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Rain effects on the air pollution (i.e., PM1, PM2.5, PM10, CO, and CO_2)

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ABSTRACT

The purpose of this study is to identify the impact of rain on the quality of the surrounding air by looking at indications of CO, CO_2, PM1, PM2.5, and PM10 gas and comparing them with Environmental policy. In this study we conducted research by measuring several parameters before and after rain. To support this research, we also calculated the number of vehicles that passed in that time period. As a model we chose Bandung as a research place because the city is one of the big cities in Indonesia and is a tourism city as well. we also compare the financial calculations that can be affected by this pollution. Results show that Bandung has a high level of air pollution even though it is still below the threshold. After rain, the concentration of pollution levels decreases. In terms of policy, Bandung still has a fairly healthy air because there are still many plants. The economic aspect of Bandung has a strong tourist attraction. An example of air control policy is found in the regulation of the city of Bandung in number 06 of 2011 concerning the implementation, protection, and management of the environment and West Java provincial regulation number 11 of 2006 concerning air pollution control. The policy states the emission threshold that should be released so as not to pollute air quality. Especially, this study focused on the city of Bandung, but vehicles must be limited to maintaining the air quality. In conclusion, this study can be used as a reference for policy makers so that we can protect the environment.

Keywords: Air pollution; impact of rain; pollution; rain effects.

INTRODUCTION

Air pollution is produced by several factors, including industrial products, vehicle fumes, and other electronic materials that produce gas emissions (Klumpp *et al.,* 1998; Van Herk *et al.,* 2003). Air pollutions are being produced over time, but one of the things that can affect the quality of air pollution is rain. Rain can affect the air quality in a place (Akimoto, *et al.,* 2003). There are several parameters for measuring impact air quality after rain (Singh *et al.,* 2013; Gunn & Phillips, 1957).

Many studies have been reported as research by Rosenfeld. In this study, they explained that urban air pollution and industry can kill rainfall from clouds that have temperatures above -10°C (Rosenfeld, 2000), while another study explained that the increase in the concentration of aerosols produced by air pollution resulted in a decrease in the incidence of rain observed in this study (Qian, 2009). In the research presented by Brook *at al.* (2010), the research described that exposure to particulate air pollution contributes to cardiovascular morbidity and mortality; this makes decreasing PM levels associated with a reduction in cardiovascular mortality in the shortest period of years in the United States (Brook, 2010), and so also with research Calculation of kinetic parameters from DTA curves using the characteristic temperature (Luo, 1995), while research on environmental policy is discussed in the study. It provides an explanation of the level of pollution variation that will directly influence decision making on environmental policy

and make the references needed in making this research related to environmental policy (Crepaz, 1995). Although their models have been referred to by many reports, the methods they use still have limitations, mainly in recognizing the effects of air pollution directly after rain at a place that is measured by looking at the quality of CO, CO_2 and particulate matter. Moreover, there is still little literature currently linking the impact of air pollution to environmental policy.

The purpose of this study is to identify the impact of rain on the quality of the surrounding air by looking at indications of CO, CO_2, PM1, PM2.5, and PM10 gas and comparing them with Environmental policy. In this study, we measured several parameters (CO, CO_2, PM1, PM2.5, and PM10). To support this research, we also counted the number of vehicles that passed in that time period. Based on our calculated data, there are a total of 1682 vehicles divided into 3 categories, which are motor bikes, cars, and trucks. As a model, we selected Bandung as a research place as one of the big cities in Indonesia and as a tourist city (Abdullah *et al.*, 2018). We also compare the financial calculations that can be affected by this pollution. Results show that Bandung has high air pollution levels even though it is still below the threshold. After rain, the concentration of pollution levels decreases. In terms of policy, Bandung still has a fairly healthy air because there are still many plants. In terms of economy, Bandung has a strong tourist attraction, but vehicles must be limited to maintaining the air quality. In conclusion, this study can be used as a reference for policy makers so that we can protect the environment.

