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# ANALYSIS OF NOX AIR QUALITY AT INTER-CITY BUS TERMINAL OF NORTH SULAWESI PROVINCE IN 2023

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**Abstract**

Background: Intercity bus terminals are a significant source of air pollution, particularly nitrogen oxide (NOx) emissions. NOx emissions frequently reach hazardous levels due to excessive vehicle activity, particularly diesel-powered buses, both when idling and accelerating. Long operational duration, high vehicle density during rush hour, and the age of the bus fleet, which is often older than other public vehicles, all have an impact on NOx emission levels. Long-term NOx pollution exposure has a direct influence on health, namely respiratory system diseases such as lung function and respiratory tract infections. Traders, passengers, and those residing near the terminal are all at greater risk of health complications. The study aimed to assess air quality using nitrogen oxide (NOx) measures. To describe the quality of nitrogen oxide air, this method employs an observational descriptive approach based on direct measurements. The investigation was carried out at the Malalayang and Paal Dua bus terminals. Measurements were obtained twice, in the morning and afternoon, with a 6-point scale. Univariate data analysis shows the minimum, maximum, and average values of the research variables. Research Results: The results of the study at the Malalayang terminal at point 2 which is located in the inner part at 11.42 - 12.41 WITA, the measurement results were 5.50 µg̃ / nm³, total volume 22.542 nm³ and at the Paal Dua terminal at point 1, at 10.00 - 11.10 WITA, the measurement results were 6.05 µg̃ / nm³ with a total volume of 22,475 nm³. Conclusion: The levels of nitrogen oxide (NOx) at the Malalayang and Paal Dua terminals remain below the quality standard set by Indonesian Government Regulation Number 22 of 2021, which supervises the implementation of environmental protection and management with a 1-hour exposure time.

**Keywords:** Ambient Air Quality, Intercity Terminal, Nitrogen Oxide (NOx)

## Introduction

Air pollution is one of the unresolved environmental issues. The increased mobility of citizens along with the expansion of transportation options in cities have resulted in a concentration of activities at intercity bus terminals. This condition has the potential to cause air pollution, particularly NOx emissions (Aida et al., 2019). Bus terminals are a significant source of NOx emissions in metropolitan settings (Atkinson et al., 2015). This is because of the large number of vehicles and extensive idle engine activity at the terminal. Based on AQLI 2021 data, Indonesia is ranked 17$^{th}$ for the highest level of pollution (Setkab, 2023).

In Indonesia, the number of vehicles has increased, particularly in large cities, which can have an indirect impact on air quality near the terminal. According to the Statistics Agency, the number of motorized vehicles in Indonesia grows by approximately 7% per year. In 2021, the total number of motorized vehicles was 141,992,573 units, a growth of 5,855,122 units, with the greatest concentration in transportation areas such as terminals (*BPS: 8302004 ISSN 2598-5612*, n.d.). The increasing number


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of vehicles will increase vehicle exhaust gases that are detrimental to human health, one of which is nitrogen oxide gas (NOx) (Shafarina Intan et al., 2023).

Nitrous oxide (NOx) reacts with water in the atmosphere, producing nitric acid in the form of acid precipitation (Burns et al., 2016). Nitrous oxide is a reddish-brown gas that turns into a yellow liquid at temperatures below 21.2°C, contributing to acid rain and increasing air pollution (Ningsi et al., 2019). The toxicity of nitrogen oxide gas is severe, and long-term exposure to nitrogen oxide (NOx) can cause respiratory system illnesses, impaired lung function, and asthma (Samoli et al., n.d.). A study indicated that an increase in Nox content of 10μg/m³ was associated with a 5.5% increase in the risk of acute respiratory illness (Zhang et al., 2011).

