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Original Article

The Analysis of Meteorological Factors and Ambient Air Quality (PM_{10}, CO, SO_2, NO_2, and O_3) with the Incidence of Acute Respiratory Infection (ARI) in Tangerang City, Indonesia During 2010-2019

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Abstract

Tangerang City is a city with a high population, vehicles, and industries, so the pollutant emissions in the air are increasing. It has a high contribution in the occurrence of ARI (Acute Respiratory Infection). These pollutants are PM_{10}, CO, SO_2, NO_2, and O_3. In addition, meteorological factors such as air temperature, relative humidity, rainfall, wind velocity, and the length of sun exposure also affect the occurrence of the disease. Research Purposes: The purpose of this research is to find out how the correlation between meteorological factors and ambient air quality with the incidence of ARI in Tangerang City during 2010 to 2019. Research Methodology: This research uses analytic observational research, quantitative approaches, and retrospective cohort study design, also ecological study. The population used as a sample is all the data of meteorological factors, ambient air quality, and the incidence of ARI in Tangerang City during 2010 to 2019. Correlation analysis was performed using regression correlation analysis, simple linear regression test, and multiple linear regression test. Research Result: The result showed that meteorological factors and ambient air quality associated with the incidence of ARI are relative humidity (p = 0,039), rainfall (p = 0,044), wind velocity (p = 0,033), the length of sun exposure (p = 0,042), PM_{10}(p = 0,024), CO (p = 0,040), NO_2(p = 0,049), and O_3(p = 0,039)

Keywords: *Meteorological factors; Ambient air quality; Incidence of acute respiratory infection (ARI)*

Introduction

Global climate change as an implication of global warming has resulted in atmospheric instability in the lower layers, especially those close to the earth's surface. Global warming is expected to reach 1.5°C between 2030 and 2052 if it continues to increase at this time (Fleischmann 2018). In addition to climate change as an impact of global warming, in line with the development of physical development of cities, industrial center, and the development of transportation has caused air quality to also changes. Pollutant that are air pollutants include O_3, SO_2, NO_2, and PM_{10}. The impact of these four pollutants causes respiratory tract irritation. Based on the results of Riskesdas 2018, the prevalence of national ARI is 4,4%. The prevalence of ARI in Banten Province itself was recorded at 5% (Ministry of Health Indonesia 2018). The concentration of pollutants in the atmosphere is not just the

result of strong emissions but also due to meteorological factors (Pal 2014).

In addition to meteorological conditions, ambient air quality also has an effect on the occurrence of ARI disease. Tangerang is a city that is the center of the economy and government. The population growth of Tangerang City in 2013 to 2018 appears to be increasing. Vehicles sales in Tangerang City are dominated by two-wheeled vehicles, reaching 39.012 units. In addition, Tangerang City has 3.261 industries. Air pollution control is the second-largest environmental issue in 2018. In recent years, ARI became the disease with the highest number of sufferers in Tangerang City. This disease can be triggered by increased transportation activities or industry activities (Tangerang City Govermental 2018). Based on the review, the formulation of the problem in this research is how the correlation between meteorological factors and ambient air quality with the incidence of ARI in Tangerang City during 2010 to 2019. In addition, this research aims to find out how the correlation between meteorological factors and ambient air quality with the incidence of ARI in Tangerang City during 2010 to 2019.

Materials and Method

This research uses a type of analytical observational research with a quantitative approach and the research design used is a retrospective cohort and time-based ecological study (time trend analysis). This research was conducted in Tangerang City, Banten Province in March to June 2020. Similar to the population, the sample in this research is all data of meteorological factor, ambient air quality, and the incident of ARI in Tangerang City during 2010 to 2019. The data collection technique used in this research is a library research technique. All data used in this research was secondary data from 2010 to 2019. The data analysis used is univariate analysis, bivariate analysis, and multivariate analysis. Univariate analysis is performed to determine the frequency distribution of each variable. Bivariate analysis is performed using Pearson correlation test. Meanwhile, multivariate analysis is performed using multiple linear regression analysis.

