation of PM10 related with meteorological factors

Variables	PM_{10}	Temperature	Wind speed	Humidity
PM_{10}	1	0.323	-0.256	-0.555*
Temperature	0.323	1	0.491*	-0.785*
Wind speed	-0.256	0.491*	1	-0.174
Humidity	-0.555*	-0.785*	-0.174	1
*$p < 0.05$				

5. Conclusion

In this study, the trend of PM10 concentration at Tanjung Malim during haze was observed. The highest PM10 concentration was recorded on October 2015. Based on the correlation between PM10 with meteorological parameter, the particulate emitted into sampling station due to the haze transported from the neighbour-

ing country. HYSPLIT analysis showed that the long-range transport of air pollutants was blowing from Sumatera, Indonesia during southwest monsoon. Due to the effects of PM10, which may incur health risks, the level and the composition of PM10 should be monitored regularly in order to maintain a healthy environment,

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