THE 4TH INTERNATIONAL CONFERENCE ON GREEN TECHNOLOGY AND DESIGN (ICGTD 2022)

Study of Monitoring Air Quality Concentrations of PM10 and PM2.5 Parameters with Aerosol Optical Depth (AOD) Measurements (Case Study: Pontianak City)

Nida Nur Rofa Rosidin[1, a)] Didin Agustian Permadi[2, b),] Mila Dirgawati[3, c)]

[1,2,3]*Environmental Engineering Department*
Institut Teknologi Nasional Bandung
Jl. PHH Mustofa No.23, Bandung, Indonesia 40124

[a)] *Corresponding author:* nidanurrofarosidin@gmail.com
[b)]didin@itenas.ac.id
[c)]mila.dirgawati@itenas.ac.id

Abstract. Aerosol Optical Depth (AOD) is an optical measurement of the extinction of light or solar radiation by aerosols quantitatively, the AOD value can be used to represent the aerosols in the entire atmosphere column. Aerosol Optical Depth (AOD) is the single most comprehensive variable representing aerosol values for long distances in the atmosphere and can be used as a key variable in climate modeling, aerosol experimental approaches and satellite verification. Human daily activities through changing land cover, burning fossil fuels, and releasing particulates and gaseous species into the atmosphere are very influential and have an impact on the local aerosol environment, the effects on the global climate are difficult to predict. Accuracy and completeness of the aerosol depth monitoring system in the atmosphere is urgently needed. Ground-based monitoring instruments will be used to determine current aerosol loads, characterize aerosols, measure pollution in the atmosphere which can be used as a definitive measure of change or modeling of air quality in the future. The relationship between PM10 and PM2.5 concentration values shows a positive and significant correlation, which means that the air quality parameters PM10 and PM2.5 concentrations with AOD values have the same trend with the results of a correlation coefficient of 0.88 0.8937 for monthly data and 0.7633 0.7673 for daily data in 2018 and the correlation coefficient is 0.678 0.8482 for monthly data and 0.2883 0.4048 for daily data in 2019. However, a correction factor needs to be done to produce a stronger and more accurate correlation value.

Keyword: Aerosol Optical Depth, Particulate Matter, Pontianak

INTRODUCTION

Aerosols are liquid or solid particles suspended in the atmosphere. Aerosols can affect regional air quality, human health and the energy of the Earth-atmosphere system in a number of ways. The aerosol immediately spreads or scatters by particles of various sizes from molecules to cloud droplets. Scattering is a continuous process, redistributing radiation in all directions for all wavelengths, but does not transfer energy and aerosols also absorb solar radiant energy in specific spectral or wave domains by molecules (H2O, CO2, O3 and others) and particles. Radiant energy is deposited in the atmosphere in the form of heat or chemical reactions. Aerosols can also affect solar infrared and thermal radiation, modify cloud size by increasing cloud reflectance and modify cloud residence time by affecting precipitation, affecting microphysics and radiation properties. This indirectly changes the radiation leaving the earth, the absorption of emitted energy by aerosols causes warming of the troposphere and cooling of the surface, which can change the relative humidity and stability of the atmosphere thereby affecting cloud formation and precipitation (precipitation). As a result, aerosols can affect temperature or climate change processes and the hydrological cycle and ecosystems on the global surface.

Aerosols have high spatial and temporal variability due to heterogeneously distributed sources, relatively short lifetimes and episodic features in emission. Therefore, continuous monitoring of aerosols and global and regional characterization can only be carried out via satellite remote sensing. (NESDIS, 2012). Aerosol Optical Depth (AOD) is an optical measurement of the extinction of light or solar radiation by aerosols quantitatively, the AOD value can be used to represent aerosols in the entire atmosphere column. Aerosol Optical Depth (AOD) is the single most comprehensive variable representing aerosol values for long distances in the atmosphere and can be used as a key variable in climate modeling, aerosol experimental approaches and satellite verification (Kazadzis, 2017). Aerosol Optical Depth (AOD) data is data derived from measurements of the sun photometer (Sun Photometer) of direct solar radiation providing information for calculating columnar aerosol optical depth (AOD). AOD can be used to calculate column water vapor (Precipitable Water) and estimate aerosol size using Angstrom parameter relationships. The processing of the AOD algorithm includes three quality levels (Level 1.0, 1.5, 2.0). Levels 1.0 and 1.5 are data provided almost in real-time, Level 2.0 data products are calibrated data (NOAA NESDIS, 2012).

Human daily activities through changing land cover, burning fossil fuels, and releasing particulates and gaseous species into the atmosphere are very influential and have an impact on the local aerosol environment. The current contribution of aerosols to the atmosphere is difficult to determine because they have shorter lifetimes and their distribution varies more than greenhouse gases (GHGs). Thus, the effect on the global climate is difficult to predict. Therefore, the accuracy and completeness of the aerosol depth monitoring system in the atmosphere is needed. Ground-based monitoring instruments will be used to determine current aerosol loads, characterize aerosols, measure pollution in the atmosphere which can be used as definitive measures of changes or future air quality modeling (Holben, 2001).