Results

A) Univariate Analysis

Table 1. Statistical Distribution of Meteorological Factors, Ambient Air Quality, and The Incidence of ARI in Tangerang City During 2010-2019

Variable	Mean	Median	SD	Min-Max	95% CI
Air temperature	28.00	27.92	0.18	27.83 – 28.40	27.87 – 28.3
Relative humidity	80.59	81.08	1.36	78.55 – 82.35	79.62 – 81.56
Rainfall	10.82	10.20	2.30	7.97 – 13.72	9.177 – 12.47
Wind velocity	2.35	2.42	0.38	1.91 – 2.97	2.07 – 2.63
The length of sun exposure	5.31	5.40	0.80	4.05 – 6.38	4.74 – 5.89
PM_{10}	88.00	68.32	67.91	20.43 – 199.13	39.42 – 136.59
CO	3.433,51	3.509,85	1.757,82	97.31 – 5.468,40	2.176,04 – 4.690,98
SO_2	32.01	23.10	35.44	1.47 – 125.33	6.65 – 57.36
NO_2	34.62	15.71	42.46	5.39 – 141.02	4.25 – 65.00
O_3	34.02	33.04	19.60	0.01 – 70.70	19.99 – 48.04
ARI	2.65	2.08	1.38	1.50 – 5.64	1.66 – 3.64

B) Bivariate Analysis

Table 2. Simple Linear Correlation and Regression Analysis Results between Meteorological Factors and Ambient Air Quality with the Incidence of ARI in Tangerang City During 2010-2019

Variable	r	R^2	Line Equation	p-value
Air temperature	- 0.334	0.111	Y = 73.314 – 2.523 (air temperature)	0.346
Relative humidity	- 0.657	0.432	Y = 56.452 – 0.667 (relative humidity)	0.039
Rainfall	- 0.644	0.415	Y = 6.839 – 0.387 (rainfall)	0.044
Wind velocity	0.673	0.452	Y = - 2.980 + 2.392 (wind velocity)	0.033
The length of sun exposure	- 0.650	0.422	Y = 8.565 – 1.111 (the length of sun exposure)	0.042
PM_{10}	0.702	0.492	Y = 1.399 + 0.014 (PM_{10})	0.024
CO	- 0.654	0.428	Y = 4.421 – 0.001 (CO)	0.040
SO_2	0.096	0.009	Y = 2.536 + 0.004 (SO_2)	0.793
NO_2	0.633	0.401	Y = 1.942 + 0.021 (NO_2)	0.049
O_3	- 0.656	0.430	Y = 4.228 – 0.046 (O_3)	0.039

C) Multivariate Analysis

Table 3. Correlation Analysis Results, Multiple Linear Regression, Partial Test, and Simultaneous Test between Meteorological Factors and AmbientAir Quality with the Incidence of ARI in Tangerang City During 2010-2019

Variable	r	R^2	t	p-value	F	p-value
Air temperature	0.880	0.774	0.160	0.881	2.734	0.716
Relative humidity			- 0.389	0.717		
Rainfall			- 0.391	0.716		
Wind velocity			0.978	0.384		
The length of sun exposure			- 0.818	0.459		
PM_{10}	0.957	0.916	0.817	0.460	8.702	0.028
CO			- 1.085	0.339		
SO_2			- 0.390	0.716		
NO_2			2.204	0.092		
O_3			- 1.885	0.132		

Discussion

A) Univariate Analysis

Based on table 1, it is known that:

1) Meteorological Factors

a) Ai rtemperature

The air temperature in Tangerang City included in the high category. The average of air temperature continues to increase from year to year over a period of 10 years. The upward trend is still comparable to the trend of global temperature rise of 0,78 ± 0.18 °C(Change 2007).

b) Relative humidity

Relative humidity in Tangerang City included in the high category. In tropical country such as Indonesia, humidity levels are generally relative high with relatively constant air temperature, humidity levels unchanged much throughout the year (Karta sapoetra 2017).

c) Rainfall

The intensity of rainfall in Tangerang City included in the medium category tends to heavy. The rainfall in Indonesia consist of three types of rain, monsoon, equatorial, and local (Giarno *et al* 2018). Tangerang itself has a monsoon rain type that has maximum rain in the western season along with the rainy season and at least during the eastern season along

with the dry season.

d) Wind velocity

The wind speed in Tangerang City included in the weak wind category. Surface wind has a friction force due to the earth's uneven structure causing wind speeds to weaken (Yue *et al* 2021). Tangerang still has a lot of trees that are quite high, causing the force of wind friction to become large and causing wind speed to become low.

e) The length of sun exposure

The length of sun exposure in Tangerang City included in long duration category. The number of perpendicular buildings in urban areas leads to changes in heating balance. In addition, it is also affected by the lack of cloud growth that can block the scorching sun (Putra *et al* 2017)(Hakim 2018).