Malalayang Terminal is a Type A terminal that provides intercity and local transit on both interprovincial and metropolitan lines throughout North Sulawesi. The large number of passengers at the terminal increases the demand for suitable terminal space. Paal Dua Terminal in Manado City is the largest terminal in the area, providing a variety of public transportation options such as buses and city transportation. The Terminal's high level of public transit activity has the potential to pollute the air, affecting the surrounding ecosystem. A contaminated environment has a substantial influence on the health of those who frequently interact with the terminal area.

Intercity bus terminals play a crucial role in terms of air quality because they have a high concentration of diesel-powered vehicles. This type of vehicle is known as the primary source of NOx emissions, with levels that can be 4-5 times greater than gasoline-powered automobiles (Hikmiyah,2018). The goal of this study is to describe the results of nitrogen oxide (NOx) air quality assessments at the Malalayang and Paal Dua terminals in Manado City, North Sulawesi Province.

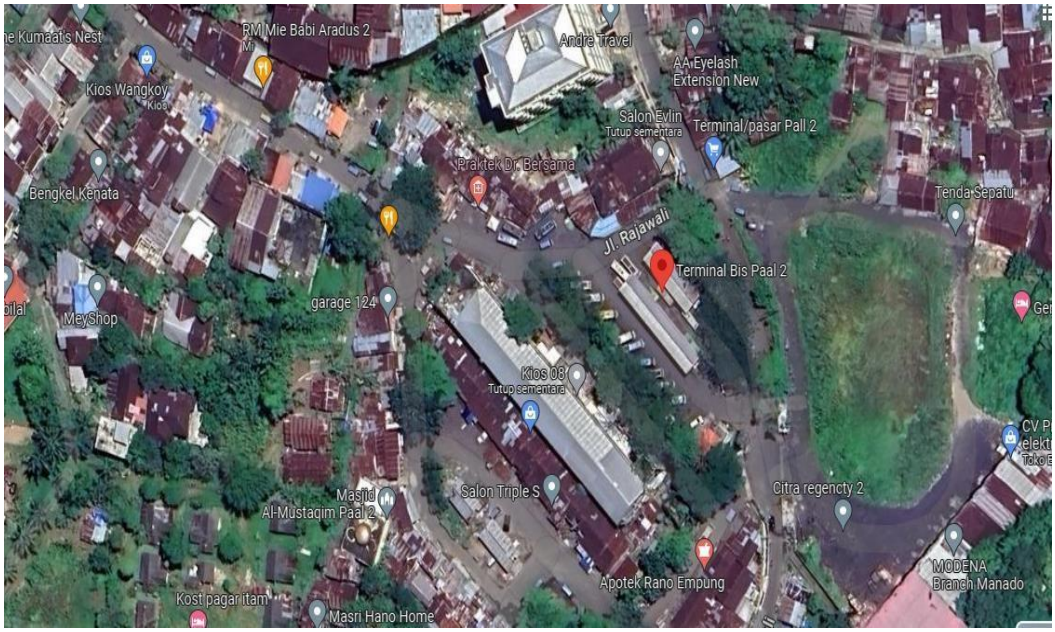
## Method

This study analyzed air quality at intercity bus terminals using a descriptive observational approach based on direct measurements of nitrogen oxide (NOx) concentrations. The research took place at the Malalayang and Paal Dua bus terminals. Data was collected in October 2023. Measurements were taken for one hour at each location point, three times. Point 1 is in the terminal at 10.10 - 11.10 WITA; point 2 is at the back door at 11.41 - 12.41 WITA; and point 3 is at the terminal's front door at 13.00 - 14.00 WITA. Points were determined using the purposive sampling method. Univariate analysis was used to obtain minimum, maximum, and average values for the variables under study.

