

The Effect of Vehicle Density on Nitrogen Dioxide (NO₂) Conditions in Makassar Indonesia

Syamsuddin S¹, Inayah¹, M. Askar²

¹Assistant Professor in Environmental Health Department, and Researcher in the Center of Excellent on Urban Health of Health Polytechnic of Ministry of Health in Makassar, Indonesia, ²Assistant Professor in Medical Laboratory Technology of Health Polytechnic of Ministry of Health in Makassar, Indonesia

Abstract

Objective: This research is expected to add insight into air pollution which is getting worse over time due to the increase in vehicles using fossil fuels, especially in big cities, such as in Makassar Indonesia, and can be used as a source of knowledge by the public about how to describe the air quality on several main streets in Makassar. **Method:** The type of research used was descriptive research by conducting direct observation with a linear regression test approach to determine the levels of Nitrogen Dioxide (NO₂) on several roads in Makassar. **Result:** The results obtained were levels of Nitrogen Dioxide (NO₂) on the S. Alauddin Street, Makassar, namely 2.51 µg/Nm³ (0.02 ppm), levels of Nitrogen Dioxide (NO₂) on Sudirman Street in Makassar, namely 1.45 µg/Nm³ (0.01 ppm) Levels of Nitrogen Dioxide (NO₂) on the Independence Pioneer Street (Gate One of Hasanuddin University) Makassar, namely 1.71 µg/Nm³ (0.07 ppm). The high level of NO₂ was caused by the number of vehicles at certain hours at each measurement point. **Conclusion:** There was no effect of vehicle density with levels of nitrogen dioxide (NO₂) on three main roads in Makassar, Indonesia.

Keywords: Vehicle Density, Nitrogen Dioxide (NO₂) Levels, Air Pollution

Introduction

Air pollution is the entry of living things, substances, energy, and or other components into the air and or changes in the composition of the air by human activities or by natural processes so that the quality of the air becomes less or cannot function anymore according to its designation.¹

Air pollution in several major cities in Indonesia is very worrying. Several studies on air pollution with all the risks were published, including the risk of blood cancer. However, it is rarely realized how many thousands of urban residents die each year due to infections as the impact of urban air pollution. The urban air was filled with smoke black and gases for human health.

The transportation sector is the biggest contributor to pollutants, due to the high growth of motorized vehicles, both two-wheeled and four-wheeled. Polluted air has a concentration of pollutants both in the form of gas and solid which is higher than generally found in the natural environment. Most motorized vehicles still use fossil fuels such as hydrogen and carbon. Data in several provinces, especially in big cities, motor vehicle emissions constitute the largest contribution to the concentration of CO and especially NO₂.²

Nitrogen dioxide in densely populated urban areas would be higher than in less populated rural areas. This is because various kinds of activities that support human life will increase the levels of Nitrogen Dioxide (NO₂) in the air, such as transportation, the problem is NO₂ pollution produced by human activities because the number would increase in certain places.³

Nitrogen Dioxide (NO₂) in urban air are usually 10–100 times higher than in rural air. Nitrogen Dioxide (NO₂) in urban air can reach 0.5 ppm (500 ppb). The increase

Corresponding Author:

Syamsuddin S

Email : syam-envi@poltekkes-mks.ac.id

Contact No.: +62 8124154704

in the number of motorized vehicles in Makassar, the largest city in eastern Indonesia and the capital city of South Sulawesi province has resulted in higher levels of congestion on several roads which have an impact on increasing pollutants (toxins) in the air. This is an increasing problem of air pollution in Makassar. Based on the data above, it shows that air pollution is increasing, therefore the authors are interested in researching “The Effect of Vehicle Density on Nitrogen Dioxide (NO₂) in Makassar?”

Method

This study was a descriptive study using direct observation. Location was taken along the S. Alauddin and Sudirman Street, Makassar by taking objects around the densely populated area of vehicles, where a category named “Point” representing along the road was determined. The point I: T-junction of the S. Alauddin Street, the Syech Yusuf Street – the Malengkeri Street. Point II: Intersection the Sudirman Street – the Ahmad Yani Street – the Hos Cokroaminoto Street – the M. Jusuf Street. Point III: Gate One of Hasanuddin University in the Independence Pioneer Street.

