Correlation between Ground-based Particulate Matter Concentration and Aerosol Optical Depth during Forest Fires in Palangkaraya City

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Abstract. Forest fire is a natural disasters that can be caused by both nature and humans. Forest fires can cause a decrease in air quality caused by particulate matter from combustion. Daily particulate concentrations are monitored from meteorological stations in Palangkaraya City. This study aims to see the correlation between ground data and AOD data. The relationship between particulate concentrations in surface data monitored at the Tjilik Riwut meteorological station, Palangkaraya City, and Aerosol Optical Depth (AOD) data obtained using the Google Earth Engine (GEE) can be seen from the correlation coefficient and determination coefficient during the rainy season, dry season, and during the rainy season. forest fires from 2018 to 2019 in Palangkaraya City show a low relationship indicated by the correlation coefficient interval of 0.40. During the period of forest fires the highest correlation coefficient of AOD and particulates ($PM_{2,5}$ and PM_{10}) showed a low correlation with a maximum value of 0.25 in 2018 while, during the period of no forest fires the maximum correlation coefficient value was 0.40 in 2018 period. This shows that the correlation between AOD and particulate matter ($PM_{2,5}$ and PM_{10}) is better in periods non forest fires. Factors that can interfere with the AOD value are cloud cover and other meteorological factors such as humidity, solar radiation, and others.

Keywords: Aerosol Optical Depth, Forest Fire, Palangkaraya City, Particulate Matter

INTRODUCTION

Forest is one of the many natural resources in Indonesia. The total land area of forest areas in 2020 according to Badan Pusat Statistik (2022) is 120,495,702.96 Ha [4]. According to the results of monitoring Indonesian forests by the Ministry of Environment and Forestry in 2020, Indonesia's forest area is 95.6 million hectares or 50.9% of the total land area. In Government Regulation number 23 of 2021, it is stated that forests have the main function of conservation forests, protection forests, and production forests[8].

Currently, the quantity and quality of forests in Indonesia are decreasing due to disasters, both natural and human. One of the disasters that affect the number of forests is forest fires. Forest fires have an impact on environmental ecosystems, biodiversity, and human health. Forest fires in Indonesia are prone to occur in the provinces of Sumatra and Kalimantan. One of the incidents of forest fires that have occurred in Indonesia was in 2015, when air pollution in several locations in Central Kalimantan, including Palangkaraya City, reached 20 times the normal threshold. Haze from fires that lasts a long time causes people to experience respiratory problems and even cause death[6].

Aerosol Optical Depth (AOD) is the value of an attenuation of solar radiation entering the earth's surface due to the presence of aerosol particles in the atmosphere with scattering and absorption[7]. Aerosol mass is monitored as particulate matter in the form of PM10 or PM2.5 where aerosols are used for assessment and regulation of air

pollution[1]. The spectral energy that interacts with particulates suspended in the atmosphere is called the scattering process. The estimation of particulates can be seen through the scattering energy from the results of spectral energy in the atmosphere[2].

METHODOLOGY

The study location chosen was Palangkaraya City, Central Kalimantan which consists of five sub-districts, There are Pahandut, Sabangau, Jekan Raya, Bukit Batu, and Rakumpit sub-districts with a total area of 2,853.52 km². The topographical condition of Palangkaraya City consists of plains and hills with a slope presentation of less than 40%. Palangkaraya City has a tropical climate with an average temperature ranging from 26.70°C to 28.10°C[3].
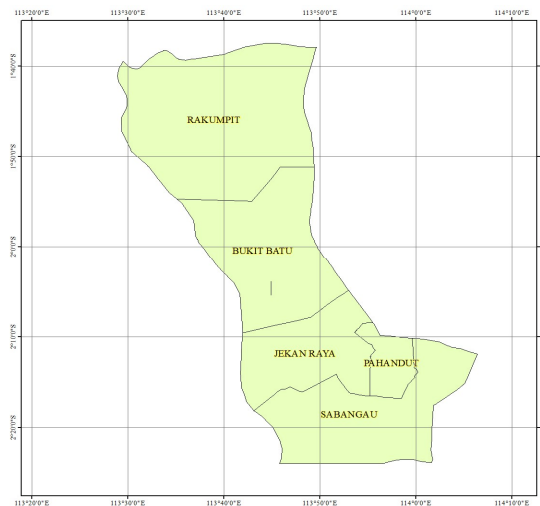