## Result

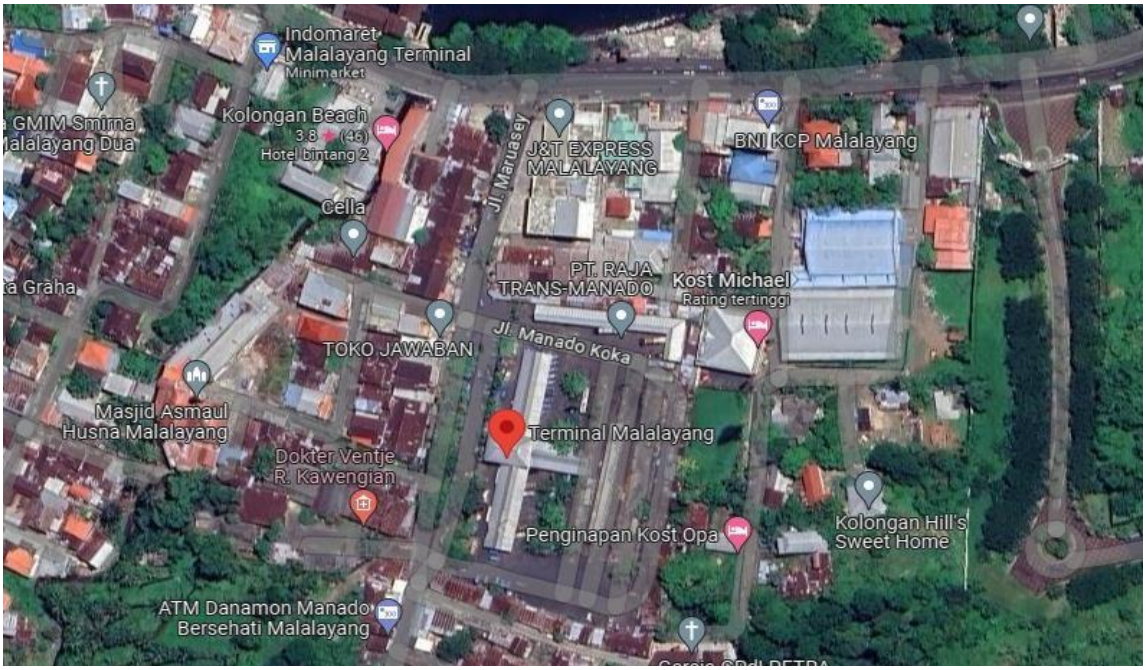
### 1 Malalayang Terminal Research Location

Malalayang Terminal is a type A terminal located on the North Sulawesi Trans route to Manado City. It has a terminal space of 15,000 m² and a capacity of 191 vehicles. Malalayang Terminal, established in 1995, is located on the collector road of the Trans Sulawesi route. It has a terminal area of 15,000 m² and operates from 05:00-19:00 WITA. Public transportation routes include AKAP, AKDP, and AKDP DAMRI. Malalayang Terminal additionally has 16 routes and 191 operational vehicles, with 227 drivers and 23 officers.




**2 Paal Dua Terminal Location**

Paal Dua Terminal is an intercity terminal located in Manado City, North Sulawesi. This Paal Dua Terminal offers various routes, and there are 383 operational vehicles that operate from 05:30 to 9:30 WITA. The Paal Dua Terminal employs 50-60 persons as drivers and 7 officers. The Paal Dua Terminal was established in 2006 and is located on St. Rajawali, Paal Dua, Paal Dua Sub-District, Manado City. It has a terminal area of 6,853 M.



## 3 Results of Research on Air Quality Measurement of Nitrogen Dioxide at Malalayang Terminal, Manado City

**Table 1. $NO_2$ air quality measurement**

| Point Sampel | Measurement Time | Water Speed (L/m) | Pressure (mmHg) | Temperature (K) | Total Volume ($Nm^3$) | Cons (ug) | Quality Standard | $NO_2$ (µg /$Nm^3$) |
|---|---|---|---|---|---|---|---|---|
| Point 1 | 1 hour | 0.3888 | 756.7 | 303.7 | 22.790 | 0.340 | 200 (1 hour) | 5.96 |
| Point 2 | 1 hour | 0.3888 | 756.2 | 303.7 | 22.774 | 0.220 | 200 (1 hour) | 3.86 |
| Point 3 | 1 hour | 0.3888 | 756.6 | 307.9 | 22.457 | 0.340 | 200 (1 hour) | 6.05 |