The research time was carried out for three days with the measurement stage at three points at different times, namely morning, afternoon, and evening. The first day was held on the S. Alauddin Street, the second day was carried out at the intersection of Jalan Sudirman

and the third day was carried out at the Gate One of Hasanuddin University on the Independence Pioneer Street. population in this study was Nitrogen Dioxide gas which was on the S. Alauddin Street and the Sudirman Street in Makassar. The number of samples in this study was 9 samples of air, taken from the three points and three times taking, namely morning, evening, and night, on the S. Alauddin Street, Sudirman Street, and Independence Pioneer Street in Makassar. Primary data means research data obtained from the results of examining the amount of Nitrogen Dioxide (NO₂). Data Secondary was data obtained from the results of literature studies and literature related to the object of research. The data analysis technique was carried out by using a linear regression test from the observations obtained during implementation and depicted in table form. The research results were accompanied by a description based on the supporting theory. From the results of research, field measurements from laboratory examination results obtained at the time of the research were analyzed descriptively and presented in the form of tables and graphs accompanied by descriptions based on this secondary supporting theory.

Results

The results of this research obtained by analyzing data obtained by measurement. The data obtained showed in Table 1 – 6 below:

Table 1. Result of Ambient Air Quality Measurement Nitrogen Dioxide (NO₂) on three main streets in Makassar, Indonesia, 15-17 August 2020.

Location	Time (GMT+8)	Concentrated NO ₂ µg/Nm ³	Quality Standard
Point I The S. Alauddin Street in Makassar	07.00-08.00 (Morning)	2.23 µg/Nm ³ (0.02 ppm)	400µg/ Nm ³ (0.4 ppm)
	13.00-14.00 (Noon)	2.41 µg/Nm ³ (0.02 ppm)	
	16.00-15.00 (Aftrenoon)	2.89 µg/Nm ³ (0.02 ppm)	

Table 1. Result of Ambient Air Quality Measurement Nitrogen Dioxide (NO₂) on three main streets in Makassar, Indonesia, 15-17 August 2020.

Point II The Sudirman Street in Makassar	07.00-08.00 (Morning)	2.30 µg/Nm ³ (0.02 ppm)	400µg/ Nm ³ (0.4 ppm)
	13.00-14.00 (Noon)	0.88 µg/Nm ³ (0.008 ppm)	
	16.00-15.00 (Afternoon)	1.19 µg/Nm ³ (0.01 ppm)	
Point III The Independence Pioneer Street in Makassar	07.00-08.00 (Morning)	3.42 µg/Nm ³ (0.03 ppm)	400µg/ Nm ³ (0.4 ppm)
	13.00-14.00 (Noon)	1.02 µg/Nm ³ (0.01 ppm)	
	16.00-15.00 (Afternoon)	0.71 µg/Nm ³ (0.007 ppm)	

Table 2. Results of Measurement of Air Temperature on three main streets in Makassar, Indonesia, 15-17 August 2020.

Location	Time (GMT+8)	Temp.	Mean
Point I Street S. Alauddin Kota Makassar	07.00-08.00 (Morning)	30°C	32.26°C
	13.00-14.00 (Noon)	34.6°C	
	16.00-15.00 (Afternoon)	32.2°C	
Point II Sudirman Street District Makassar.	07.00-08.00 (Morning)	28°C	28.66°C
	13.00-14.00 (Noon)	28°C	
	16.00-15.00 (Afternoon)	30°C	
Point III Street Independence Pioneer Kota Makassar	07.00-08.00 (Morning)	28°C	30.33°C
	13.00-14.00 (Noon)	33°C	
	16.00-15.00 (Afternoon)	30°C	

Table 3. Results of Air Humidity Measurement on three main streets in Makassar, Indonesia, 15-17 August 2020.

