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Original Research Article

Impact of haze on air quality: SO_2 and NO_2 levels during 2015 Malaysian haze episode

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Abstract

Malaysia frequently experienced haze since the 1990s. However, very dense haze episodes rarely happened, especially in the state of Perlis, which located in the northern part of the west coast of Peninsular Malaysia. In this study, sulfur dioxide (SO_2) and nitrogen dioxide (NO_2) concentrations were measured during haze days and non-haze days in October 2015 at two locations, namely; Ulu Pauh (rural area) and Jejawi (semi-rural area) using portable monitors and GSE sensors. Daytime SO_2 and NO_2 levels were found higher during haze days (Ulu Pauh: 0.25 ppm and 0.07 ppm; Jejawi: 0.31 ppm and 0.08 ppm) compared non-haze days (Ulu Pauh: 0.11 ppm and 0.05 ppm; Jejawi: 0.13 ppm and 0.06 ppm). Different locations displayed distinguishable concentrations of SO_2 and NO_2 during the dense haze episode in Perlis.

Keywords: Air quality, Haze, Sulfur dioxide, Nitrogen dioxide, Peninsular Malaysia

Introduction

Haze is defined as the presence of fine particles (0.1-1.0 µm in diameter) in the air that dispersed at high concentrations which diminish the horizontal visibility (Soleiman et al., 2003). The main focus of most air pollution epidemiological studies were the health effects of particulate matter (WHO, 2000; WHO, 2006). But several studies have considered sulfur dioxide (SO_2) and other gaseous pollutants as potential confounders of the effects of particulate matter on human health. Many studies also noted a high correlation between nitrogen dioxide (NO_2) and particulate matters generated from the same combustion sources (WHO, 2006).

Malaysia had experienced deterioration of air quality during 2015 haze due to massive land and forest fires in Sumatra and Kalimantan, Indonesia during the southwest monsoon (DOE, 2015; Phys.org, 2015; CIMSS, 2015). On 15th September 2015, 34 areas in Malaysia recorded unhealthy air quality status for the first time in Malaysia's history since 1997 (DOE, 2015). Figure 1 shows the Southeast Asian region during the haze (CIMSS, 2015). Human health could greatly be affected by the haze as air pollutants could remain in the atmosphere for a long time depending on the weather. The study on traditional pollutant gases is essential. Therefore, the sulfur dioxide (SO_2) and nitrogen dioxide (NO_2) concentrations were investigated during and after the haze episode in Perlis, Malaysia.

Materials and Methods

In this study, sulfur dioxide (SO_2) and nitrogen dioxide (NO_2) concentrations in Perlis (northern-most state of Peninsular Malaysia) were measured using portable gas monitors (Aeroqual Series 500) at the main campus of Universiti Malaysia Perlis (UniMAP) in Ulu Pauh and Centre of Excellence for Advanced Sensor Technology (CEASTech) in Jejawi. Different local ambient air quality was identified through the Air Pollutant Index (API) of Department of Environment Malaysia (DOE) website (APIMS, 2015a). Gas measurements were conducted on (i) 21-23 October 2015 (haze days) with API values >100 (unhealthy) to

>200 (very unhealthy), and (ii) 26-28 October 2015 (non-haze days) with API values <50 (good), and executed in the morning (8:30 to 10:30) and late afternoon (16:30 to 18:30), when people normally outdoors. Figures 2 and 3 shows noon scenery of a small hill nearby UniMAP Ulu Pauh library during and after the haze.

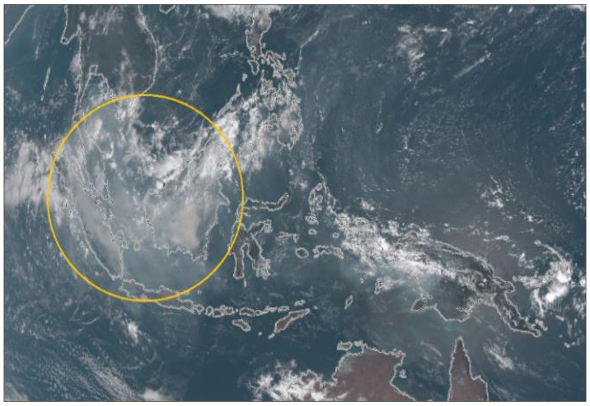

Fig – 1: CIMSS satellite image of the Southeast Asian region during the haze (October 22, 2015)

Fig – 2a and 2b: Noon scenery at Ulu Pauh (October 21, 2015) during the haze.

