Analysis of the impacts of Motor Vehicle Exhaust Emissions at Pancasila University on health in order to create A Green Campus

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Abstract : The current carbon monoxide (CO) emissions are the main component of diseases, such as cough, dizziness, nausea, and shortness of breath for those who inhale them. Pancasila University is one of the colleges in the city of Jakarta that cares about the poor quality of air in the city of Jakarta; therefore, Pancasila University wants to apply the concept of green campus as a form of concern for the environment. This research was conducted at Pancasila University to discover the relationship between air quality in the campus, especially carbon monoxide (CO) substance, and its impact on the health of the university’s academic community members. The methods used in this study are simple linear regression, HIRARC, and hierarchy of control. The results of this study show a relationship between CO substance variables and complaints about diseases suffered by members of the university’s academic community due to the substance, with an R count value of 0.9519. There are substantial risks that the students can experience, including student activities that cause nausea and outdoor employee activities that cause dizziness and nausea. These big risks can be prevented by issuing a decision letter to reduce air pollution at Pancasila University.

Keywords: Air Quality, Motor Vehicle Exhaust Gas, Pancasila University, Green Campus

1. Introduction

Air is definitely a vital component of life for the survival of humans and other living beings, such as plants and animals. Humans often consider dusty, cloudy, smoky, and smelly air as a normal thing, although bad quality air really affects health\cite{1}.

Bad air can also be produced from motor vehicles. Indonesia is a very potential market for selling motor vehicles of any types and brands. This can be seen clearly from the significant increase of the number of motor vehicles. This high growth of motor vehicles, on the one hand, can improve the economic growth rate; on the other hand, it can cause a very serious environmental impact. One of the environmental impacts occurring is air pollution due to exhaust emissions produced by motor vehicle machines. On 4 August 2019, Jakarta ranked second as the most air polluted city in the world according to the data of AirVisual. Air Quality Index (AQI) of Jakarta is 160, meaning that the Jakarta’s air quality is not healthy. AQI is an index describing the air quality severity level in a region\cite{4}. Due to the hazard of the air pollution risks, particularly the health impacts of CO pollutant produced by motor vehicles, and the inexistence of a management program towards the risks that are caused by the pollution from...
motor vehicles, the campus of Pancasila University located in the capital city of Indonesia, namely DKI Jakarta, has become the research location applying the green campus concept [5].

Currently, Pancasila University is implementing the green campus concept, but there are still several obstacles occurring, such as the lack of the studies of the green campus concept implementation or the inexistence of the tools that can assist students or teachers in conducting research. This present research discusses the impacts of CO (carbon monoxide) pollutant from motor vehicles coming to and going from the area of Pancasila University on the health of the academic community members. It is known that CO pollutant has impacts on health if inhaled in a high amount, and some of the impacts are fainting, fatigue, nausea, dizziness, and also shortness of breath; it might also lead to death [6].

2. Methods

2.1. Research Object
The research was conducted in the campus area of Pancasila University on the CO substance as a vehicle exhaust gas entering the area of Pancasila University, and the study focused on its health impact in the academic community members [2].

2.2. Pilot Study
A pilot study was conducted as the basis for obtaining a clear picture on the problems examined and theories applied in this research. This pilot study was divided into two forms as follows.
Field Study A field study is an activity to search for accurate data, explanation, and information suitable for the problems that are brought up in this research by doing direct observation in the field.
Literature Study. A literature study is the phase that has to be conducted to obtain references and the theoretical framework that can support the research. This theoretical framework becomes the reference for solving problems while conducting the research. The sources used in this theoretical framework are, among others, journals, undergraduate theses, and other data [3].

2.3. Data Collection
Ambient Air Quality Standards of the DKI Jakarta Province Governor’s Decision
The decision of the DKI Jakarta Province Governor number 551/2001 states that the high growth of industry, transportation, and other development in the DKI Jakarta Province can cause ambient air pollution.