2) Ambient Air Quality

a) PM10 concentration

PM10 concentration in Tangerang City has passing through Treshold Limit Value (TLV) based on Indonesian Government Regulation No. 41 of 1999. Increasing the number of people in activity can increase emissions resulting from anthropogenic activities, both in the industrial and transportation sectors. One of the most numerous contaminants produced by anthropogenic activities is particulates. These emissions contribute significantly to warming the atmosphere, not only diffusing but also absorbing solar radiation (Lu *et al* 2015).

b) CO concentration

CO concentration in Tangerang City does not pass TLV. Slowing vehicle flow and traffic density are among the main factors in the increase in CO concentrations in the air. Vehicle exhaust emissions in traffic jams (stop position) can produce CO as much as 12 times higher than in smooth road condition (Gunawan 2015).

c) SO2 concentration

SO2 concentration in Tangerang City does not pass TLV. The source of SO2 is the combustion process and industrial process. The combustion process can produce SO2 is the burning of coal on electric generator and machinery. The industrial process that produce SO2 are petroleum refining industry, sulphuric acid industry, and steel smelting industry (Panayiotou *et al* 2017).

d) NO2 concentration

NO2 concentration in Tangerang City does not pass TLV. The highest sources of NO pollution in the air come from cars with gasoline fuel (32%), coal burning (19,4%), and industrial activities (1,0%) (Guan *et al* 2016). This is compounded by the number of congestion points in Tangerang City and NO2 concentration will be produced at the congestion point. The more congestion point, the higher NO2 concentration will produce.

e) O3 concentration

O3 concentration in Tangerang City does not pass TLV. Air pollution with ozone in the short term will increase respiratory inflammation (Pirozzi *et al* 2015). Conversely, for the long term it is closely related to respiratory function, as well as it can potentially be asthma.

3) Acute Respiratory Infection(ARI)

The prevalence of ARI in Tangerang City exceeds the National prevalence value based on Riskedas in 2018, which is 4,4%. It happened because Tangerang City is a thriving area and has tropical climate. ARI disease occur as a result contamination by particle pollutants produced from transportation, industrial process, and economic activity.

B) Bivariate Analysis

Based on table 2, it is known that:

1) The correlation between air temperature with the incident ofARI

There is no correlation between air temperature and the incidence of ARI. The higher temperature on the earth's surface then it's getting higher level of atmospheric instability of the atmosphere causes the concentration of polluting gas in ambient air become lower because the polluting gas easily moves upward vertically leaving the

earth's surface (Winardi 2014).

2) The correlation between relative humidity with the incidence ofARI

   There is a significant correlation between relative humidity with the incidence of ARI. When the relative humidity decrease, the concentration of pollutants will increase. This is caused when the relative humidity tends to be low the air condition will be dry, the source of pollutants will easily lifted and floated in the free air. So, it is easier to be exposed and will increase the concentration of particulate. The authors assumes that hot weather during the dry season can cause fatigue. The heat causes a lot of sweat to be released and become dehydration.

3) The correlation between rainfall with the incidence of ARI

   There is a significant correlation between the rainfall with the incidence of ARI. Heavy rainfall can help clean pollutants in the atmosphere through washing process that involves accumulation and absorption. One of the pollutants that are a risk factor of ARI disease is NO_2. Research shown that the concentration of NO_2will tend to decrease if the rainfall is relatively heavy (Yoo *et al* 2014). The author assumes that during the rainy season, people will tend to settle in a room that can increase the risk for cross-infection.

4) The correlation between wind velocity with the incidence of ARI

   There is a significant correlation between wind velocity with the incidence of ARI. Wind velocity is not a direct cause of ARI disease, but cause a great potential for pollutants exposure. The faster wind blows, the wider distribution areas affected by air pollution which causes small pollutants concentration (Rahmawati 2014). The authors assumes that wind in Tangerang City tends to carry pollutants far in all directions. Moreover, anthropogenic activity tends to be more active during theday.

5) The correlation between the length of sun exposure with the incidence of ARI

   There is a significant correlation between the length of sun exposure with the incidence of ARI. The high sun exposure during the day will make the pollutant concentration increase and decrease at night (Li *et al* 2014). Urban air pollutants (aerosol, dust, and oxidants) can reduce the intensity of sun exposure between 20% and 30%. It will cause the rising of the air temperature. The authors assumes that ths sun exposure has no direct effect on the incidence of ARI, but rather become a contributing factor to one of causes of the concentration ofpollutants.