The measurement results using an impenger and spectrophotometer show that the $NO_2$ measurement results at the first point are 4.42 µg̃/Nm³ with a total air volume of 22,610Nm₃ and a concentration of 0.250µg̃, the second point with a measurement result of 5.50 µg̃/Nm³, a total air volume of 22,542Nm₃ and a concentration of 0.310µg̃, and the third point 4.41 µg̃/Nm³. The entire air volume is 22,433Nm₃, with a concentration of 0.247 µg̃. The Malalayang terminal at point 2 has much higher $NO_2$ levels compared to points 1 and 3, which have lower values.

## 4. Research Results on Air Quality Measurement of Nitrogen Dioxide at Paal Dua Terminal, Manado City

**Table 2. The results of measurements and examination of nitrogen dioxide air quality on Sunday October 22, 2023**

| Sample Point | Measurement Time | Water Speed (L/m) | Pressure (mmHg) | Temperature (K) | Total Volume ($Nm^3$) | Cons (ug) | Quality Standard | $NO_2$(µg /$Nm^3$) |
|---|---|---|---|---|---|---|---|---|
| Point 1 | 1 hour | 0.3888 | 756.5 | 306.0 | 22.610 | 0.250 | 200 (1 hour) | 4.42 |
| Point 2 | 1 hour | 0.3888 | 757.0 | 307.2 | 22.542 | 0.310 | 200 (1 hour) | 5.50 |
| Point 3 | 1 hour | 0.3888 | 758.1 | 309.1 | 22.433 | 0.247 | 200 (1 hour) | 4.41 |

Show that the results of the first point measurement obtained were 5.96 µg̃ / Nm³ with a total air volume of 22,790 Nm₃ and a concentration of 0.340 µg̃. Measurements at the second point were 3.86 µg̃ / Nm³, a total air volume of 22,774 Nm₃ with a concentration of 0.220 µg̃. At the third point, the values were 6.05 µg̃/Nm³, with a total air volume of 22,475 Nm₃ and a concentration of 0.340 µg̃.

## Discussion

### Analysis of nitrogen oxide (NOx) measurement results

The difference in nitrogen oxide (NOx) concentrations between Malalayang Terminal and Paal Dua Terminal was established from direct measurement results at the two terminals. At 11.42 - 12.41 WITA, measurements at Malalayang Terminal's point 2 in the inner section revealed a NOx concentration of 5.50 µg/nm³ and a total sample volume of 22.542 nm³. Measurements at Paal Dua Terminal at point 1 between 10.00 - 11.10 WITA resulted in a decreased NOx concentration of 6.05 µg/nm³ with a total sample volume of 22.475 nm³. Factors influencing the discrepancy include measuring time and the volume of vehicles entering and leaving.

**Comparison with Environmental Quality Standards**

Nitrogen oxide (NOx) levels remain below the government's threshold established by Government Regulation No. 22 of 2021 (Hidup, 2021) concerning the implementation of environmental protection and management in Indonesia, according to measurement results from the Malalayang Terminal and the Paal Dua Terminal. The Paal Dua Terminal has a higher concentration than the Malalayang Terminal, however, the difference is not significant and is below permitted levels under current regulations. The dense transportation activity in the terminal region indicates that the nitrogen oxide (NOx) content remains within safe limits, although it must be checked continually. The difference in concentration between the two terminals can be used to evaluate each terminal's ventilation and vehicle control systems.

**Conclusion**

The levels of Nitrogen Oxide (NOx) at the Malalayang and Paal Dua Terminals remain below the quality standards by Indonesian Government Regulation Number 22 of 2021 on the Implementation of Environmental Protection and Management, with a 1-hour exposure time.