| No | Parameter                | Measurement time | Quality Book          |
|----|--------------------------|------------------|-----------------------|
| 1  | Sulfur Dioxide (SO₂)     | 1 Hour           | 900 µg/Nm³ (0.34 ppm)|
|    |                          | 24 Hour          | 260 µg/Nm³ (0.1 ppm) |
|    |                          | 1 year           | 60 µg/Nm³ (0.02 ppm) |
| 2  | Carbon Monoxide (CO)     | 1 Hour           | 26000 µg/Nm³ (23 ppm)|
|    |                          | 24 Hour          | 9000 µg/Nm³ (8 ppm)  |
| 3  | Nitrogen Dioxide (NO₂)   | 1 Hour           | 400 µg/Nm³ (0.2 ppm) |
|    |                          | 24 Hour          | 92.5 µg/Nm³ (0.05 ppm)|
Table 1 Ambient Air Quality Standards Based on the DKI Jakarta Province Governor’s Decision (continued)

| No | Parameter                  | Measurement time | Quality Book       |
|----|---------------------------|------------------|--------------------|
| 4  | Oxidant (O₃)              | 1 year           | 60 µg/Nm³ (0.03 ppm) |
|    |                            | 1 Hour           | 200 µg/Nm³ (0.05 ppm) |
|    |                            | 1 year           | 30 µg/Nm³ (0.03 ppm) |
| 5  | Hydrocarbon (HC)          | 3 Hour           | 160 µg/Nm³ (0.04 ppm) |
| 6  | Particulate < 10 um (PM₂₅) | 24 Hour         | 150 µg/m³           |
| 7  | Particulate < 2.5 um (PM₁₀) | 24 Hour         | 65 µg/m³            |
|    |                            | 1 year           | 15 µg/m³            |
| 8  | Dust (TPS)                | 24 Hour           | 230 µg/m³           |
|    |                            | 1 Year            | 90 µg/m³            |
| 9  | Lead (Pb)                 | 24 Hour           | 2 µg/m³             |
|    |                            | 1 Year            | 1 µg/m³             |

2.4. Number Of Samples

The number of academic community members at Pancasila University is 13,921. To determine the minimum number of the samples, a calculation was conducted by using the Slovin formula with the error margin of 10% as follows [4].

\[
n = \frac{N \cdot n}{1 + N \cdot e^2}
\]

\[
n = \frac{13921}{1 + 13921 \cdot (0.1)^2}
\]

\[
n = 99.2866 \approx 99
\]

There were 99 academic community members at Pancasila University that were researched as samples. Primary data are the data that were acquired directly through observation and recorded for the first time. There are several ways to acquire primary data, some of which are as follows.

1. Direct data measurement
   Data were directly acquired through the measurement of air quality in the campus area of Pancasila University and the number of academic community members.

2. Observation
   Observation is data collection by viewing and conducting direct observation of the research object.

3. Questionnaire
   The questionnaire was aimed at 99 members of the academic community of Pancasila University. Secondary data are the data acquired by searching for the literature from various sources, such as journals, books, and reports of the research conducted and intended to support our research. The data that were obtained were managed using the following method.

1. Questionnaire Validation Test
   The questionnaire that was obtained was validated to discover whether the questions have been understood by the respondents or not.

\[
r_{xy} = \frac{n \sum xy - \sum x \sum y}{\sqrt{(n \sum x^2 - (\sum x)^2)(n \sum y^2 - (\sum y)^2)}}
\]
\[ r_{xy} = \frac{99 \times 343 - 3111}{\sqrt{(99 \times 1267 - 343^2)(99 \times 23662 - 3111^2)}} \]

\[ r_{xy} = 0.6353 \]

The result of \( r \) count was compared with the result of \( r \) table, where \( r \) table for \( df = n - 2 \) (99-2=97) is 0.1663, so \( r \) count is > \( r \) table, so that the question number 1 is considered valid. The same calculation was conducted to discover the validity of every question as follows.

| No | Question                                                                 | \( r \) Count | \( r \) Table | Valid / Invalid |
|----|---------------------------------------------------------------------------|---------------|---------------|----------------|
| 1  | Do you feel shortness of breath due to inhaling exhaust motor vehicles     | 0.6353        | 0.1663        | Valid          |
| 2  | Do you feel nauseous due to inhaling exhaust gas from a motorized vehicle  | 0.5943        | 0.1663        | Valid          |
| 3  | As a result of exhaust gas from motorized vehicles at Pancasila University, there was a feeling of dizziness | 0.4467        | 0.1663        | Valid          |
| 4  | Did you experience respiratory symptoms during your activities at Pancasila University? | 0.1784        | 0.1663        | Valid          |
| 5  | Do you think air quality at Pancasila University is classified as poor    | 0.6733        | 0.1663        | Valid          |

2. Simple Linear Regression

| NO | X   | Y   | X^2   | Y^2   | XY   |
|----|-----|-----|-------|-------|------|
| 1  | 2291| 73  | 5248681| 5329  | 167243|
| 2  | 1146| 63  | 1313316| 3969  | 72198 |
| 3  | 1145| 61  | 1311025| 3721  | 69845 |
| 4  | 1146| 60  | 1313316| 3600  | 68760 |
| 5  | 1145| 64  | 1311025| 4096  | 73280 |
| \[ \sum \] | 6873| 321 | 10497363| 20715 | 451326|

After acquiring the value of the variables \( x \) and \( y \), the variables \( x \) and \( y \) are as follows.