METHOD

This research was conducted on March 30, 2019, starting at 6:30 a.m. - 1:40 p.m. (Indonesian time) with the time span of each hour taking existing data. We conducted this research with 3 tools, namely, HT-200 (CO_2 meter), air quality monitor, and Benetech GM8805 (carbon monoxide monitor). This research was conducted in the city of Bandung, precisely on the street along the University Computer Indonesia campus. So this research takes 2 points of traffic, one headed for upper Dago and anther headed for Monument Perjuangan (see Figures 1 and 2).

Fig. 1. Location of Bandung.

Fig. 2. Location study, Dipatiukur street.

In this study we conducted research by measuring several parameters (CO, CO_2, PM1, PM2.5, and PM10) before and after rain. The aim of this is to see whether the rain impacts the content of particulates in the area, so that the results of this study can be seen on whether rain can reduce its levels or not. To support this research we also counted the number of vehicles that passed in that time period. As a model we chose Bandung as a research place as one of the big cities in Indonesia and a tourist city. The choice of Dipatiukur is deemed valid as the location because it is a busy road due to the existence trade, education, and other economic activities in the area and it is the road to the tourist location of Monument Perjuangan and an alternative road to Gedung Sate.

RESULTS AND DISCUSSION

Particulates are solids or liquids dispersed in air smaller than a single molecule (0.0002 mm) and smaller than 500 mm (Goembira, 2014**).** The air we breathe consists of particles that are mutually integrated, and the air quality of a place is affected by air particles that are good or bad. It can be said somewhere that the air is healthy if the particulates contained in a place are still in the range of 0 - 50. The figure is calculated from several parameters, namely, Carbon monoxide (CO), carbon dioxide (CO_2), and particulate matter (PM10) (Nandiyanto *et al*., 2018). From the research conducted, there are some results that show air quality in Bandung, especially in the Indonesian Computer University environment.

Suspended Particulate Matter (SPM) is a very complicated mixture of various organic and inorganic compounds that are spread in air with very small diameters, ranging from <1 micron to a maximum of 500 microns. The dust particulate will be in the air for a relatively long time in a state of floating in the air and into the human body through the respiratory tract. Naturally particulate dust can be produced from dry soil dust carried by the wind (Table 1) (Kurniawati, 2016).

Table 1. Air quality data.

Time	CO_2	CO	Air Quality Monitor					Temperature (celcius)	Average RH
	ppm	ppm	PM2.5	PM1	PM10	HCHO	TVQC		
06.30	563	0	34	22	45	0,038	0,016	23,67	82,45%
07.30	561	0	48	27	59	0,023	0,194	25,5	78,7%
08.30	565	5	72	44	93	0,01	0,397	26,1	76,25%
09.30	557	0	40	22	49	0,046	0,024	28,5	66,55%
10.30	539	2	35	20	44	0,016	0,222	26,7	66,35%
Rain									
11.40	526	0	42	26	54	0,03	0,155	29,2	33,96%
12.40	525	1	24	15	31	0,025	0,115	28,5	32,35%
13.40	526	0	34	22	45	0,041	0,041	29,8	30,14%

Table 1 describes air quality that is calculated once every hour in the time of 06.30 AM to 01.40 PM. The highest levels of ppm for CO_2 are found after the rain, unlike the most significant CO (Carbon Monoxide) content, when the third piece of data is still in the working departure hour.

Particulate meter data tends to be the same between PM 1.0, PM 10, PM 2.5, and Carbon Monoxide (CO). The fourth piece of data continues to decline one hour after the work departure hour range and slightly rises some time after the rain. But rain has a positive impact in an effort to reduce the level of air pollution, as evidenced by the data taken after the rain the level of air pollution decreases and the impact on both health and the environment. The air threshold value in the air pollution unit index is divided into several within a certain range of numbers (Table 2) (Widodo & Andrian, 2015).

