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AIR POLLUTION OF CARBON MONOXIDE: A CASE STUDY ON CITY TRAFFIC JAM

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ABSTRACT

Data of Environmental Agency states that the highest CO concentration is in Bundaran HI Jakarta. In 2015, CO concentration was572.760 µg/Nm^3, while in 2016, CO concentration was 798.690 µg/Nm^3. This research aims at identifying the differences of carbon monoxide concentration in Bundaran HI based on time. It used cross-sectional design with anova test as statistical analysis. This research was conducted onApril – June 2017. The results of univariate analysis found that vehicles passing Bundaran HI in the morning at the average was 2364 units, in the afternoon 1793 units and in the evening 2806 units with the mean level of carbon monoxide in the morning was 32217.5 µg/Nm^3, in the afternoon 30072 µg/Nm^3 an in the evening 33770,5 µg/Nm^3. The results of bivariate analysis using ANOVA test show that there were differences in carbon monoxide (CO) concentration in Bundaran HI (Sudirman) based on sample collection time wherep < 0.05. It can be concluded that CO concentration in Bundaran HI (Sudirman) is high and it is suggested that people should use the public transportation, the government should provide counseling and promoting health, using the standard euro 4, and revitalization of the vehicle over 20 years.

KEY WORDS : Air pollution, Carbonmonoxide, CO, Vehicle, Traffic jam

INTRODUCTION

DKI Jakarta is the capital of the Republic of Indonesia and as a metropolitan city as well as the center of economic and trade, complicated problems in transportation is unavoidable. The large population with increasing purchasing power has made the number of vehicle ownership to increase. This condition is aggravated by hundred thousands of vehicles from outside Jakarta going to this city everyday (Central Bureau of Statistics, 2015).

The impact of the great number of vehicle means more residual oil fuel combustion. Motor vehicle discharges residual fuel oil combustion in the form of Carbon Monoxide (CO), Carbon Dioxide (CO_2), Nitrogen Oxide (NO), Carbon (C), Hydrocarbon (HC), Aldehyde and Lead (Pb) contributing to air pollution. Air pollution is any discharge of substance into the environment that cause harm to the source (Hill, 2010).

One of the air pollutants from motor vehicles is Carbon monoxide (CO). CO will enter the blood through the lung and bind the hemoglobin, substance in blood that delivers oxygen to the cells so that it reduces the oxygen reaching to the organs and tissues. In the worst case, people with cardiovascular disease such as coronary artery is at the highest risk. The symptoms of CO poisoning are headache, fatigue, dizziness, and nausea. CO poisoning can happen faster in people who are more susceptible such as young people, elderly, and patients with lung or coronary diseases (Harper and Croft-Baker, 2012). Air pollution is linked to deadly diseases and infections that nearly 600,000 children under five die every year (World Health Organization, 2014). Pneumonia accounts for 16% of all deaths of children under five years old(World Health Organization, 2019) and more than half the deaths caused by pneumonia in children is associated with air pollution (Darrow *et al.*, 2014) CO

inhaled to the lung, together with hemoglobin will form carboxyhemoglobin that binds with 250 times higher affinity than oxygen (Hall, 2017).

Indonesia is the third-worst air pollution countries in the world. Contribution of motor vehicle gas emission as the highest source of air pollution is about 60 – 70%, compared to industrial waste of 10 – 15%. The remaining comes from household waste incineration, forest fires/field burning, etc. In the research of (Gunawan, Hendra; Ruslinda,Yenni and Anggela, n.d.). The highest concentration of CO at Jalan Perintis Kemerdekaan was 376.99 µg/Nm^3, at Jalan Bagindo Aziz Chan was 331.95 µg/Nm^3, and at Jalan Raya by Pass was 285.16 µg/Nm^3. The pattern of CO concentration was in line with the volume and traffic density, that on Friday it increases since 07.00 WIB and reaching the peak hour at 15.00 – 18.00 WIB and then decreases since 06.00 WIB until dawn.