FIGURE 1. Study Area Kota Palangkaraya

Data Collection

Daily air quality data was collected from January 2018 to December 2019 from the Tjilik Riwut meteorological station in Palangkaraya City. AOD data collection uses the Moderate Resolution Imaging Spectroradiometer (MODIS) Terra and Aqua satellites. The Terra and Aqua satellites cross the equator at 10.30 and 13.30 local time. MODIS has 36 channels that are used in the aerosol collection. MODIS data collection uses the Google Earth Engine (GEE) application with the MODIS MCD19A2 channel with a spatial resolution of 1 km. The analysis was carried out by looking at the relationship between the available particulate data and AOD with regression analysis. AOD and particulate analysis were carried out regardless of other factors such as cloud cover and humidity.

Hot spot location data was extracted from the forest fire monitoring website of the ministry of environment and forestry (https://sipongi.menlhk.go.id/) from January 2018 to December 2019.
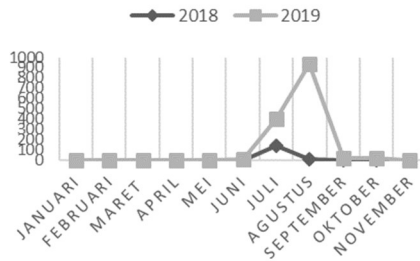
FIGURE 2. Numbers of hotspot in Kota Palangkaraya 2018-2019

Data Analysis

Analysis of particulate and AOD data in Palangkaraya City by determining the value of the correlation coefficient using the Pearson Product Moment method to show the strength of the relationship between two or more variables[5]. the Pearson Product Moment equation :

$$r = \frac{n\sum xy \quad (\sum x)(\sum y)}{\sqrt{(n\sum x^2 - (\sum x)^2)(n\sum y^2 - (\sum y)^2)}} \tag{1}$$

Furthermore, simple linear regression analysis is used to determine the relationship between $PM_{2.5}$ and PM_{10} concentrations and Aerosol Optical Depth (AOD) values in Palangkaraya City from 2018 to 2019 and when forest fires occur.
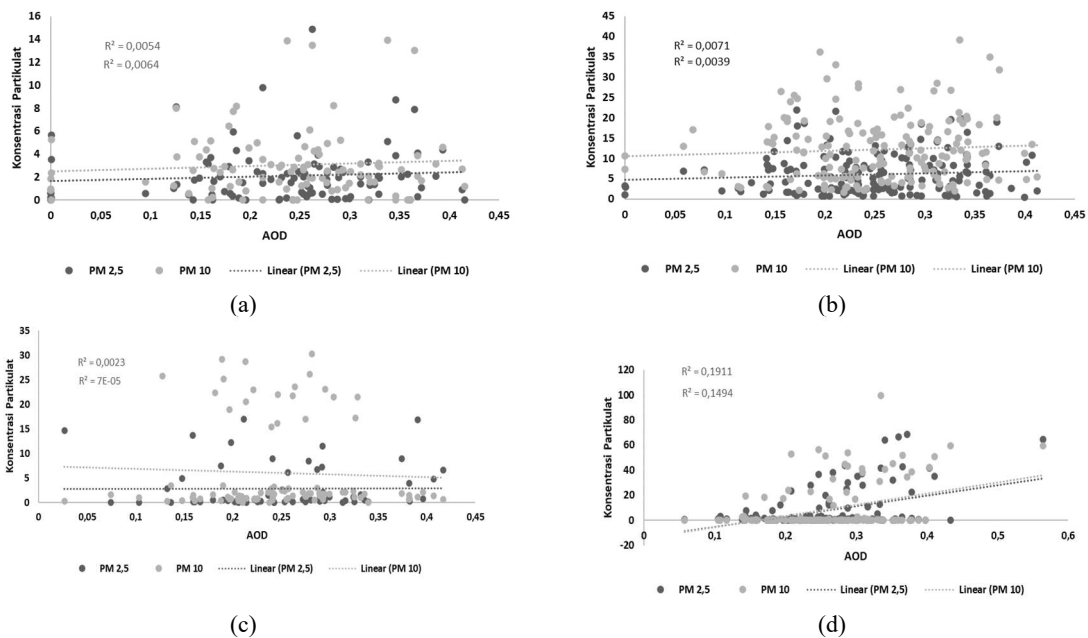
RESULT AND DISCUSSION