Suggestion

1. Conduct routine measurements at different times and more representative sampling locations to maintain air quality.
2. Mitigation strategies such as enhanced air circulation and more effective vehicle operation schedules should also be introduced to prevent pollutant buildup in the Terminal.

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**References**

[1] Aida, R., Rohmawati, F. Y., & Turyanti, A. (2019). *Pengaruh Hari Bebas Kendaraan Bermotor terhadap Emisi Polutan di Jalan Alternatif ( Studi Kasus : Jalan RE Martadinata , Kota Bogor ) The Effect of Car Free Day ( CFD ) on Pollutant Emissions at Alternative Roads ( Case Study : RE Martadinata Street , Bog*. *33*(April 2016), 8–19. https://doi.org/10.29244/j.agromet.33.1.8-19

[2] Atkinson, R. W., Mills, I. C., Walton, H. A., & Anderson, H. R. (2015). *Fine particle components and health — a systematic review and meta-analysis of epidemiological time series studies of daily mortality and hospital admissions*. *44*(September 2014), 208–214. https://doi.org/10.1038/jes.2014.63

[3] Burns, D. A., Aherne, J., Gay, D. A., & Lehmann, C. M. B. (2016). Acid rain and its environmental effects: Recent scientific advances. *Atmospheric Environment*, *146*, 1–4. https://doi.org/*https*://doi.org/10.1016/j.atmosenv.2016.10.019

[4] Handoko, E. D. (2020). *Analisis Dampak Nitrogen Dioksida (NO2) Di Kota Yogyakarta* [Tugas Akhir]. Universitas Islam *Indonesia*. https://dspace.uii.ac.id/123456789/30728

[5] Hikmiyah, A. F. (2018). *Analisis kadar debu dan NO2 di udara ambien serta keluhan pernapasan pada pekerja penyapu di Terminal Purabaya Kabupaten Sidoarjo. Kesehatan Lingkungan*, *10*(2), 138-147.

[6] Ningsi, N. P., Puanana, G. S., Fajriah, E. Y., Fikriyanti, Ferawati, Faemu, F., & Ischak, I. E.

(2019). *Studi Kualitas Udara Di Kabupaten Kolaka Utara Tahun 2016-2017. Jurnal Kesehatan Masyarakat* Celebes, *1*(1), 18–24.https://jkmc.or.id/ojs/index.php/jkmc/article/view/8

[7] Samoli, E., Aga, E., Touloumi, G., Nisiotis, K., Forsberg, B., Lefranc, A., Pekkanen, J., Wojtyniak, B., Schindler, C., Niciu, E., Brunstein, R., Dodič Fikfak, M., Schwartz, J., & Katsouyanni, K. (n.d.). Short-term effects of nitrogen dioxide on mortality: an analysis within the APHEA project. *European Respiratory Journal*, *27*(6), 1129–1138. https://doi.org/10.1183/09031936.06.00143905

[8] Setkab. (2023, August). Peningkatan *Polusi Udara di Indonesia: Perspektif Ekonomi Berdasarkan Teori* Freakonomics. https://setkab.go.id/peningkatan-polusi-udara-di-indonesia-perspektif-ekonomi-berdasarkan-teori-freakonomics/

[9] Shafarina, M. I., Rachmaniyah, R., & Sari, E. (2023). A*nalisis Risiko Pajanan Gas Nitrogen Dioksida pada Petugas Parkir di Pasar Kapasan Surabaya*. *Jurnal Keselamatan Kesehatan Kerja dan Lingkungan*, *4*(2), 91-102.

[10] Zhang, K., Batterman, S., & Dion, F. (2011). Vehicle emissions in congestion: Comparison of work zone, rush hour and free-flow conditions. *Atmospheric Environment*, *45*(11), 1929–1939. https://doi.org/https://doi.org/10.1016/j.atmosenv.2011.01.030