Analysis of Ambient Air Quality of Carbon Monoxide in Parking Areas: Case Study of Type B and Type C Hospitals in Surabaya City

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Abstract

The human respiratory system is vulnerable to the impacts of carbon monoxide (CMO) emissions, a colorless and odorless gas. The aim of this research is to analyze the CMO levels in the air and its relation to regulations governing air quality, specifically referring to Government Regulation Number 22 of 2021. This study also discusses the correlation between CMO levels with air temperature and the number of motor vehicles. Measurements were conducted using a CMO meter, and manual counting of motor vehicles was included as part of the purposive sampling procedure over a period of 3 days. On Saturdays, the average CMO concentration was at its highest point, ranging from 64.131 µg/m3 in the morning to 52.106 µg/m3 in the afternoon and 37.791 µg/m3 in the evening. The average temperatures recorded were 31°C in the morning, 32°C in the afternoon, and 30°C in the evening. There was an increase in CMO levels at Hospital X exceeding the permissible limit stated in Government Regulation Number 22 of 2021. Regarding air quality at Hospital Y, CMO concentrations were 33.210 µg/m3 in the morning, 11.451 µg/m3 in the afternoon, and 29.775 µg/m3 on Monday afternoon, all of which were above normal levels. With a value of α of 0.000, which is less than 0.01 according to Pearson correlation test, a significant relationship between temperature and CMO levels was revealed, with a Pearson correlation coefficient (r) of -0.917. There is a perfect negative correlation between these two variables. To determine the presence of a relationship between the number of motor vehicles and CMO concentration, the Pearson correlation test yielded a significant result with a value of α of 0.048 and an r value of 0.670. The correlation between the two variables is evident.

Keywords: *Motor Vehicles, Carbon Monoxide, Pearson Correlation*

1. Introduction

Major cities experience rapid development across various sectors alongside an increase in population. In 2022, Surabaya had a population of 2,887,223 according to BPS data. The rapid transportation activities, coupled with the growing number of motor vehicles within the city, inevitably lead to air pollution that can adversely affect the survival of surrounding living organisms. One of the sources of air pollution can occur in hospital parking areas [2].

The transportation sector is a significant contributor to the increasing traffic density in Indonesia, with the number of vehicles rising from 1,944,802 in 2015 to 2,081,449 in 2016 and 2,159,069 in 2017, with an annual growth rate of 7.03%. Therefore, traffic in Surabaya has increased, negatively impacting air quality due to vehicle emissions [7].

Several factors influence the amount of carbon monoxide (CMO) gas emitted by motor vehicles, including vehicle age, type, operating conditions, and engine type [3]. This study aims to analyze the CMO levels in the air and its relation to regulations governing air quality, specifically Government Regulation Number 22 of 2021. Additionally, it seeks to determine the correlation between CMO gas and air temperature, as well as CMO gas and the number of motor vehicles.

2. Materials And Methods

The research idea is based on the increasing number of motor vehicles along with the population growth each year. To achieve the research objectives, this study analyzes the relationship between CMO concentration and motor vehicle traffic using the Pearson correlation test. The research also examines the relationship between ambient air temperature and CMO concentration to determine the strength of that relationship. Furthermore, the CMO concentration values are compared with the quality standards stipulated in Government Regulation Number 22 of 2021. The sampling conducted for specific purposes is referred to as purposive sampling [1]. The selection criteria for the locations are derived from the research objectives' outcomes:

1. Area with high pollutant concentration.
2. Parking area closest to the hospital lobby.
3. Representative of the entire study area.