1. Point 1 of the CO substance measurement was located in front of the rectorate building. This activity obtained as much as 2291 \( \mu g/m^3 \) with the number 1 question index around 73% prioritizing shortness of breath due to CO. This is because the front part of the rectorate building is the gateway where vehicles come to and go out from Pancasila University. This front part of the building has the largest number of vehicles and pollutants due to heavy traffic as there is a zebra cross for crossing the street from the bus stop of Pancasila University to the train station of Pancasila University.

2. Point 2 of the CO substance measurement was located at the FEB motorcycle parking place. This activity obtained as much as 1146 \( \mu g/m^3 \) with the number 2 question index around 63%. There was not so many pollutants in the area because the parking place alone did not produce a high amount of CO. Because of this, the potential disease here is only nausea.

3. Point 3 of the CO substance measurement was located at the FEB yard. This activity obtained as much as 1145 \( \mu g/m^3 \) with the number 3 question index around 61%. There were not many pollutants in the area because its location is close to the parking place so that it only causes dizziness.

4. Point 4 of the CO substance measurement was located in front of the Faculty of Pharmacy. This activity obtained as much as 1146 \( \mu g/m^3 \) with the number 4 question index around 60%. There were
not many pollutants in the area because its location is far from the main street, but in that area the amount of CO is quite high, so it can cause symptoms of a disease related to breathing.

5. Point 5 of the CO substance measurement was located in front of LIA (English language course) building. This activity obtained as much as 1145 μg/m³ with the number 5 question index around 64%. Based on the perception of the academic community members, the air quality in this part of Pancasila University is considered bad.

The next step to determine the constant value (a) and the regression coefficient value (b) is as follows.

\[
a = \frac{(\Sigma x^2)(\Sigma y) - (\Sigma x)(\Sigma xy)}{n \Sigma x^2 - (\Sigma x)^2}
\]

\[
b = \frac{n \Sigma xy - (\Sigma x)(\Sigma y)}{n \Sigma x^2 - (\Sigma x)^2}
\]

The simple linear regression equation can be made as follows.

\[
Y = 51.001 + 0.0096(X)
\]

The value of a (constant) is 51.001, showing the amount of the CO substance as a motor vehicle gas that does not affect the disease complaint in a long run and can be defined when the value of CO is 0, so the value of the health complaint of the academic community is 51.001. The regression coefficient (slope) of b is 0.0096, meaning that CO as the motor vehicle gas has a positive correlation with the health complaint of the academic community of Pancasila University, such as dizziness, cough, shortness of breath, and nausea.

3. Simple Correlation

The correlation is used to discover whether variables x and y are mutually related, so they will be tested with the formula as follows.

\[
 r = \frac{n \Sigma xy - (\Sigma x)(\Sigma y)}{\sqrt{(\Sigma x^2 - (\Sigma x)^2)(\Sigma y^2 - (\Sigma y)^2)}}
\]

\[
 r = \frac{5(451326) - 6873(321)}{\sqrt{(5(10497363) - (6873)^2)(5(20715) - (321)^2)}} = 0.9519
\]

The value of r (correlation coefficient) has been known to be as much as 0.9519, where the value of r count is > the value of r table. The value of r table is 0.8054, so it can be assured that there is a correlation between CO produced by motor vehicles and the disease complaints suffered by the academic community members of Pancasila University.

![Figure 1](Source: Data Management, 2019)
\( R^2 \) (determinant coefficient) is 0.9062, showing that the variable of CO, the motor vehicle gas affecting the variable of the disease complaint, is 90.62%, while 9.38% is affected by smoking, dust, and others.

3. **Results And Discussion**

**Identification of Academic Community Members’ Activities at Pancasila University and the Health Impacts of Air Pollution on Health.** The identification in this study observed the activities of academic community members (lecturers, employees, and students) and the health impacts of CO as a motor vehicle exhaust gas at the campus area of Pancasila University.

