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CORRELATION OF CLIMATE TO PARTICULATE MATTER IN PALEMBANG

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ABSTRACTS

Climate affects the concentration of ambient particles through particulates which affects the human health. The study aims to measure and analyze the correlation between climate factors (temperature and relative humidity) with the exposure of particulate pollutants ($PM_{2.5}$ and PM_{10}) in Palembang. In this study, the data was obtained from the direct measurements to 39 Puskesmas (Primary Health Care) in Palembang. The results showed that with the mean for temperature, relative humidity, $PM_{2.5}$, and PM_{10}were 32.5(1.98) ^{0}C, 67.2(7.13) %, 10.8(5.59) ug.m^{-3}, and 19.5(9.37) ug.m^{-3}, respectively. There was a correlation between temperature and humidity with $PM_{2.5}$ and PM_{10} in Palembang.

KEY WORDS : Climate, $PM_{2.5}$, PM_{10}, Palembang.

INTRODUCTION

The climate can affects the exposure of particulate pollutants (Yao *et al.*, 2007; Giri *et al.*, 2008; Rathla *et al.*, 2015) in which the concentration of ambient particles is determined by the relative humidity and wind velocity(Lin *et al.*, 2013; Csavina *et al.*, 2014) and temperature (Li *et al.*, 2012; Jallad *et al.*, 2013; Li *et al.*, 2015). The particles of pollutant form small solid or liquid particles contained in the air (Brook *et al.*, 2010; WHO, 2016). The ambient particulates have detrimental effects on the human health (Katsouyanni, 2003; Pope III and Dockery, 2009; Brook *et al.*, 2010; Du *et al.*, 2016; Chen *et al.*, 2016; Lin *et al.*, 2016). These small particles pose a risk to the human health because it can be easily inhaled, passing through the throat and entering the lungs (Brook and Rajagopalan, 2010; Brook *et al.*, 2010).

The most dangerous particles are the particles that are classified as the fine particles, having the smaller diameter than 2.5 microns (about 30 times smaller than the diameter of human hair) (WHO, 2016). The microscopic particles are known as $PM_{2.5}$. The short-term exposure of $PM_{2.5}$can make the health problem in which the long-term exposure exacerbates the respiratory problem. In higher concentration, the exposure can generate some health problems such as cough and some disturbances in eyes, nose, throat (WHO, 2016), lung irritation, shortness of breath (Brunekreef *et al.*, 2009), cardiovascular (Freitas *et al.*, 2010; Brook *et al.*, 2010; Du *et al.*, 2016; Stockfelt *et al.*, 2017), and atherosclerosis (Brook and Rajagopalan, 2010; Du *et al.*, 2016). The children, the elderly, and people with the existing respiratory problem including asthma, and respiratory organ problem and liver pose the high risk and sensitive to $PM_{2.5}$. Long-term $PM_{2.5}$ exposure is positively associated with the increased mortality (Brook *et al.*, 2010; Du *et al.*, 2016).

The current research shows that the short exposure can initiate the heart attack in the risk population and increases the mortality (Brook *et al.*, 2010). The WHO database has compilated the information about the status of $PM_{2.5}$and $PM_{10}$of

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3.000 cities around the world. It is estimated in 2014, one of ten people breathe with the clean air (WHO, 2016).

The particulate emission, aerosol, and its transportation can be predicted to prevent the hazard impact to human health (Chen *et al*., 2013; Csavina *et al*., 2014). Pant *et al.* (2016) reported that India was the highest mortality rates related to air pollution exposure. However, a deeper understanding of the level of ambient pollutants is required as a source of information that is particularly important not only in the city but also in the rural areas. All the information can be used to extend the people attention to detail. This purpose becomes the basis of this study to measure and monitor the environmental quality in terms of temperature, relative humidity, and particulate pollutants in Palembang.

MATERIALS AND METHODS

The climatic data (Temperature, and relative humidity) and the particulate data of $PM_{2.5}$ and PM_{10}were obtained from the direct measurements using mini particle counter DT-96 (CEM, Shenzhen-China) at39 puskesmas (primary health care) in Palembang. The data were obtained on the fourth week of January 2018. All the data was processed in the forms of average, standard deviation, max, and min data, and analyzed with the Spearman method.

RESULTS

All the location of Puskesmas was shown in Fig. 1. All the data of particulate and climate measurements were presented in Fig. 2 and Table 1. Furthermore, the correlation test results were shown in Table 2.