Table 2 explains that the number of particulates in the graph shows the average air quality in the medium category. This is quite good considering that the number of vehicles is increasing every time. However, on the other hand it is necessary to make a policy to reduce air pollution so that it does not fall into the category of being unhealthy. Good relations between the population and the policies set by environmentalists and government agencies are needed to maintain air quality.

Table 2. Air pollution unit index.

Index	Category
1 – 50	Healthy
51 – 100	Medium
101 – 199	Not Healthy
200 – 299	Very not healthy
> 300	Dangerous

Based on Table 2, Bandung, based on the air pollution / ISPU standard index that is updated by the Ministry of Environment and Forestry last time on June 13, 2019, has a value of 23 with SO2 parameters, which means it is good. This research was conducted by calculating the number of vehicles passing in a certain period of time to see the graph of vehicle data and then compare it with the amount of air pollution obtained. Vehicle data calculated can be seen in Figure 5.

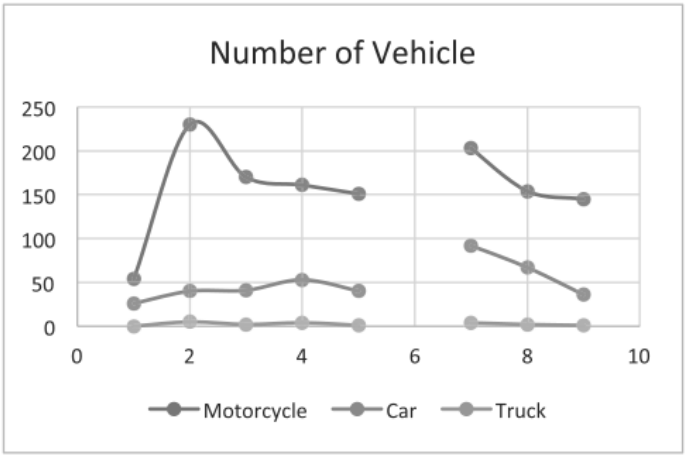

Fig. 3. Number of vehicles.

The data on the number of vehicles we take takes into account two things, namely, before and after rain. From the above data we can see that the most significant number of vehicles is during working hours, which is between 07.00 and 08.00, and increases again some time after rain. But when rain occurs it decreases air pollution; this is because the ambient temperature becomes moist and pollutants in the air are carried by rainwater. On the other hand, the number of vehicles affects the quality of the surrounding air. The more vehicles pass, the more air quality around them decreases. Vehicles produce CO gas which is harmful to the surrounding air (Syarifuddin, 2017); if the use of vehicles in an area increases, the air quality decreases.

Bandung is a city that is well-known in Indonesia and abroad as a tourist city with good air quality, cool and natural air (Katerina *et al.,* 2012). From the data taken, it shows that Bandung's air quality peaks close to 93, calculated from PM.10, which means it is still medium. However, the figure will certainly continue to rise if the use of vehicles continues to increase, so good policies from the local government are needed to maintain air quality in the city of Bandung to keep it comfortable, cool, and healthy. With the existence of policies that pay attention to the environment, it can attract tourists to visit the city of Bandung and the regional economy will continue to increase from the tourism sector. At this point, policies that help with air control are found in the regional regulation of the city of Bandung number 06 of 2011 concerning the implementation, protection and management of the environment and the West Java provincial regulation number 11 of 2006 concerning air pollution control. The policy states the emission threshold that should be released so as not to pollute air quality. Found in article 21 in the regional regulation of the city of Bandung number 06 of 2011 name which is everyone who issues emissions and/or disturbances from both movable and immovable sources, it must meet the emission quality requirements and/or disturbances specified. So this reference is in accordance with the table described in the explanation above.

CONCLUSION

This study succeeded in measuring air quality in a certain period of time which can then be used as a reference for taking environmentally oriented policies. This policy needs to be considered and realized because it affects the economic sector which is very vital in life to maintain regional economic balance. Literature that discusses air quality in Bandung is still very limited, so there are not many references that provide concrete data to be used as a reference in making environmental policies. This research is expected to be a reference in taking policies that affect the economy.

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