Aeroqual Gas Sensitive Electrochemical (GSE) sensors; SO_2 (0.00-10 ppm) and NO_2 (0.000-1 ppm) were used. Data logging was set for 60-seconds average (recorded once per minute). Data collection was 5 minutes with repetitions, ±1.5 m above the ground. Handling and calibration procedures of the portable devices were based on Aeroqual User Guide Manual. Daily wind speed data from weather stations located at Ulu Pauh and Jejawi were acquired from the database of UniSense – IoT for Environmental Sensing of CEASTech, UniMAP (Official website: https://unisense.ceastech.com). Data analyses were performed using Series 500 monitor PC software, MS Excel, and SPSS Statistics software.

Fig – 3a and 3b: Noon scenery at Ulu Pauh (October 27, 2015) after the haze.

Results and Discussion

The statistical description of sulfur dioxide (SO_2) and nitrogen dioxide (NO_2) are shown in Table 1. Gas concentrations were significantly higher ($p<0.05$) during the haze days compared to non-haze days at Jejawi and Ulu Pauh. During haze, Jejawi has higher SO_2 and NO_2 levels than Ulu Pauh. Jejawi is a semi-rural area located close to a few developing areas (e.g., Arau and Kangar) and more populated compared to Ulu Pauh which is a rural area and more secluded. Anthropogenic emissions, mainly the fossil fuels combustion from motor vehicles and industrial facilities might have contributed to higher SO_2 and NO_2 levels during the haze and shortly after the haze episode.

Table – 1: Statistical description of parameters during haze and non-haze days in Perlis, Malaysia.

Variables	Unit	Statistics	Haze days (21-23 October 2015)		Non-haze days (26-28 October 2015)		Ratios of haze / non-haze	
			Jejawi	Ulu Pauh	Jejawi	Ulu Pauh	Jejawi	Ulu Pauh
SO_2	ppm	Min	0.14	0.15	0.08	0.07	1.75	2.14
		Max	0.57	0.42	0.20	0.14	2.85	3.00
		Mean	0.31	0.25	0.13	0.11	2.38	2.27
		SD	0.12	0.07	0.03	0.02	-	-
NO_2	ppm	Min	0.01	0.01	0.02	0.01	0.50	1.00
		Max	0.14	0.13	0.09	0.08	1.56	1.62
		Mean	0.08	0.07	0.06	0.05	1.33	1.40
		SD	0.04	0.03	0.02	0.01	-	-

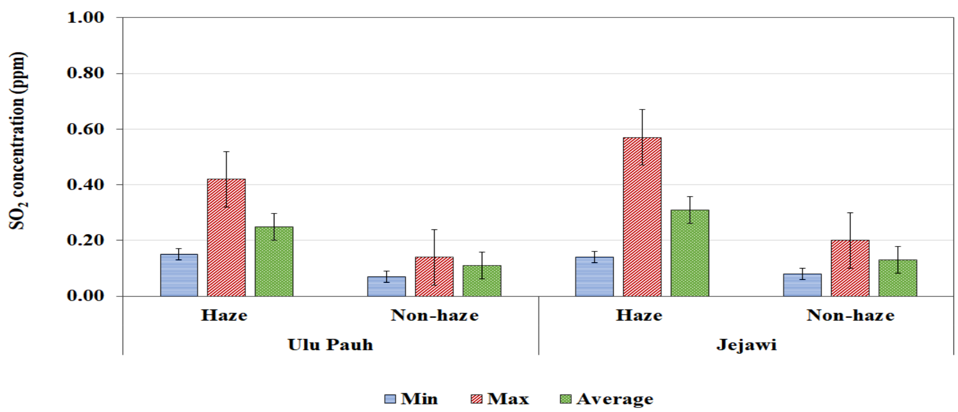

Fig – 4: Daytime SO_2 concentrations during haze and non-haze days at Jejawi and Ulu Pauh.

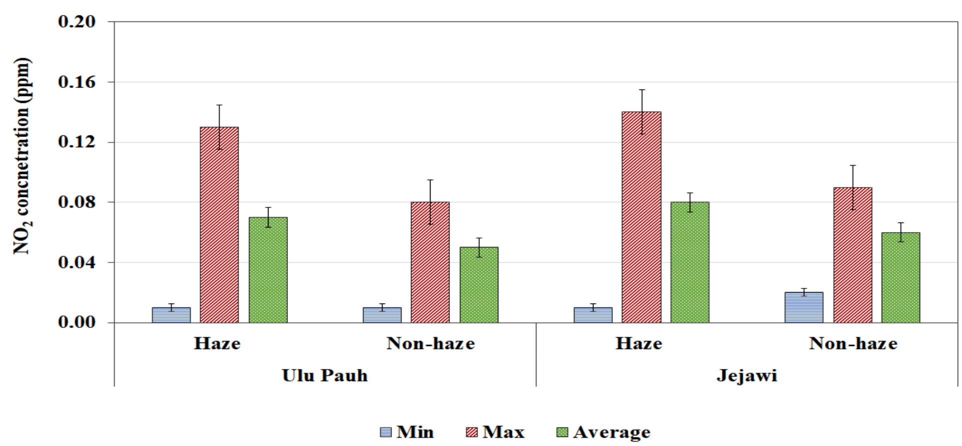

Fig – 5: Daytime NO_2 concentrations during haze and non-haze days at Jejawi and Ulu Pauh.