METHODOLOGY

Pontianak City is the capital of West Kalimantan Province. Pontianak City has an area of 118.31 km2 which consists of 6 sub-districts and 29 sub-districts. Pontianak City is traversed by the equator, which is located at 0º 02' 24" North Latitude to 0º 05' 37" South Latitude, and 109º 16' 25" East Longitude to 109º 23' 04" East Longitude. The height of Pontianak City ranges from 0.10 to 1.50 meters above sea level (masl).

The Pontianak City Administrative Map can be seen in the following figure.

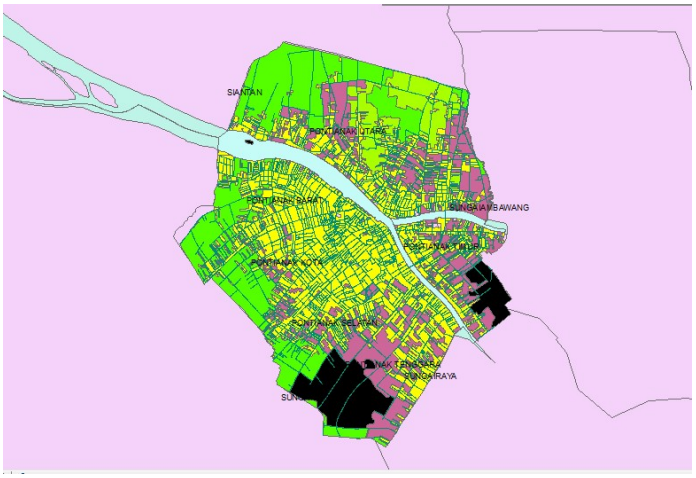


Figure 1. Study Area of Pontianak
(Pontianak, 2022)

The subdistrict in Pontianak City which has the largest area is North Pontianak Subdistrict (34.52 percent), followed by West Pontianak Subdistrict (15.71 percent), Pontianak Kota Subdistrict (14.39 percent), Southeast Pontianak District (13.75 percent), South Pontianak District (13.49 percent) and East Pontianak District (8.14 percent). The Pontianak City area there are many rivers and ditches, a total of 61 rivers/ditches, the river/ditch is used by some people for their daily needs and as a support for transportation facilities. Soil conditions in Pontianak City consist of Organosol, Gley, Humus, and Alluvial soil types, each of which has different characteristics Astronomically, Pontianak City is located between 0º 02' 24" North Latitude and 0º 05' 37" South Latitude and between 109º 16' 25" East Longitude to 109º 23' 04" East Longitude. Based on this specific geographical location, Pontianak City is directly traversed by the equator, thus making Pontianak City one of the tropical areas with quite high temperatures and high humidity.

Data Collection

The methodology used to analyze Aerosol Optical Depth (AOD) data comes from Google Earth Engine (GEE) data. Google Earth Engine is a cloud-based platform that enables large-scale processing of satellite imagery to detect changes, map trends and measure differences in the Earth's surface. Google Earth Engine is a very capable tool in monitoring the environment. This tool has been designed for geographers, scientists and researchers to enable them to quickly access and analyze more than 600 remote sensing datasets, including satellite imagery from 1970 to the present.

Earth Engine has a database of satellite imagery and remote sensing data. All the different datasets are tagged and each has ready-to-use code samples that allow you to jump right into Earth Engine's Code Editor and start exploring and analyzing the dataset. Earth Engine Code Editor is a web-based development environment for the Earth JavaScript API. The Code Editor features are designed to make developing complex geospatial workflows quick and easy.

The data used to analyze AOD on Google Earth Engine (GEE) uses MCD19A2.006 data: Terra & Aqua MAIAC Land Aerosol Optical Depth Daily 1km, MCD19A2 V6 data product is MODIS Terra and Aqua which incorporates Multi-angle Atmospheric Correction Implementation (MAIAC) A gridded Level 2 Land Aerosol Optical Depth (AOD) product that is produced every day with a resolution of 1 km. The measurement results of Particulate Matter data (PM10 and PM2.5) and meteorological factor data were obtained from secondary data from measurements carried out by the Pontianak City Ministry of Environment and Forestry (KLHK) monitoring station. The analysis carried out to determine the relationship and correlation of PM10, PM2.5 and AOD concentrations will use regression analysis, which will obtain the results of the equation to estimate the concentration of air quality parameters with AOD values. The AOD data obtained will also be related to meteorological factors which will affect the results of AOD image recording.

RESULT AND DISCUSSION

From the results of data processing carried out on the parameter values of AOD, PM2.5 and PM10 in Pontianak City in 2018-2019 respectively, the following results obtained AOD values with a range between 0.00-3.12. The air quality parameters PM2.5 obtained results with a range of concentration values between 0-436 µg/m3 and PM10 obtained results with a range of concentration values between 0-548 µg/m3.