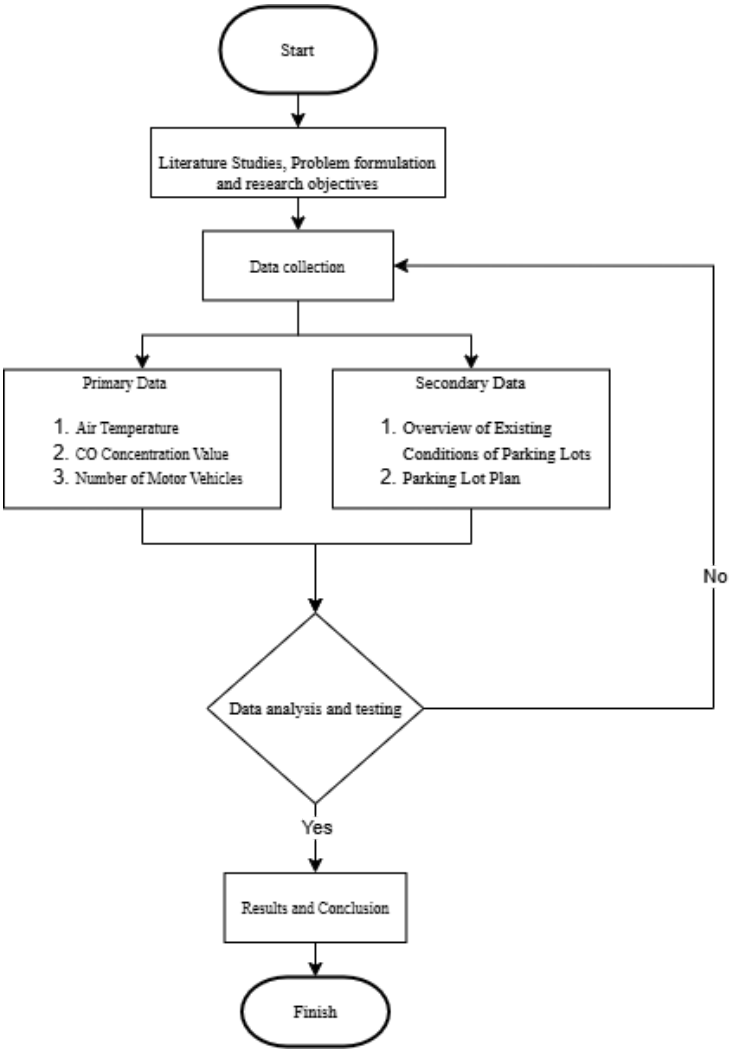

Figure 1. Research Flowchart

Figure 1 illustrates that after the research idea is formulated, the next steps involve collecting primary and secondary data. The research locations are two type B and type C hospitals in Surabaya City. Primary data is obtained through direct observation and sampling at the research locations, including CMO concentration and air temperature measured using a CMO meter, and the number of vehicles counted using a traffic counter application. Sampling is conducted for 3 days on Saturday, Sunday, and Monday, at different time intervals: morning (08:00-09:00 AM), afternoon (12:00-13:00

PM), and evening (16:00-17:00 PM) local time. Secondary data includes parking lot layouts of the hospitals and an overview of the existing conditions.

Subsequent steps involve data processing through descriptive analysis and statistical analysis. Descriptive analysis aims to explain the CMO concentration values compared to the quality standards stipulated in Government Regulation No. 22 of 2021. Statistical analysis is conducted using the Pearson correlation test to determine the relationship between air temperature and CMO concentration, as well as the relationship between the number of vehicles and CMO concentration.

3. Results And Discussion

Results of Motor Vehicle Counting in Hospital Parking Areas

Table 1. Calculation of Motor Vehicle Count

Day	Time	Carbon Monoxide Concentration (μ/m³)		Total (Unit/Day)	Average (Units/Day)
		Hospital X	Hospital Y		
Saturday	Morning	250	42	292	146
Sunday		63	19	82	41
Monday		237	39	276	138
Saturday	Afternoon	225	42	267	134
Sunday		132	12	144	72
Monday		246	41	287	144
Saturday	Evening	241	26	267	134
Sunday		88	14	102	51
Monday		259	21	280	140

In Table 1, it can be observed that Hospital X has a higher number of passing vehicles compared to Hospital Y. This difference may be attributed to the distinction between Hospital Type B and Type C, which can influence the number of visitors. The highest number of vehicles was recorded at Hospital X on Monday evenings, totaling 259 units. This peak coincides with the time when hospital staff typically leave work, resulting in an increase in vehicle traffic. Conversely, Hospital Y recorded the highest number of vehicles on Saturday mornings and afternoons, with 42 units, likely due to internal events taking place at the hospital during those times.