Table 1 showed that the ambient of $PM_{2.5}$had an average value of 10,77 μg.m^{-3}with a standard deviation of 5.59. The minimum and maximum value of $PM_{2.5}$were 4 μg.m^{-3}and 33 μg.m^{-3}located in the puskesmas of Multi Wahana and Plaju. For the ambient of PM_{10}, the average value was measured as 19.46 μg.m^{-3} with a standard deviation of 9.37.the obtained minimum and maximum value of PM_{10} were 9 μg.m^{-3}and 44 μg.m^{-3}, respectively which

Table 1. Data of PM Ambient and Climate Parameter of Puskesmas in Palembang.

Variables	Mean	SD	Min	Max
$PM_{2.5}$ (ug.m^{-3})	10.8	5.59	4	33
PM_{10} (ug.m^{-3})	19.5	9.37	9	44
Temperature (°C)	32.5	1.98	27.2	38.0
Relative Humidity (%)	67.2	7.13	50.3	89.5

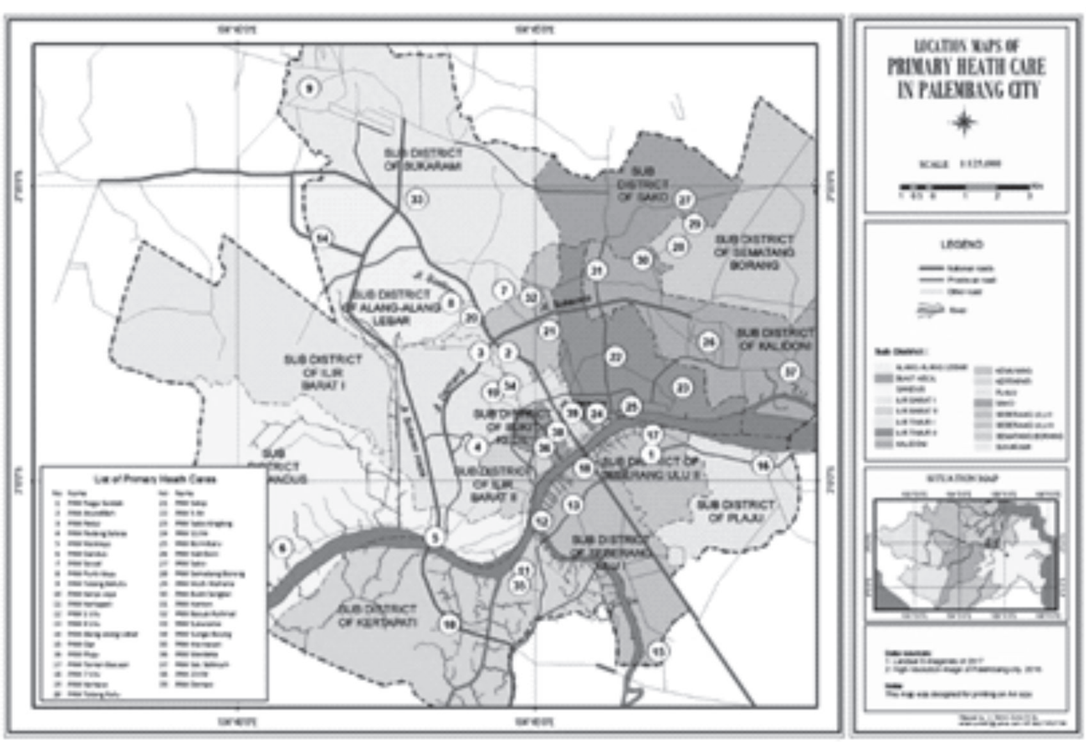

Fig. 1. Map location of Puskesmas in Palembang

located in the puskesmas of Multi Wahana and Boom Baru. According to the threshold value standard of $PM_{2.5}$ and PM_{10}- issued by the Meteorology, Climatology, and Geophysics Agency (BMKG). All the puskesmas in the studied area had no exceed the daily threshold value standard.

For the climate measurements, the average temperature in the studied area was obtained in 32.52°C with a standard deviation of 1.98. The minimum and maximum temperated were detected as 27.2°C and 38°C, respectively and located in the puskesmas of plaju and alang-alang lebar. Furthermore, the average value of relative humidity in the studied area had 67.17 % with a standard deviation of 7.13. The minimum and maximum value were detected as 50.3% and 89.5%, respectively and located in the puskesmas of Ariodillah and Plaju. According to the BMKG of Palembang, the climate statue was in the rainy season (wet season).