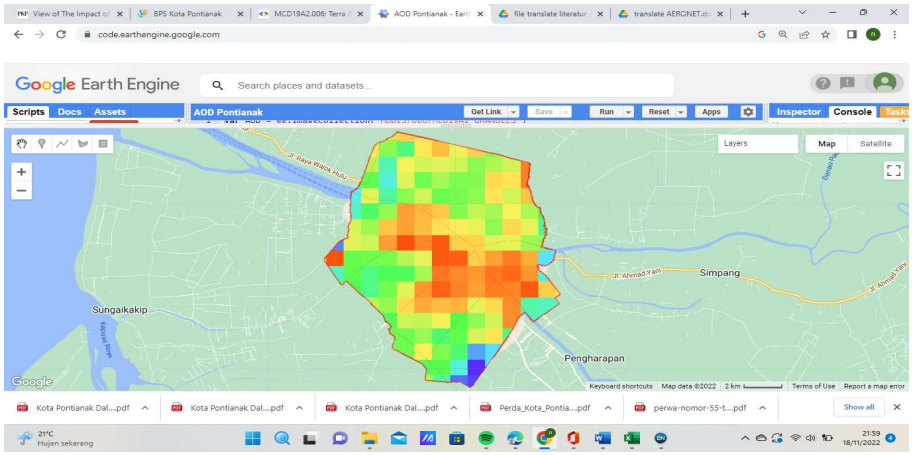


Figure 2. Measuring AOD using Google Earth Engine

The result of AOD values and concentration of particulate in Pontianak City in 2018 and 2019 presented in Figure as follows.

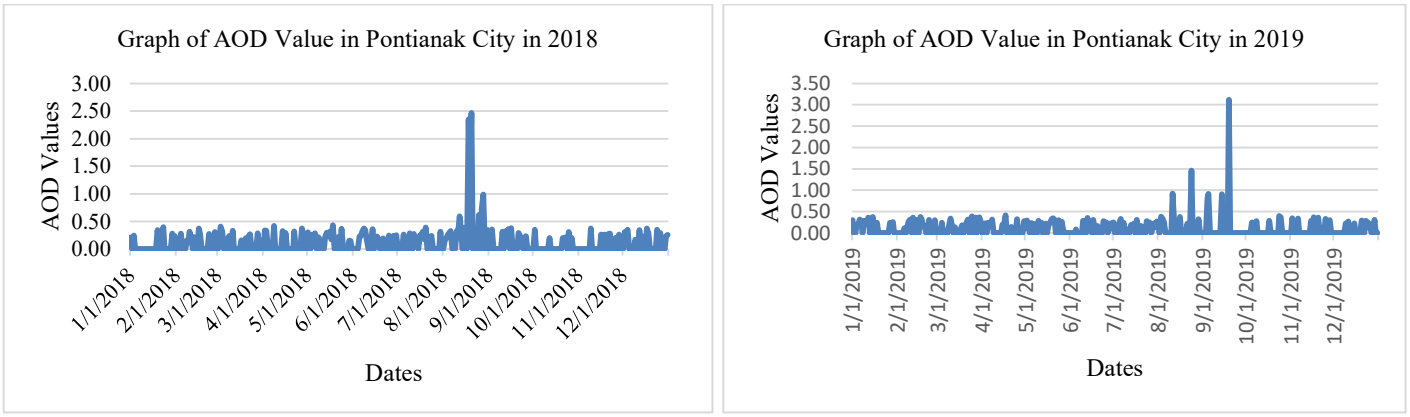


Figure 3. Graph of AOD Value in Pontianak City in 2018 and 2019

The result of of the relationship of PM10 and PM2.5 concentrations in Pontianak City 2018 and 2019 presented in Figure as follows.