3.1. **Likelihood**

After discovering the activities of the academic community members, the next step was to determine the likelihood or frequency assessment.

| Table 4 Likelihood Score |
|--------------------------|
| Number of Outdoor Employee Illness Complaints |
| **Type of Complaint** | Number of Complaints | Frequency | Likelihood |
| Coughing | 21 | 84 | 4 |
| Shortness of breath | 18 | 72 | 4 |
| Dizziness | 23 | 92 | 5 |
| Nausea | 12 | 48 | 3 |

| The Number of Complaints from Employee in the room |
| **Type of Complaint** | Number of Complaints | Frequency | Likelihood |
| Coughing | 13 | 54,1 | 3 |
| Shortness of breath | 16 | 66,6 | 4 |
| Dizziness | 12 | 50 | 3 |
| Nausea | 9 | 37,5 | 2 |

| The Number of Complaints from Lecturer Diseases |
| **Type of Complaint** | Number of Complaints | Frequency | Likelihood |
| Coughing | 15 | 60 | 3 |
| Shortness of breath | 8 | 32 | 2 |
| Dizziness | 11 | 44 | 3 |
| Nausea | 6 | 24 | 2 |

| The Number of Student Illness Complaints |
| **Type of Complaint** | Number of Complaints | Frequency | Likelihood |
| Coughing | 16 | 64 | 4 |
| Shortness of breath | 13 | 52 | 3 |
| Dizziness | 19 | 76 | 4 |
| Nausea | 10 | 40 | 2 |

3.2. **Severity**

Severity is the level of danger/graveness incurred from an activity.
Table 5 Severity Risks

| Level | Description | Disease Complaint |
|-------|-------------|-------------------|
| 1     | Insignificant | Cough            |
| 3     | Moderate     | Shortness of breath |
| 1     | Insignificant | Dizziness         |
| 2     | Minor        | Nausea            |

3.3. Hazard Identification Risk Assessment and Risk Control (HIRARC)

After the scores of likelihood and severity were obtained, the next step was to do the assessment and control of risks by using the HIRARC method:

Table 6 HIRARC due to CO as a Motor Vehicle Exhaust Gas

| No. | Activity                        | Risk/impact   | L | S | RPN | Hazard Prevention                                           |
|-----|--------------------------------|---------------|---|---|-----|------------------------------------------------------------|
| 1.  | Student activity                | Cough (1v)    | 4 | 1 | 4   | Using personal protective equipment such as a protection mask |
|     |                                 | Shortness of breath (1x) | 4 | 1 | 4   | Using personal protective equipment such as a protection mask |
|     |                                 | Dizziness (1y) | 2 | 2 | 4   | Using personal protective equipment such as a protection mask |
|     |                                 | Nausea (1z)   | 3 | 3 | 9   | Issuing a decision letter to reduce air pollution on campus |
|     |                                 | Cough (2v)    | 3 | 1 | 3   | Using personal protective equipment such as a protection mask |
| 2.  | Lecture activity                | Shortness of breath (2x) | 2 | 1 | 2   | Using personal protective equipment such as a protection mask |
|     |                                 | Dizziness (2y) | 3 | 2 | 6   | Using personal protective equipment such as a protection mask |
|     |                                 | Nausea (2z)   | 2 | 3 | 6   | Issuing a decision letter to reduce air pollution on campus |
|     |                                 | Cough (3v)    | 3 | 1 | 3   | Using personal protective equipment such as a protection mask |
| 3.  | Staff activity (inside the building) | Shortness of breath (3x) | 4 | 1 | 4   | Using personal protective equipment such as a protection mask |
|     |                                 | Dizziness (3y) | 3 | 2 | 6   | Using personal protective equipment such as a protection mask |
|     |                                 | Nausea (3z)   | 2 | 3 | 6   | Using personal protective equipment such as a protection mask |
|     |                                 | Cough (4v)    | 4 | 1 | 4   | Using personal protective equipment such as a protection mask |
| 4.  | Staff activity (outside the building) | Shortness of breath (4x) | 4 | 1 | 4   | Using personal protective equipment such as a protection mask |
|     |                                 | Dizziness (4y) | 5 | 2 | 10  | Issuing a decision letter to reduce air pollution on campus |
|     |                                 | Nausea (4z)   | 3 | 3 | 9   | Issuing a decision letter to reduce air pollution on campus |

3.4. Risk Matrix

The risk mapping or risk matrix was done based on the value obtained in the Risk Priority Number (RPN) resulting from likelihood multiplied by the existing severity. The risk level is represented in colors to discover how big the hazard potential that can be caused is. Below is the risk matrix.