Table 2 showed that $PM_{2.5}$ positively significant and correlated to PM_{10} (r = 0.952; p = 0.001) and the relative humidity (r = 0.580; p = 0.001) in which showed the negative correlation to temperature (r = -0.389; p = 0.014).In addition, PM_{10}exhibited the positively significant and correlated to the relative humidity (r = 0.620; p = 0.001) and negatively correlated to temperature (r = -0.432; p = 0.006). Furthermore, temperature represented the negative correlation to the relative humidity (r = -0.623; p = 0.001).

The exposures of $PM_{2.5}$ and PM_{10} were generated from two different sources. $PM_{2.5}$ was obtained from the vehicle exhaust discharges while $PM_{10}$was generated from the friction of vehicle tires by road. It could be shown that the closer the location of puskesmas with the main road through the vehicle, the higher of particulate detected ($PM_{2.5}$ dan PM_{10}). It was supported by the data of particulate matter which detected in the puskesmas near the main road such as Plaju (33 ug.m^{-3}; 43 ug.m^{-3}), Boom Baru (22 ug.m^{-3}; 44 ug.m^{-3}), and Talang Betutu (22 ug.m^{-3}; 44 ug.m^{-3}). In the other side, the puskesmas that located away from the main road had the small particulate matter such as Multi Wahana (4 ug.m^{-3}; 9 ug.m^{-3}), Bukit Sangkal (7 ug.m^{-3}; 12 ug.m^{-3}) and Kalidoni (7 ug.m^{-3}; 13 ug.m^{-3}).

The particulate exposure ($PM_{2.5}$ dan PM_{10}) were also affected by the weather condition such as temperature and relative humidity. The increasing of temperature generated the decreasing of particulate exposure whereas the increase of relative humidity decreased the particulate exposure.

In the puskesmas plaju, there was a high of particulate exposure in which the $PM_{2.5}$ and PM_{10} showed 33 ug.m^{-3} and 44 ug.m^{-3}, respectively. The

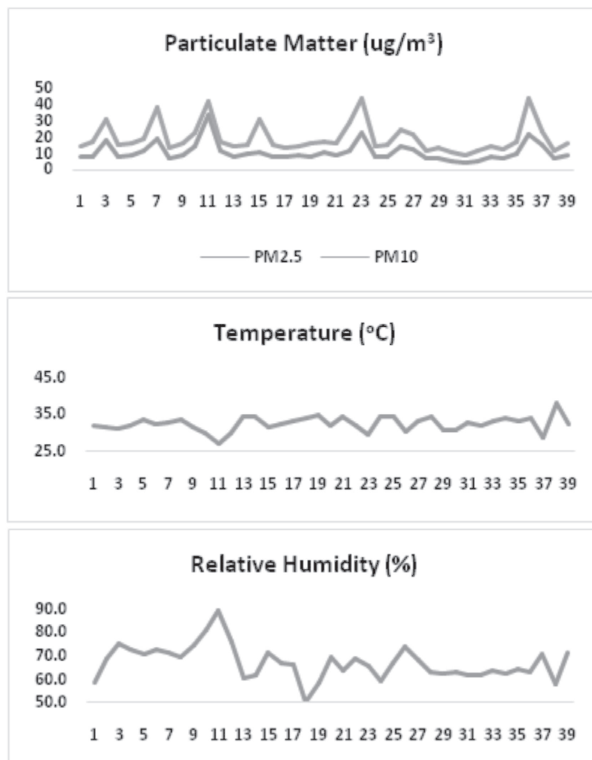

Fig. 2. The measurement results of 39 Puskesmas in Palembang.

Table 2. Results of Correlation test with the Spearman method.

	Variables	PM_{10}	Temp.	R. Humidity
$PM_{2.5}$	Cor. Coefficient	0.952**	-0.389*	0.580**
	Sig. (2 tailed)	0.001	0.014	0.001
PM_{10}	Cor. Coefficient		-0.432**	0.620**
	Sig. (2 tailed)		0.006	0.001
Temp.	Cor. Coefficient			-0.623**
	Sig. (2 tailed)			0.001

*p<0.05; **p<0.01

high of particulate exposure was supported by the measurement of temperature and the relative humidity in which in Plaju, the temperature was relatively low temperature (27.2 ^{o}C) and the relative humidity was quite high (89.5%). Compared to the puskesmas of Plaju, the temperature in the puskesmas Alang-alang Lebar had the higher temperature (38.0 ^{o}C)and lower relative humidity (58.1 %) that the $PM_{2.5}$and PM_{10} of the puskesmas of Alang-alang lebar had the lower particulate exposure in which the $PM_{2.5}$and PM_{10} showed 7 ug.m^{-3} and 11 ug.m^{-3}, respectively.