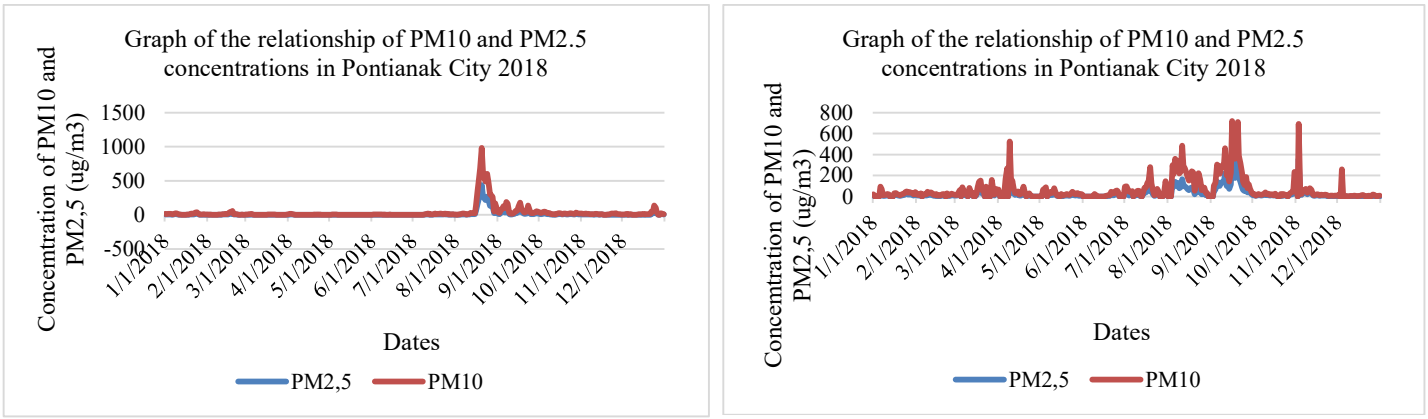


Figure 4. Graph the relationship of PM10 and PM2.5 concentrations in Pontianak City 2018 and 2019

The result of of the correlation of concentrations of PM10 and PM2.5 and AOD Values for monthly and daily in Pontianak City 2018 presented in Figure as follows.

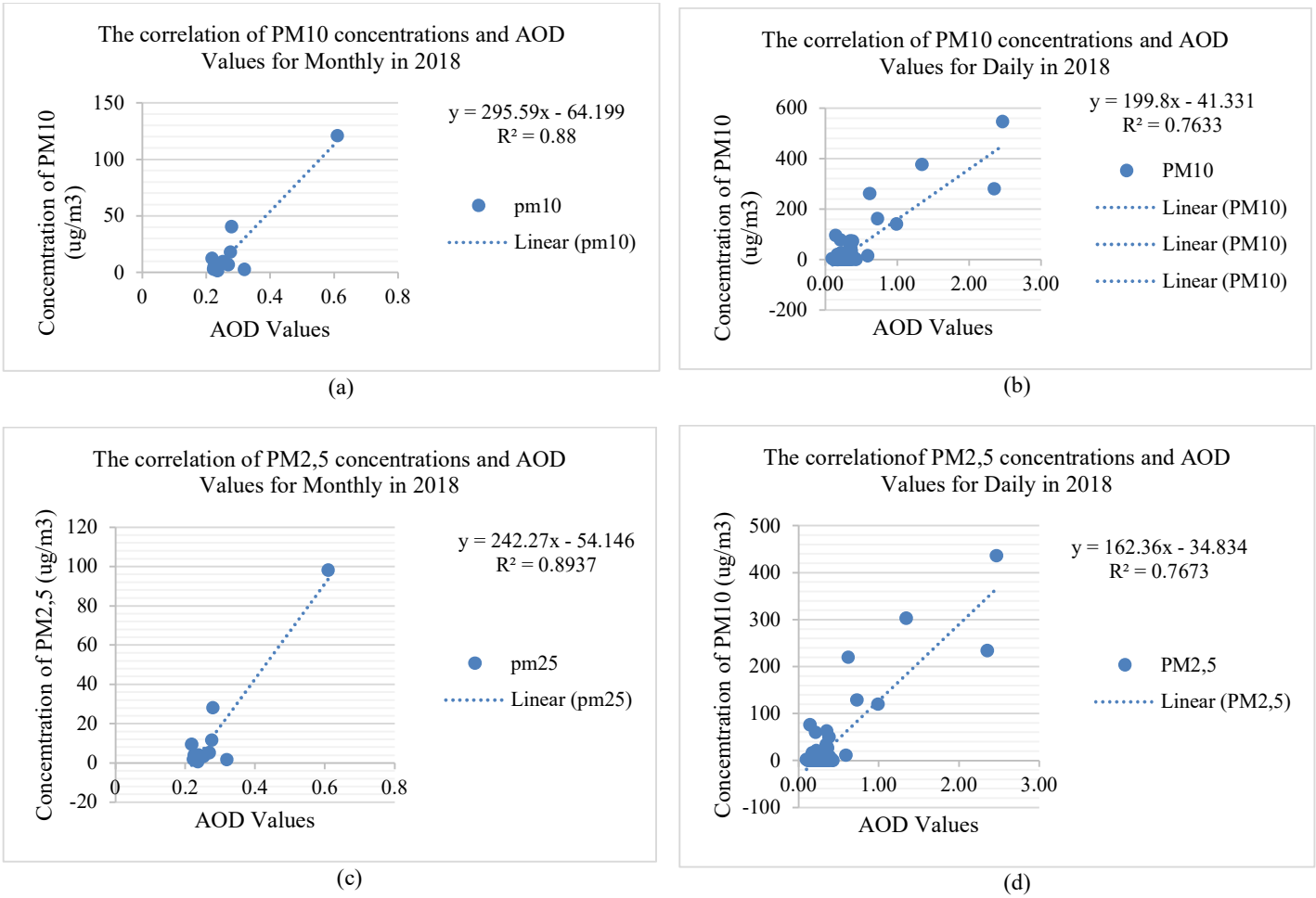


Figure 5. Graph the relationship of concentrations of PM10 and PM2.5 and AOD Values for monthly and daily in Pontianak City 2018