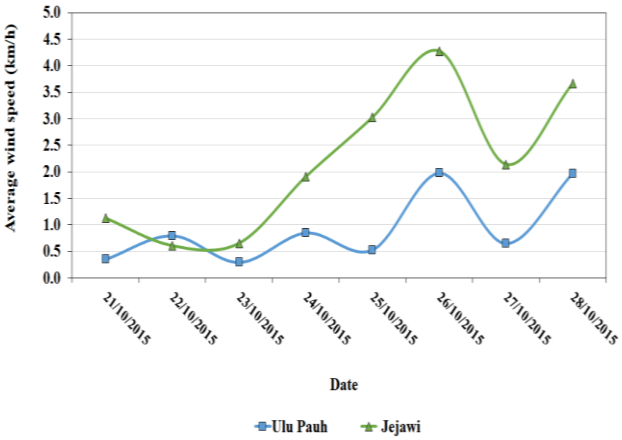

Fig – 6: Average daily wind speed at Jejawi and Ulu Pauh (October 21, 2015 until October 28, 2015).

According to the DOE, Malaysian Ambient Air Quality Standard (MAAQS) were adopted into the Air Pollutant Index calculation (APIMS, 2015b), and the guideline represents the "safe levels" which no adverse health effects have been observed (based on present knowledge) if recorded pollutants were below recommended levels. The MAAQS for SO_2 are 0.19 ppm (10-minute mean), and 0.13 ppm (1-hour mean), and for NO_2 is 0.17 ppm (1-hour mean). Overall, results show that SO_2 in Jejawi (semi-rural area) and Ulu Pauh (rural area) have exceeded the "safe level" during the haze and still close to the recommended level after the haze receded. Meanwhile, the NO_2 levels at Jejawi and Ulu Pauh were high but below the recommended level during and after the haze period. Nonetheless, the deterioration of air quality is a growing public health concern worldwide. Higher SO_2 and NO_2 concentrations could greatly increase the likelihood of respiratory symptoms and breathing discomfort in active children, the elderly, and people with lung disease such as asthma.

According to Sahani et al. (2014), the average SO_2 and NO_2 during the haze and non-haze days in the Klang Valley (Malaysia); 5.2 ppb and 26.8 ppb (haze days), 4.5 ppb and 20.8 ppb (non-haze days). The average gas concentrations in China cities; Beijing, Shanghai, and Guangzhou (Zhang et al., 2015a), SO_2 were 8.6 ppb, 7.3 ppb, and 7.2 ppb, whereas NO_2 were 25.4 ppb, 20.3 ppb, and 24.4 ppb, respectively. The findings of this study also notably different from studies conducted in other parts of Perlis (Abdullah et al., 2017; Nadiah et al., 2017) after the haze episode. Hence, the haze and non-haze days in Perlis have higher air pollutant levels compared to existing local and regional records. Difference concentrations of SO_2 and NO_2 during dense haze days and non-haze days at Jejawi and Ulu Pauh shown in Figure 4 and Figure 5.

Meteorological conditions such as the wind could affect the haze in many ways. The daily average wind speed during the haze days (0.29-1.13 km/h) were lower than non-haze days (0.65-4.28 km/h). The wind speed at Jejawi and Ulu Pauh can be seen in Figure 6. After the haze period, SO_2 and NO_2 levels were lower and this likely due to higher wind speed occurrences, which transported the air pollutants to other locations. In general, higher wind speed is correlated with lower air pollutant levels (Zhang et al., 2015a). Thus, findings were agreeable with several studies (Tan et al., 2009; Hayasaka et al., 2014; Zhang et al., 2015b), haze days are characterized by low visibility, low wind speed and high levels of air pollutants.

Conclusion

This study shows that sulfur dioxide (SO_2) and nitrogen dioxide (NO_2) concentrations were higher during haze days than non-haze days. Differences of gas levels between semi-rural area (Jejawi) and rural area (Ulu Pauh) were also distinguishable. Therefore, different ambient conditions (i.e., haze and non-haze days) and locations (i.e., semi-rural and rural areas) displayed dissimilar gas levels since they are highly influenced by various anthropogenic and natural factors.

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