![Figure 2 Risk Matrix](image)

There are four colors in the risk matrix table, namely red, blue, green, and yellow. Those colors mark the criteria of how risky a hazard found in an activity is. The red color shows the extreme hazard level, so we really must pay attention to the risk. The blue color shows a high hazard level, and there are three
activities found in this position. Those are student activities causing nausea and staff activities outside the building causing dizziness and nausea. The yellow color shows a medium hazard level, and there are nine activities leading to risks. The green color shows a low hazard level, and there are four activities leading to risks. After doing the risk matrix on CO as a motor vehicle exhaust gas at Pancasila University with the health impact suffered by the academic community members, it is necessary to control or measure the hazards incurred.

4. Conclusion
1. The influence of CO as a motor vehicle exhaust gas having the value of R (correlation coefficient) as much as 0.9519 > 0.8054 (r count > r table) shows that there is a correlation between CO as a motor vehicle exhaust gas and its health impacts on the academic community members of Pancasila University. CO as a motor vehicle exhaust gas causes cough, dizziness, nausea, and shortness of breath.
2. CO as a motor vehicle exhaust gas has an impact on the academic community members of Pancasila University who inhale it so that it causes cough, dizziness, nausea, and shortness of breath. The HIRARC table shows two activities leading to a high risk level. First, the staff activities outside the building causes dizziness and nausea; second, the student activities cause nausea. The effort to prevent these diseases is by using administrative controls in the form of issuing a decision letter to reduce the air pollution at Pancasila University and by using personal protective equipment in the form of wearing a protective mask.

5. References
[1] P. Insyira, 2016 Evaluasi Kinerja Badan Lingkungan Hidup dalam Uji Emisi Gas Buangan Kendaraan Bermotor Di Kota Pekanbaru, ejournal Universitas Riau 3.
[2] I. W. Prasetya, Galih Budi, Meidiana, Christia, and Agustin, 2017 Pengurangan Emisi CO2, N2O, dan CH4 dari Kendaraan Bermotor Universitas Negeri Malang, Jurnal Sosial Ekonomi Pekerjaan Umum 9(1).
[3] N. D. Santosos, E. Akmalah, I. Irawati, 2017 Implementasi Konsep Green Campus di Kampus Iteanas Bandung Berdasarkan Kategori Tata Letak dan Infrastruktur, Ejournal Institut Teknologi Nasional 3(4).
[4] D. Gusnita, 2010 Berita Dirgantara Green Transport: Transportasi Ramah Lingkungan Dan Kontribusinya Dalam Mengurangi Polusi Udara 2010 Berita Dirgantara 11(2)
[5] S. Surpriadji, A. Naubah, and A. Rizaal, 2015 Identifikasi Bahaya dan Penilaian Risiko K3 pada Tindakan Perawatan dan Perbaikan Menggunakan Metode HIRARC (Hazard Identification and Risk Assessment Risk Control) 2015. Prosiding Seminar Nasional Riset Terapan SENASSET, ISBN: 978-602-73672-0-3.
[6] Anonim 2001 Keputusan Gubernur Provinsi DKI Jakarta Nomor 551/2001, pp. 1–4.
[7] T. Mayasari, Andhika; Mardyani, Yus A Prasetya; Sundari, Studi Perencanaan Pengembangan Universitas Hasyim Asy’ari Sebagai Green Campus, 2016 Jurnal Reaktom, 01(01).
[8] A. Budiyono, 2001 Dampak Pencemaran Udara Pada Lingkungan. Jurnal Berita Dirgantara 2(1).
[9] M Y M Solihin, M Arafat 2018 Analisa Pengaruh Perubahan Pacing pada bejana silinder terhadap kompresi mesin motor 100cc simrestek 2018, proseding e-ISSN : 2621-5934, p-ISSN : 2621-7112
[10] M Y M Solihin, 2018 Optimalisasi sistem perawatan dan perbaikan terencana berdasarkan analisis keandalan pada mesin Diesel pengerak generator C10, Teknobiz jurnal ilmiah program studi Magister Teknik Mesin.