(a)

(b)

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FIGURE 3. a) Correlation of $PM_{2.5}$ and PM_{10} concentrations with AOD in the 2018 rainy season; b) Correlation of $PM_{2.5}$ and PM_{10} concentrations with AOD in the 2018 dry season; c) Correlation of $PM_{2.5}$ and PM_{10} concentrations with AOD in the 2019 rainy season; d) Correlation of $PM_{2.5}$ and PM_{10} concentrations with AOD in the 2019 dry season

TABLE 1. Correlation coefficient of $PM_{2.5}$ and PM_{10} during the rainy, dry, and forest fire seasons

Periods	2018		2019	
	$PM_{2,5}$	PM_{10}	$PM_{2,5}$	PM_{10}
Rainy Season	0,07	0,08	0,28	0,12
Dry Season	0,05	0,06	0,44	0,40
Forest Fire	0,07	0,11	0,23	0,24
Non Forest Fire	0,40	0,35	0,07	0,04

The highest concentration of particulate matter from 2018 to 2019 was when forest fires from July to September 2018 and July to December 2019. AOD is generally of high value in the hot or dry season[9]. Factors that affect the AOD measurement value are meteorological factors that can affect the spatial-temporal characteristics of aerosols in an area[2]. Mothly average of particulate ($PM_{2.5}$ and PM_{10}) and Aerosol Optical Depth (AOD) values in 2018-2019 are shown in **Figure 4**. From the monthly average we can see that between particulate concentration and AOD have a low correlation. The better correlation is comparison $PM_{2,5}$ and AOD in 2019 that shown the AOD chart aligned with the $PM_{2,5}$ chart.
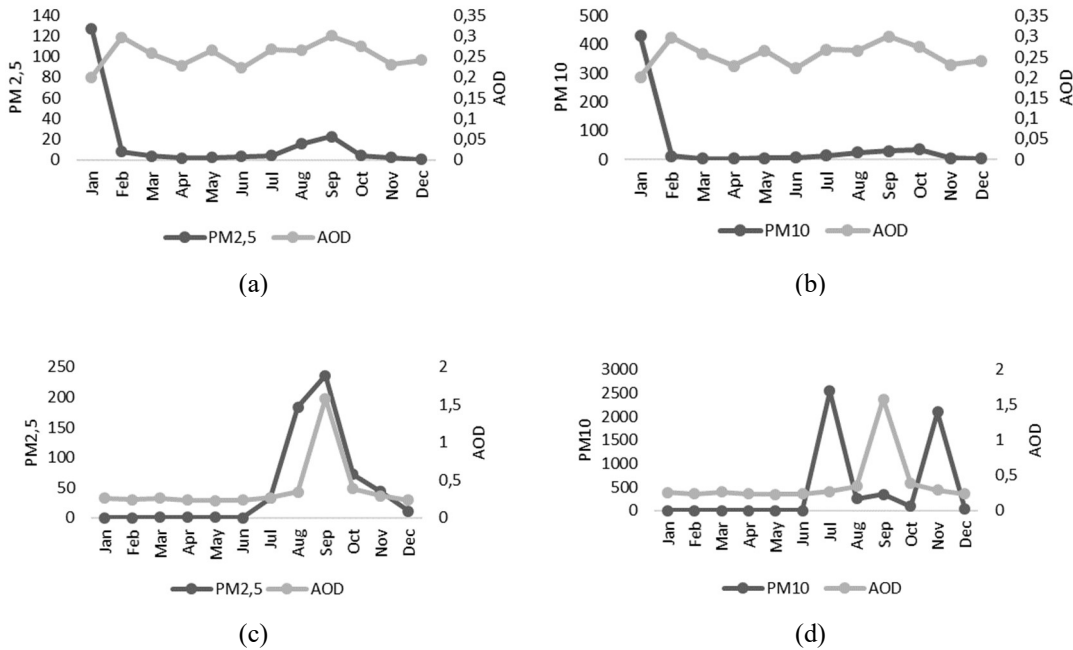
(a)