The result of of the correlation of concentrations of PM10 and PM2.5 and AOD Values for monthly and daily in Pontianak City 2019 presented in Figure as follow

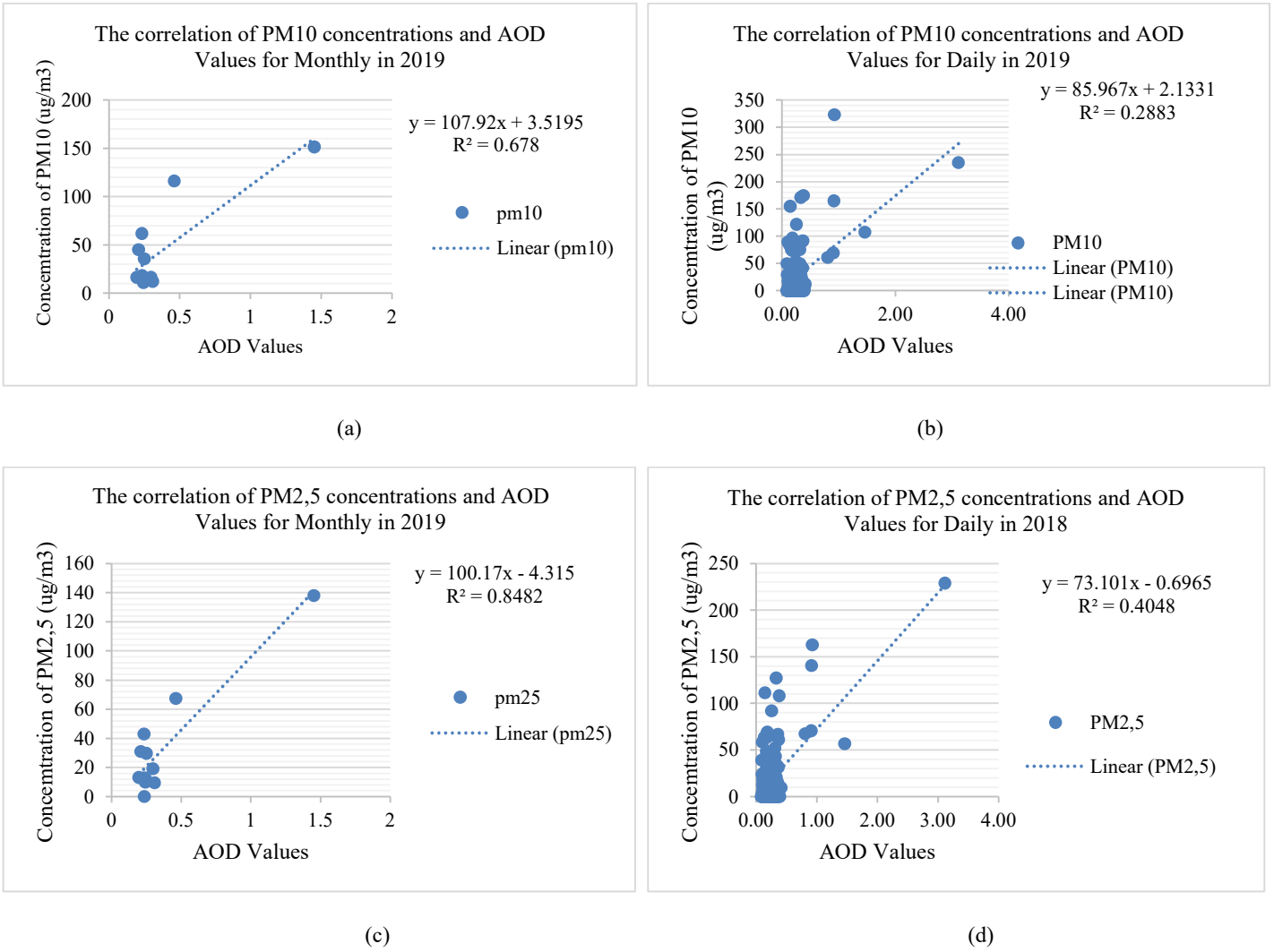


Figure 6. Graph the relationship of concentrations of PM10 and PM2.5 and AOD Values for monthly and daily in Pontianak City 2019