In the research of (Sudarno, Novalia and Handayani, 2013) the highest concentration of CO at Jalan Ahmad Yaniarea Simpang Lima, Semarang, was on Tuesday at 07.00-08.00 of 18 ppm (20.613 µg/Nm^3). While (Kusumaningtiar and Ardillah, 2016) found that CO reaches its highest concentration in the morning of 662.63 µg/m^3, in the afternoon of 606.57 µg/m^3, and the lowest was 466.63 µg/m^3 at night. In addition, (Jansen, 2012) stated that the CO level at Jalan Sam Ratulangi, Manado was highest during the working days (Monday) by 115,577.07 µg/m^3, while on Saturday, it was 1,028.31 ug/m^3, on Sunday was 9809.96 µg/m^3.

Based on the data obtained from Environmental Agency, from the 5 spots (Bundaran HI, Kelapa Gading, Kelapa Gading, Jagakarsa, Lubang Buaya, Kebon Jeruk) of Air Pollution Index in 2016, Bundaran HI has the highest CO concentration compared to the other 4 spots of Air pollution Index where Kelapa Gading has 769.820 µg/Nm^3, Jagakarsa 440.110 µg/Nm^3, Lubang Buaya 201.910 µg/Nm^3 and Kebon Jeruk 517.080 µg/Nm^3.

Bundaran HI is an area in South Jakarta with busy traffic every day. Based on the preliminary study obtained from Sanitary Agency of DKI Jakarta, Bundaran HI has the highest concentration of CO in 2016. During 2015 to 2016, CO level increased from 572.760 µg/Nm^3 in 2015 with the average 1.610 µg/Nm^3 per year to 798.690 µg/Nm^3 in 2016 with the average 2.280 µg/Nm^3 per year.

The preliminary study was conducted by direct observation in the morning, afternoon, and evening on the number of vehicles passing in Bundaraan Hotel Indonesia (HI) area for 15 minutes. It obtained that in the morning (06.00 – 09.00) the number of vehicle passing this area for15 minutes was 211 units. In the afternoon (11.00- 14.00) the number of vehicles passing this area for 15 minutes was 135 units, while in the evening (16.00 – 19.00), it was 250 units. Based on the data obtained from the Environmental Agency, the concentration of CO in Bundaran HI in increasing each year.

Methods

This research used a quantitative approach with cross-sectional design. This research is aimed to analyze the differences in carbon monoxide levels based on time and case study in Bundaran HI (Sudirman). The population of this research was air pollutants in the form of carbon monoxide in Bundaran HI obtained from direct measurement. The sampling was conducted in 2 spots which wasat Jendral Sudirman and Bundaran HI during the peak hours in the morning (06.00-09.00 WIB), afternoon (11.00 – 14.00 WIB) and evening (16.00-19.00 WIB). CO concentration testing was based on SNI 7119.10:2011 regarding ambient air using Non-Dispersive Infra Red (NDIR) method.

Principle

CO analysis tools worked based on infrared absorption by analyte. The infrared was non-dispersive infrared. Zero gas dan sample test were included in the measurement cell in a constant amount and set by solenoid valve that was running for a certain period. The measurement is based on the capacity of CO in absorbing infrared. The intensity of the light absorbed was proportional to CO concentration. With this condition, the analysis tools would use modulation that occurred due to infrared absorption by the sample test. The infrared produced by the source directed to the measurement tube then entered to the detector. Energy from infrared passed through the measurement tube was then absorbed by the sample test. If the sample test flows into the tube, the infrared energy entering the detector would fluctuate according to the intensity of infrared absorbed by the sample test. The detector has a membrane to measure the pressure fluctuation of the sample test. Pressure fluctuation happens when there is a gap between the amount of infrared absorbed by the sample test and zero gas inside the cell. This gap creates fluctuation that is equivalent to the pressure gap in the membrane. Then, it was converted into amplified electrical fluctuating signal.

Materials

1. Zero Gas : N2 or He containing less than 0.1 ppm CO
2. Master range gas : standard CO for full scale 80% to calibrate instrument range and
3. Working range gas: standard CO required for linearity test with the range of 10%; 20%; 50% and 80% from full scale.