(b)

(c)

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FIGURE 4. a) Comparison between $PM_{2,5}$ and AOD in 2018; b) Comparison between PM_{10} and AOD in 2018; c) Comparison between $PM_{2,5}$ and AOD in 2019; d) Comparison between PM_{10} and AOD in 2019

TABLE 2. Average concentrations of $PM_{2.5}$, PM_{10}, and AOD during the rainy, dry, and forest fire seasons

Periods	2018			2019		
	$PM_{2,5}$	PM_{10}	AOD	$PM_{2,5}$	PM_{10}	AOD

Rainy Season	2	3	0	2,266	5,999	0,249
Dry Season	6,076	12,205	0,252	7,846	8,690	0,257
Forest Fire	11	17	0	18,430	20,977	0,286

The relationship between particulate concentration and AOD in both the dry season and the rainy season shows a small correlation coefficient with the correlation coefficient on the relationship between $PM_{2.5}$ and AOD in the 2019 rainy season was 0.074 and 0.047 in the dry season. The correlation coefficient between PM_{10} and AOD in the 2019 rainy season was 0.08 and 0.062 in the dry season. Whereas in 2018 the relationship between $PM_{2.5}$ concentration and AOD in the rainy season was 0.28 and 0.43 in the dry season. Meanwhile, the relationship between PM_{10} and AOD in the 2018 rainy season was 0.12 and 0.39 in the dry season. The correlation coefficient in the interval 0,00 to 0.199 indicates a very low relationship, 0.20 to 0.399 indicates a low relationship, 0.40 to 0.599 indicates a moderate relationship, 0.60 to 0.799 indicates a strong relationship, and 0.80 to 1. 00 indicates a strong relationship. The results of the correlation coefficient obtained in the 2019 rainy season for the relationship between AOD and $PM_{2.5}$, it has a very low relationship, as well as in the dry season. The relationship between AOD and PM10 during the rainy and dry seasons in 2019 has very low relationship. The relationship between AOD and $PM_{2.5}$ in 2018 for the rainy season has a low relationship, while during the dry season it has a moderate relationship. The relationship between AOD and PM_{10} in 2018 for the rainy season has very low relationship, while in the dry season it has a low relationship.

From the results of simple linear regression analysis, it is obtained that the degree of determination is very low, which means that the AOD value cannot explain the concentration of particulate matter on the earth's surface. This shows that the use of AOD in explaining the concentration of particulates on the earth's surface, especially in the City of Palangkaraya, cannot be used.

CONCLUSION

The highest concentration of particulate matter from 2018 to 2019 in Palangkaraya City was when forest fires occurred from July to September 2018 and July to December 2019. To see the correlation between particulate concentrations ($PM_{2.5}$ and PM_{10}) and AOD by looking at the correlation coefficient and coefficient of determination from simple linear regression. The results obtained are that the measurement of particulates using AOD is less efficient as seen from the very low correlation between the concentration of particulates and AOD. The correlation of particulates and AOD can be seen from the correlation coefficient in the 2018 rainy season $PM_{2.5}$ with an AOD of 0.28 having a low correlation and in the dry season 0.43 having a moderate correlation. PM_{10} correlation coefficient with AOD in the rainy season is 0.12 has a very low correlation and 0.39 in the dry season has a low correlation. In 2019 the correlation of $PM_{2.5}$ with AOD during the rainy season was 0.074 and 0.047 during the dry season which shows a very low relationship. While the correlation coefficient of PM_{10} with AOD in the rainy season is 0.08 and 0.062 in the dry season which shows a very low relationship.

ACKNOWLEDGMENTS

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