When viewed based on the trend plot of the relationship between PM10 and PM2.5 concentrations and AOD values from 2018-2019, several graphic images show the same pattern. When the particulate concentration value increases, the AOD value also increases. However, some chart patterns show the opposite relationship. Aerosol Optical Depth is a measurement that can usually express the size of the aerosol in optical depth from a measure of the proportion of solar radiation absorbed or scattered, then the measured aerosol is distributed in the air column from the surface of the earth to the upper atmosphere. AOD is an aerosol measure that has no dimensions and depends on the size of the wavelength. According to (Kazadzis, 2017) the visible size of AOD can be classified based on the source of the aerosol pollutant, namely as follows;
0.02 – very clean remote areas.
0.2 – moderately clean urban areas
0.4 – slightly polluted urban areas
0.6 – moderately polluted area
1.5 – heavy biomass burning or dust events
The results of the AOD values in Pontianak City in 2018-2019 obtained with a value range between 0.00-3.12 can be influenced by several factors and pollutant sources.
Sources of pollutants or aerosols that can affect the high AOD value and the concentration of air quality parameters PM10 and PM2.5, namely the presence of daily human activities including changes in land cover, burning of fossil fuels and emission of particulates into the atmosphere which are very influential and have an impact on the aerosol environment local. One of the contributions to aerosol income was obtained from the process or occurrence of forest fires in 2018-2019 in Pontianak City. Based on the results of the distribution of hotspots obtained from the website (https://sipongi.menlhk.go.id/) 2042 hotspots were recorded by three satellites, namely TERRA/AQUA, SNPP and NASA-MODIS, which are expressed with different levels of confidence. namely High (High), Medium (Medium) and Low (Low). The following is a number hotspot points in Pontianak City in 2018-2019.

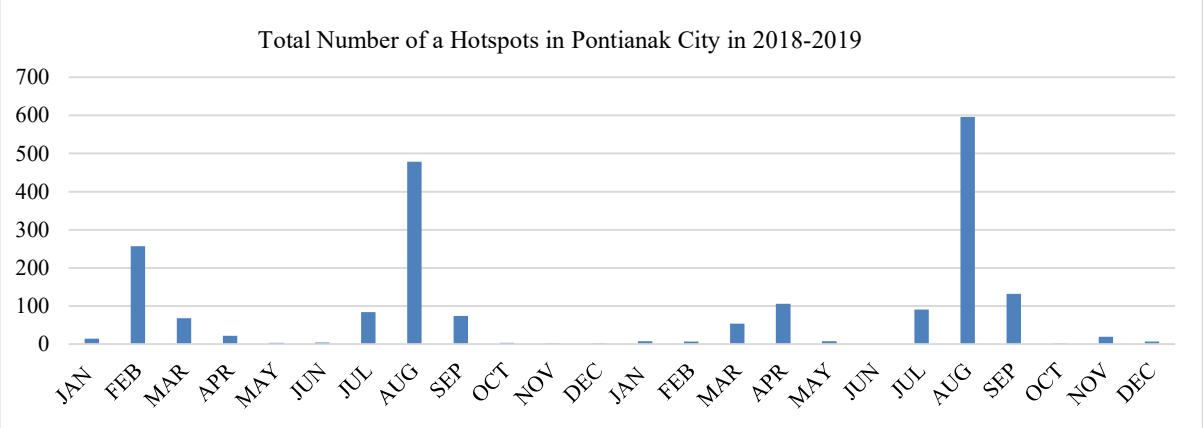
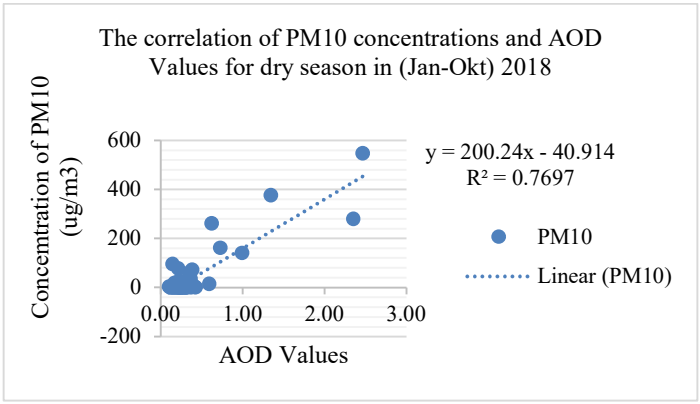


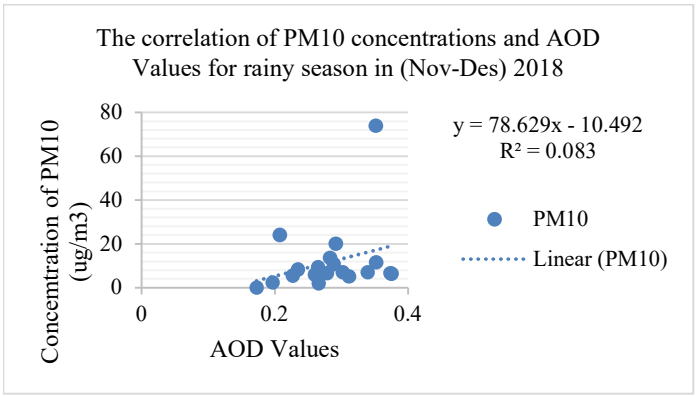
Figure 7. Total Number of a Hotspots in Pontianak City in 2018-2019

Meteorological factors also greatly affect the measurement of AOD values, because meteorological factors affect the spatial and temporal characteristics of aerosols in an area, such as changes in temperature, humidity, wind direction and wind speed, solar radiation and rainfall (Soedomo, 2001). This data will be used to see how much influence meteorological factors have on the AOD value. Based on meteorological factor data, humidity data will affect the relationship in cloud formation and the potential for rain. Changes in temperature will occur due to changes in the heating characteristics of the surface and reduce the intensity of sunlight. Wind speed and wind direction will affect the transport of pollutants carried by the dominant wind. Variations in changes in the rainy and dry seasons that occur in Indonesia are related to pollutant sources that will affect the AOD value, because the process of washing or cleaning aerosols that occurs will affect the accumulation of aerosols on the surface.