Tools

1. CO sample collecting bag (Tedlar Bag)
2. CO measuring tool with NDIR detector

Carbonmonoxide (CO) testing

Condition the measuring tool for measurement, make sure that the tools are calibrated according to the calibration curve instruction, connect the container of CO sample test into the gas inlet of the measurement tool, and then measure and record the data.

Counting of motor vehicle

The vehicle passing Bundaran HI was counted using Stop Watch for 3 hours in the morning (06.00-09.00 WIB), afternoon (11.00 – 14.00 WIB) and evening (16.00-19.00 WIB). The number of vehicles passing the area was recorded.

Data Analysis

The data was analyzed using univariate and bivariate analysis. Univariate analysis was to explain or describe the frequency distribution of each variable under study. Bivariate analysis was conducted using ANOVA test with a condition that the data was normally distributed. Moreover, Kruskall Walls test was utilized if the data was not normally distributed.

RESULTS

This research was conducted in urban traffic jams. in this study stated that the highest air testing is in the afternoon compared to morning or afternoon. In this research, the distribution of vehicle is divided into 2 spot which is in Bundaran HI and Jalan Jendral Sudirman as presented in Table 1 below:

Based on the results in Table 1, it shows that the greatest number of vehicle in Bundaran HI is during the evening as many as 2871 units, while the least number is in the afternoon of 1877 units. The greatest number of vehicle at Jalan Jendral Sudirman based on Table 1. is in the evening of 2741 units, while the least number is during the afternoon amounted to 1708 units.

According to the results of the research, the average number of vehicle passing Bundaran HI and Jalan Jendral Sudirman is 2806 unit at the highest during the evening and 1793 units at the lowest during the afternoon. This is in line with the research by (Sengkey, 2011)that in Manado, the greatest number of vehicles is in the evening.

In this research, carbon monoxide levels are collected in 2 different places which is in Bundaran HI and at Jalan Jendral Sudirman.

Overview of Carbon Monoxide Concentration in Bundaran HI

Carbon Monoxide sample collection in Bundaran HI was conducted in 3 times: in the morning 06.00 – 09.00 WIB, in the afternoon 11.00 – 14.00 WIB and in the evening 16.00 – 19.00 WIB.

According to the results of the research, carbon moxide concentration in Bundaran HI in the morning is 324355 µg/Nm^3, in the afternoon 30058µg/Nm^3 and the evening 34006 µg/Nm^3. The air quality standard for CO concentration in 1 hour according to Law number 41 of 1999 is 30.000 µg/Nm^3.

Overview of Carbon Monoxide Concentration at Jalan Jendral Sudirman Based on Time

In this research, carbon monoxide sampling at Jalan Jendral Sudirman was conducted in 3 times: in the morning 06.00 – 09.00 WIB, in the afternoon 11.00 – 14.00 WIB and in the evening 16.00 – 19.00 WIB.

According to the results, carbon monoxide concentration at Jalan Jendral Sudirman in the morning is 32000 µg/Nm^3, in the afternoon 30086 µg/Nm^3 and in the evening 33535 µg/Nm^3. The air

Table 1. Distribution of Vehiclein Bundaran HI (Jendral Sudirman) Based on Time

Sample Collection Time	Sampling Collection Spot		Total	Average
	Bundaran HI	Jalan Sudirman		
Morning	2417	2311	4728	2364
Afternoon	1877	1708	3585	1793
Evening	2871	2741	5612	2806

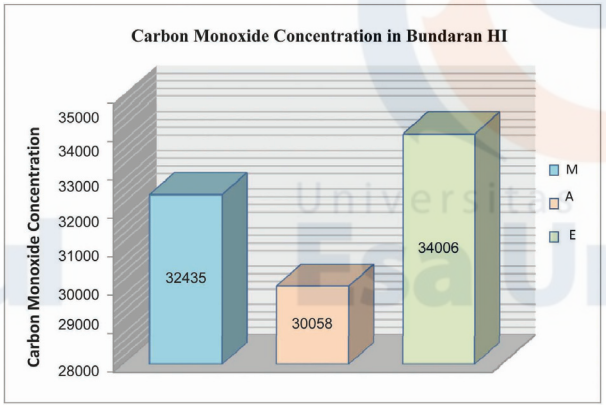

Fig. 1. Carbon monoxide concentration in Bundaran HI Based on Time

quality standard for CO concentration in 1 hour according to Law number 41 of 1999 is 30.000 µg/Nm^3.