DISCUSSION

According to the threshold value standard of $PM_{2.5}$ and PM_{10-} issued by the Meteorology, Climatology, and Geophysics Agency (BMKG) based on EPA-US, the results of ambient pollutant measurements ($PM_{2.5}$and PM_{10}) in Palembang had the particulate concentrations below the threshold value. The low concentration of particulate matter was due to the measurement in the rainy season (wet). The results were supported by the study of Owoade *et al.* (2012) reported that the seasonal variations of $PM_{2.5}$ and $PM\text{-}_{2.5\text{-}10}$ would vary in which the high PM concentration occurred in the dry season and the low concentration occurred in the rainy season. Furthermore, Jallad *et al.* (2013) showed that the summer generated the higher PM concentration compared the rainy season.

In general, the developing countries with the large population had increased the concentration of particulate ambient pollutants including Indonesia (WHO, 2016). Chu and Paisie (2006) evaluated the current state of $PM_{2.5}$ in the united states studied over 5 years with the federal data reference methods. The critical design value for each monitoring station was calculated. The higher risk of 24-hour TLV NAAQS in the western United States (California) was affected by annual variability, particularly emissions in nature matters such as forest fires, as these events played a significant role in the rapid emergence of short $PM_{2.5}$ short-term exposure in the west of the United States. Fang *et al.* (2017) assessed the ambient sources of $PM_{2.5}$ and $PM\text{-}_{10}$ in Haikou, China and found that the particle concentration was higher in the winter than in spring. The ratio of $PM_{2.5}$ to PM_{10} was greater than 0.6. Furthermore, it was found that the ambient particulates consisted of dust suspended (17.5 – 35.0%), vehicle exhaust (14.9 – 23.6 %), and the particle from the secondary source (20.4 – 28.8%). Tai *et al.* (2010) obtained that the mean of the concentration of $PM_{2.5}$ was 2.6 ug.m^{-3} that was higher in the stuck condition than non-jam. The fine particulate composition included sulfate, organic carbon (OC), and elemental carbon (EC). Owoade *et al.* (2012) conducted a study in Nigeria and found that the daily variation of PM with a mean concentration for $PM_{2.5}$ and $PM_{2.5\text{-}10}$ were 25.37 ug.m^{-3}and 37.15 μg.m^{-3}. Furthermore, the analysis of PM composition with INAA assay was obtained by fourteen elements (As, Br, Cu, K, La, Na, Sb, Sr, Zn, Ce, Co, Cr, Sc and Th) and Br, K, Na, Sr, and Zn became the dominant elements. The PM was generated from local anthropogenic and long-term sources of pollutants.

Kim and Hopke (2006) examined the characterization of the composition of fine particle sources in the great smoky mountains and found that there were 8 composition of the extraction which were summer-high secondary sulfate (55%), carbon-rich secondary sulfate (16%), summer-low secondary sulfate (2%), gasoline vehicle emissions (13%), diesel emissions (1%), airborne soil (6%), industry (5%), and secondary nitrate (2%).

The results showed that there was a negative correlation between temperature to the relative humidity in which the higher temperature would affect lower humidity and vice versa.The results were supported by Yao *et al.* (2007).

There was a negative correlation between the temperature to the particulate matters in which the higher temperatures gave the decreasing of particulate concentration. The result was supported by the work conducted by Yao *et al.* (2007) that reported that the temperature was negatively correlated to particulate (black carbon). Tai *et al.* (2010) obtained the different result. They reported that the temperature was positively correlated with the particulate in sulfate form, organic carbon (OC), and carbon element. In the other hand, Owoade *et al.* (2012) claimed that the temperature was not correlated with the particulate matters.

There was a positive correlation between the relative humidity and the particulate in which the increased relative humidity would increase the particulate concentration. Tai *et al.* (2010) proved that the relative humidity was positively correlated with the particulates in the form of sulfate and nitrate. Yao *et al.* (2007) obtained the different result. The relative humidity was believed showing the negative correlation to the formation of fine particles of the vehicle with various vehicle particle size distribution in Hong Kong. Similarly, the results of research that were conducted by Jallad *et al.* (2013); Frietas *et al.* (2009), and Csavina *et al.* (2014) proved that the temperature and the relative humidity lead to change the particulate concentration.

CONCLUSION

The exposure of $PM_{2.5}$ and PM_{10} in Palembang had no exceed the daily threshold value standard arranged by BMKG of Indonesia. The exposures of $PM_{2.5}$ and PM_{10} in Palembang was negatively correlated with temperature, whereas positively correlated to the relative humidity. In addition, the temperature was negatively correlated with the relative humidity.

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