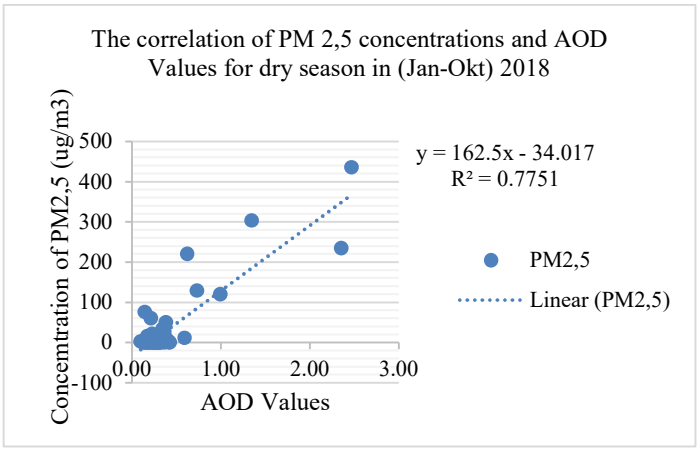
The following is the result of the statistical equation for the relationship between concentrations of PM10 and PM2.5 and AOD values for the rainy and dry seasons in Pontianak City in 2018.



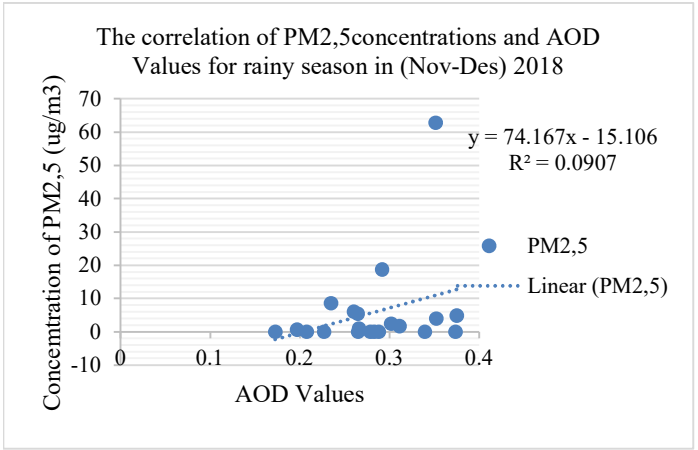
(a)



(b)



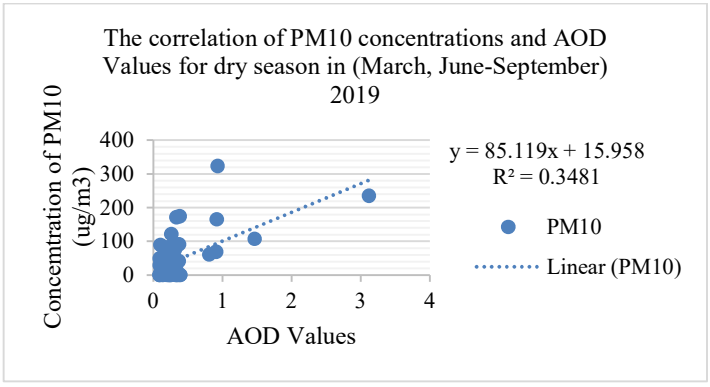
(c)



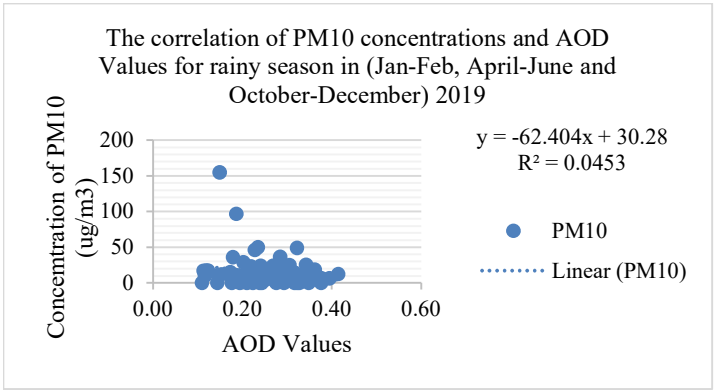
(d)