The results of the research on the average concentration of CO in Bundaran HI (Jendral Sudirman) in the morning is 32217.5 µg/Nm^3, in the afternoon 30072 µg/Nm^3 and in the evening 33770.5 µg/Nm^3. AS for the air quality standard for CO concentration is 30.000 µg/Nm^3. Therefore, it is known that the highest average concentration of CO is in the evening while the lowest average is in the afternoon. According to (Turmuzi, Suryati, Mashaly, & Batubara, 2018)CO concentration on Thursday morning is 20.613 µg/m^3 and 27.484 µg/m^{3}in the evening. Meanwhile, (Kusumaningtiar and Ardillah, 2016) stated that in Jogyakarta, the highest concentration of CO is in the morning by 662.63 µg/m^3, at night 606.57 µg/m^3 and in the afternoon 466.63 µg/m^3. The air quality standard for CO concentration in 1 hour according to Law number 41 of 1999 is 30.000 µg/Nm^3.

Table 2 shows that the analysis result of Anovatest is(p value = 0.002) less than the critical value of $\alpha = 0.05$ ($p < 0.05$). It means that there are differences in carbon monoxide (CO) concentration in Bundaran HI based on sample collection time.The concentration of Carbon Monoxide (CO) is significantly increased in the morning and evening than in the afternoon. The highest increase of Carbon Monoxide (CO) concentration occurs in the evening with an average value of 33770,5 µg/Nm^3. It is because in the evening, the number of vehicles passing the area is increasing, as it is the time when people get off from their works, so the concentration of CO is higher than that of in the morning and afternoon.

Table 2. Analysis of Anova Test Based on Time with CO Concentration in Bundaran HI

Variable	p(sig)
CO Concentration	0.002*

*Significant

DISCUSSION

Based on the observations, the number of vehicles in the evening is higher than in the morning and afternoon. It is because in the evening, many employees get off work at the same time. Moreover, Bundaran HI (sudirman) is the central of Jakarta lanes toward East, South, and West Jakarta as well as the office block and shopping centre. Based on the results of observations, the majority of vehicle passing Bundaran HI (sudirman) are private vehicles and a few public transportation aged over 20 years. Many people prefer to use private vehicle due to the poor facilities of public transportation such as broken seats, engine noise, and uncomfortable compartment as the passengers jostling one another.

One of the sectors accounting for the decrease of air quality is the transport sector (motor vehicle). In China and India, death due to air pollution caused by transportation sector has increased from 5% to 12% (OECD, 2014) (Saikawa *et al.*, 2011). Transportation sector contributes to the highest level of carbonmonoxide (CO) pollution approximately 80.22%-90%(Lu Fu, Wei Wan, 2015). The government had enforced the traffic restriction on private vehicle by implementing 3-in-1 policy. 3-in-1 policy requires a private vehicle to travel with 3 or more passengers which was effective since 2000 to 2016 until it replaced by even-odd plate policy. This policy meansvehicles with license plates ending with odd numbers will only be allowed to travel on odd-numbered dates in certain streets in Jakarta and vice versa, but it does not apply on holidays or weekend. This policy replaces 3-in-1 system (3 or more people) may harm the drivers with no 2 or more people on the car, so they rent jockeys 3-in-1 (3 or more people).

Based on the results of observation in Bundaran HI (Sudirman), the highest concentration of CO is during the evening due to the great number of vehicle passing the area. Moreover, the climate in that area with the temperature of 32 ^{o}C and above can give rise to air pollution as well as higher

humidity (80%) that may induce corrosion which increase SO_2 and air pressure of 758. Whereas in the research conducted in the evening, the number of vehicle 2806 units with the majority of private vehicle since the area is a shopping center and office blocks. The people choose private over public transportation as it has poor facilities. Furthermore, the great number of vehicle passing the area in the evening is because during this time people leave their works.