6) The correlation between PM10concentration with the incidence of ARI

   There is a significant correlation between PM10concentration with the incidence of ARI. It is known that emissions from the transportation sector produced by the District Tangerang, South Jakarta, and Tangerang City. The pollutants was carried away by the wind and accumulates in the direction of the wind (Noor and Sofyan 2012). The authors assume that ARI occurs in Tangerang City due to the concentration of PM10 from the industrial sector, increase number of vehicles, and burning fuel processes.

7) The correlation between CO concentrations with the incident ofARI

   There is a significant correlation between CO concentrations with the incidence of ARI. Incomplete combustion of fossil fuels in motor vehicle engine produces various kinds of pollutants that are emitted into the air. Traffic jams in Tangerang City are quite frequent. In addition, there are also many traffic light points. High traffic density causes an increase in CO concentrations, where motorcycles are the main source of CO pollutants (Rahmawati 2014).

8) The correlation between SO2concentrations with the incidence of ARI

   There is no correlation between SO2concentration with the incidence of ARI. The air incident in very likely to occur due to SO2which is generated from exhaust gases from motor vehicle fuels. WHO determines that SO2is included in the category of pollutants that are very dangerous or toxic to human health [21]. However, the

increase in the number of ARI incidents in Tangerang City is not dominated by SO2, but it caused by the other factors. The authors assumes that SO2tends to be more produced by burning coal, especially coal with a high sulfur content.

9) The correlation between NO2concentrations with the incident of ARI

There is a significant correlation between NO2concentration and the incidence of ARI. Motor vehicle emissions contribute 73% of NO2as a pollutant in the air. NO2inhalation can lead to decreased lung function, increasing the frequency of infection depending on the concentration and mode of exposure (Pospelov *et al*2020).

10) The correlation between O3 concentrations with the incident of ARI

There is a significant correlation between O3concentration with the incidence of ARI. Ozone can damage body cells through lung parenchyma cells, both alveolar and matrix cells. Research on a minimum of 6 hours of exposure or lung function (Wagner *et al* 2020). The authors assumes that O3can affect the incidence of ARI because it is a secondary pollutant that is more solubility than SO2and NO2, so it can causes cough symptoms, dry throat, chest pain, and also headache.

C) Multivariate Analysis

Based on table 3, it is known that:

1) The correlation between meteorological factors with the incidence ofARI

The correlation between meteorological factors with the incidence of ARI shows a very strong correlation and positive pattern. Meanwhile, based on table 3, known that meteorological factors does not affect the incidence of ARI, either partially or simultaneously. Pollutant concentration in the atmosphere not only the result of strong emission but also due to meteorological factors (Pal 2014). Pollutant concentration in the air can be affected by meteorological factors, such as wind direction, highly dynamic atmospheric stability, either temporal or spatial (Guo *et al* 2016). The authors assumes that urban activity has been shown to bring changes to meteorological factors that will have a major influence in the spread of air pollution emissions. It cause increased pollution exposure and leading to the incidence of ARI.

2) The correlation between ambient air quality with the incident ofARI

The correlation between ambient air quality with the incidence of ARI shows a very strong correlation and positive pattern. Meanwhile, based on table 3, known that ambient air quality does not affect the incidence of ARI partially. However, it affect simultaneously. When an area's ambient air quality is not good, it indicates that air pollution has occurred (Zeng & Zhang 2017). The authors assumes that increasing pollution is not only caused by a growing population, but also because of the growing human needs year to years, either quantity and quality. So, the industrial waste is also increasing.

Conclusion

Based on the results of the research and discussion that have been outlined, the following conclusions can be drawn: meteorological factors conditions in Tangerang City during 2010 to 2019, including high category of air temperature, high category of relative humidity, rainfall with moderate category tends to be heavy, weak wind speed category, and the length of sun exposure with longduration. The concentration of ambient air qualiy polluting parameters in Tangerang City during 2010 to 2019 does not exceed the Treshold Limit Value(TLV). The prevalence of ARI incidence in Tangerang City during 2010 to 2019 is included in lowcategory. There is a significant correlation between the relative humidity, rainfall, wind velocity, the length of sun exposure, PM_{10}, CO, NO_2, and O_3concentration with the incidence ofARI.There is no correlation between air temperature and SO_2concentration with the incidence ofARI. Meteorological factors has no spatial and simultaneously affect on the incidence ofARI. Ambient air quality has no spatial effect on the incidence of ARI. However, it simultaneously affects the incidence of ARI.

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Conflicts of Interest

The authors declare no conflict of interest.

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