Figure 8. Graph of the correlation for the relationship between concentrations of PM10 and PM2.5 and AOD values for the rainy and dry seasons in Pontianak City in 2018

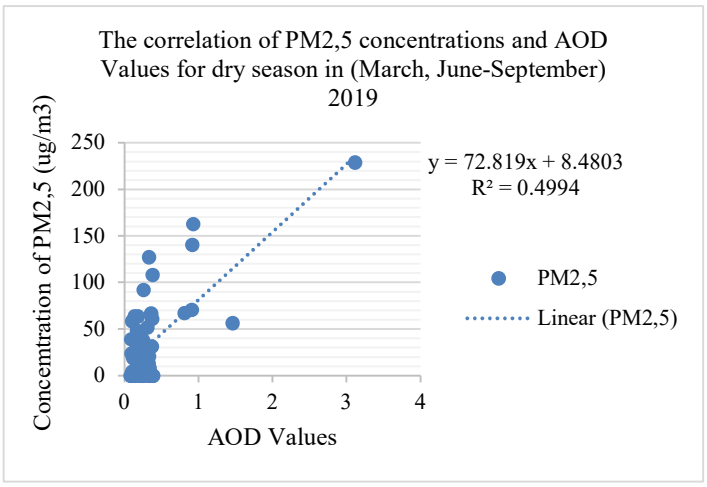
The following is the result of the statistical equation for the relationship between concentrations of PM10 and PM2.5 and AOD values for the rainy and dry seasons in Pontianak City in 2019.



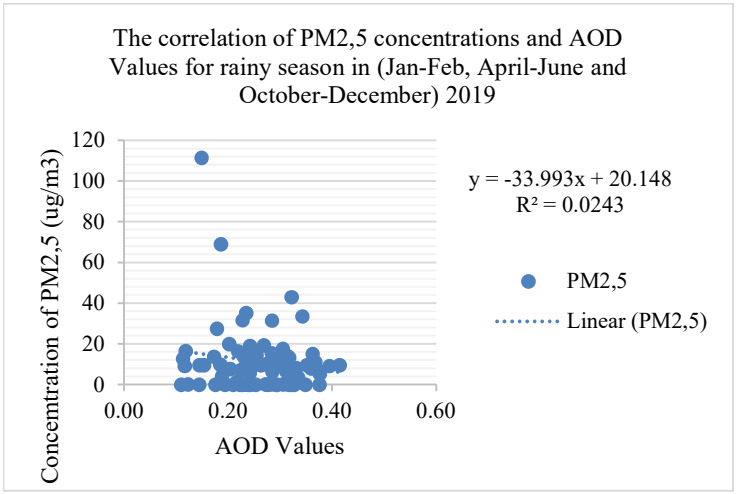
(a)



(b)



(c)



(d)

Figure 9. Graph of the correlation for the relationship between concentrations of PM10 and PM2.5 and AOD values for the rainy and dry seasons in Pontianak City in 2019

Based on the statistical results of the correlation between AOD values and concentrations of PM10 and PM2.5, it gives a positive correlation with a correlation coefficient of 0.88 0.8937 for monthly data and 0.7633 0.7673 for daily data in 2018 and a correlation coefficient of 0.678 0.8482 for monthly data and 0.2883 0.4048 for daily data in in 2019. In statistics there are 3 ranges of correlation coefficient values, where 0-0.3 has a weak correlation, 0.3-0.7 has a moderately strong correlation and 0.7-1.0 has a strong correlation. The positive correlation shows that the concentration of air quality parameters PM10 and PM2.5 with AOD values has the same trend. To obtain a stronger relationship or correlation, a correction factor is needed which can affect the value of the AOD relationship with air quality parameters.

CONCLUSION

Based on the result of this study, the conclusion is:

1. The relationship between PM10 and PM2.5 concentration values in Pontianak City in 2018-2019 shows a positive and significant correlation.
2. the concentrations of PM10 and PM2.5 air quality parameters with AOD values have the same trend with the results of a correlation coefficient of 0.88 0.8937 for monthly data and 0.7633 0.7673 for daily data in 2018 and a correlation coefficient of 0.678 0.8482 for monthly data and 0.2883 0.4048 for daily data in 2019.
3. A correction factor is needed to produce a stronger and more accurate correlation value.

BIBLIOGRAPHY

Holben, B. N. (2001). An emerging ground-based aerosol climatology: Aerosol optical depth from AERONET *JOURNAL OF GEOPHYSICAL RESEARCH, 106*(NO. Dll), 12,067-012,097.

Kazadzis, S. (2017). Aerosol optical depth ground-based sensors, homogenization activities between different networks.

NESDIS, N. (2012). GOES-R Advanced Baseline Imager (ABI) Algorithm Theoretical Basis Document For Suspended Matter/Aerosol Optical Depth and Aerosol Size Parameter.

KOTA PONTIANAK DALAM ANGKA 2022, (2022).

Soedomo, M. (2001). *Pencemaran Udara*. Bandung: ITB.