According to the Department for Environment Food & Rural Affairs, (2019) carbon monoxide (CO) is produced when the fuel contains carbon. Even though transportation nowadays using catalytic converter for CO emission, it is still a significant source of air pollution. However, the lowest concentration of CO in Bundaran HI (Sudirman) is in the afternoon due to the least number of the passing vehicle. In the afternoon, as many as 1793 vehicles passing the area during 3 hours. The low concentration of CO in Bundaran HI (Sudirman) is also affected by the temperature where the highest temperature in the afternoon is 32.75 ^oC. Stated that air pollutant concentration decreases as the temperature increases.

CO pollution binds COHB in the body, it is so it can cause nausea, vomiting, dizziness, and even lung cancer to humans. Therefore, it is recommended to use mask when traveling on the road. While for the government, it is suggested to revitalize the vehicle aged over 20 years. The reason behind this suggestion is because based on the field observation, the majority of the vehicle is private vehicle. The government regulation on revitalization of vehicle with 20 years or above has not been implemented since there is no regulation regarding the maximum service life of vehicle. Yet, in 2018 the government set a program of exhaust gas emission euro 4. Euro 4 emission is a program to reduce CO emission for all private vehicle. However, until now this program is still planned and will be fully applied in the end 2018 along with its sanctions.

Based on the field observation, the great number of vehicles accounts for a high concentration of CO, particularly in the evening. However, the number of vehicle passing Bundaran HI (Sudirman) is lower in the morning since some people go to work earlier in the morning to avoid traffic jam. The increasing concentration of CO in the evening can cause harm to human since it the high concentration of CO binds COHbin the blood. The researcher suggests that the pedestrian should wear masks when passing the area of Bundaran HI Sudirman.

The results from the observation in Bundaran HI (Sudirman) show that the highest concentration of CO occurs in the evening of 33770.5 $\mu g/Nm^3$ since it is the time when people leave their works. Based on the field observation, the community around Bundaran HI (Sudirman) area have poor awareness of their health because many of them do not wear mask when passing that area. According to (Wu and Juurlink, 2014) the signs and symptoms of CO poisoning are headache, fatigue and most likely affecting cardiovascular and nervous system.

In this research, the samples of CO concentration was collected in 2 spots which are Bundaran HI and Jalan Jendral Sudirman. These spots were chosen as Bundaran HI is the round about toward office blocks and shopping center, while Jalan Jendral Sudirman is the office block area. Since 2016, the government has implemented even-odd traffic regulation to reduce air pollution (including CO), yet the results of this research is considered less effective because the air pollution level around Bundaran HI (Sudirman) is still high as referred to API 2015 that unhealthy event was 0 and in 2016, API recorded 2 unhealthy events.

The government program that has not been implemented is program euro 4. This is a program with the standard residual emission of NOx concentration that should not exceed 80 mg/km for petroleum-fuel vehicles and 250 mg/km for diesel-fuel vehicles. Finally, the researcher suggests that the government should immediately apply the standard euro 4 or low residual emission in Bundaran HI (Sudirman) to reduce the concentration of CO. It is because the standard euro 2 is still applied at present and the public transportation with poor facilities should immediately revitalized since the older a vehicle, the higher residual emission exhausted. In the observation, it is found that many cars aged 20 or above are still operated.

CONCLUSION

1. The highest of carbon monoxide concentration in Bundaran HI in the evening 34006 $\mu g/Nm^3$ and the highest of carbon monoxide concentration at Jalan Jenderal Sudirman in the evening 33535 $\mu g/Nm^3$
2. There is a significant difference in carbon monoxide (CO) concentration in Bundaran HI Jakarta based on sample collection time (p value = 0.002)

Ethical Conciderations

Ethical issues including plagiarism, informed consent, data fabrication and/ or falsification, double publication and/or submission, redundancy, etc. have been completely considered by the authors.

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Conflicts of Interest Statement

The authors declare that there is no conflicts of interests.

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