Comparison of CMO Concentration with Air Quality Standards

Table 2. Comparison of CMO Concentration with Air Quality Standards

Day	Time	Carbon Monoxide Concentration (μ/m³)		Average/day
		Hospital X	Hospital Y	
Saturday	Morning	95.051	33.210	64.131
Sunday		46.952	8.016	2.,484
Monday		68.711	8.016	38.364
Saturday	Afternoon	92.760	11.451	52.106
Sunday		104.212	3.435	53.824
Monday		28.629	29.775	29.202
Saturday	Evening	67.566	8.016	37.791
Sunday		29.775	4.581	17.178
Monday		43.517	8.016	25.767

Based on Table 2, it is evident that Hospital X exceeds the air quality standard stipulated in Government Regulation No. 22 of 2021, with concentrations above 10,000 μ/m³ each day. In contrast, Hospital Y only exceeds the standard on Saturday mornings with a concentration of 33,210 μ/m³, Saturday afternoons with 11,451 μ/m³, and Monday afternoons with 29,775 μ/m³. According to

Pangerapan et al. (2018), the more vehicles that pass through the streets, the more carbon monoxide (CMO) is released into the air. The primary source of carbon pollution is the combustion of fossil fuels emitted into the air as exhaust gas.

Polluted air has adverse health effects such as heart attacks, asthma, shortness of breath, sore throat, allergies, eye irritation, and potential lung cancer. Air pollution needs to be reduced as it impacts the health of urban residents [4].

Results of Pearson Correlation Test between Air Temperature and CMO Concentration

Table 3. Results of Pearson Correlation Test between Temperature and CMO Concentration

Correlations			
		CMO Concentration	Temperature
CMO Concentration	Pearson Correlation	1	-,917**
	Sig. (2-Tailed)		,000
	N	9	9
Temperature	Pearson Correlation	-,917**	1
	Sig. (2-Tailed)	,000	
	N	9	9

**. Correlation is significant at the 0.01 level (2-tailed)

In Table 3, the analysis results of the Pearson correlation coefficient between variables indicate a perfect negative correlation relationship, with a value (r) of -0.917 and a Sig value < 0.05, specifically 0.000. This indicates that as the air temperature increases, the CMO concentration decreases, and vice versa. Conversely, as the air temperature decreases, the CMO concentration increases.

Results of Pearson Correlation Test between Number of Motor Vehicles and CMO Concentration

Table 4. Results of Pearson Correlation Test between Number of Vehicles and CMO Concentration Correlations

Correlations			
		Number of Vehicles	CMO Concentration
Number of Vehicles	Pearson Correlation	1	,670*
	Sig. (2-tailed)		,048
	N	9	9
CMO Concentration	Pearson Correlation	,670*	1
	Sig. (2-tailed)	,048	
	N	9	9

*. Correlation is significant at the 0.05 level (2-tailed).

In Table 4, the results of the Pearson correlation test show a Sig value of 0.048 < 0.05 and a Pearson correlation coefficient (r) of 0.670. This indicates that there is a correlation between the two variables, specifically a positive correlation between the variables. The carbon monoxide (CMO) concentration will increase proportionally with the number of motor vehicles.

4. Conclusion

The concentration of CMO exceeding the air quality standard in Regulation PP No. 22 of 2021 occurred at Hospital X every day, while Hospital Y exceeded the air quality standard only on Saturday mornings with a concentration of 33,210 µg/m3 and in the afternoons with a concentration of 11,451

μg/m3, as well as on Monday afternoons with a concentration of 29,775 μg/m3. The correlation between air temperature and CMO concentration is perfectly negative. This means that the higher the air temperature, the lower the CMO concentration, and vice versa. The relationship between CMO concentration and the number of motor vehicles shows a positive correlation between the two variables. This indicates that as the CMO concentration increases, there is an increase in the number of motor vehicles.

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