Location	Time (GMT+8)	Air Humidity	Mean
Point I The S. Alauddin Street in Makassar	07.00-08.00 (Morning)	47 %	40.8%
	13.00-14.00 (Noon)	35%	
	16.00-15.00 (Afternoon)	40.4%	
Point II The Sudirman Street in Makassar	07.00-08.00 (Morning)	55 %	53.4%
	13.00-14.00 (Noon)	48%	
	16.00-15.00 (Afternoon)	57.4%	
Point III The Independence Pioneer Street in Makassar	07.00-08.00 (Morning)	57.8 %	53.9%
	13.00-14.00 (Noon)	49.2%	
	16.00-15.00 (Afternoon)	54.8%	

Table 4. Wind Speed Measurement Results on three main streets in Makassar, Indonesia, 15-17 August 2020.

Location	Time (GMT+8)	Kecepatan Angin	Average
Point I The S. Alauddin Street in Makassar	07.00-08.00 (Morning)	5.3 km/ hours	5.3 Km/ hours
	13.00-14.00 (Noon)	5.5 km/ hours	
	16.00-15.00 (Afternoon)	5.3 Km/ hours	
Point II The Sudirman Street in Makassar	07.00-08.00 (Morning)	3.6 km/ hours	3.6 km/ hours
	13.00-14.00 (Noon)	3.5 km/ hours	
	16.00-15.00 (Afternoon)	3.7 Km/ hours	
Point III The Independence Pioneer Street in Makassar	07.00-08.00 (Morning)	10 km/ hours	13.4 Km/ hours
	13.00-14.00 (Noon)	18.1 km/ hours	
	16.00-15.00 (Afternoon)	12.3 Km/ hours	

Table 5. Vehicle Density on three main streets in Makassar, Indonesia, 15-17 August 2020.

Location	Number Of Vehicles			Average
	Morning	Noon	Afternoon	
Point I	10.165	8.455	7474	8.698
Point II	1.864	2925	3124	2.637
Point III	6.887	5.588	7.045	6.506

Table 6. Linear Regression Test Results Effect of Vehicle Density, Temperature, Air Humidity, Wind Speed on NO Levels, on three main streets in Makassar, Indonesia.

No	Parameter	F	Sig
1	Vehicle Density	1.123	0.324
2	Temperature	0.000	0.988
3	Air Humidity	0.310	0.595
4	Wind Speed	0.497	0.504

Discussion

Air is a mixture of several types of gases whose ratio is not fixed, depending on air temperature, air pressure, and the surrounding environment. If the composition of the air changes from normal conditions and disturbs the humans, animals, and plants' life, it means that the air has been polluted. One of the technologies that cause air pollution is motorized vehicles. Most of the air pollution (70%) is caused by transportation activities.⁴

The growth rate of motorized vehicles contributes greatly to air pollution. The main air pollutants in the world are exhaust gases from the combustion of fossil fuels from motor vehicles. Various research results showed that motorized vehicles type were vehicles that have a major contribution to air pollution.⁵

NO₂ levels in the air if it is too high above the Air Pollution Standard Index (ISPU) 100 will result in

negative impacts, namely: acid rain, causing breathing difficulties for asthmatics, causing coughing for children and the elderly, decreased visibility, and various respiratory problems, and can cause death. Besides, people need to know the levels of nitrogen dioxide (NO₂) which are safe for health.⁶

Based on the results of measurements of Nitrogen Dioxide (NO₂) on S. Alauddin Street, Independence Pioneer Street (Gate One of Hasanuddin University), and Sudirman Street in Makassar were the main factors that greatly influence the concentration of NO pollutants. The number of vehicles each year has increased, one of which is in Makassar. In 2017 the number of motorized vehicles in Makassar reached 1.000.050 units, while in 2018 it reached 1.062.943 units. every year the number of vehicles in Makassar has increased by 6-7%. If the number of vehicles each year has increased by around

6-7%, it is estimated that in 2020 it will be around 1.190.000 to 1.195.000 units.²

Measurement of vehicle density at the point I showed an average of 2,637 units which can produce nitrogen (NO_2) content in ambient air of about $2.51 \mu\text{g}/\text{Nm}^3$ (0.02 ppm), at point II showed an average of 46,506 units can release nitrogen dioxide (NO_2) content around $1.71 \mu\text{g}/\text{Nm}^3$ (0.07 ppm) while at point III showed an average of 8,698 units can release nitrogen dioxide (NO_2) content of about $1.45 \mu\text{g}/\text{Nm}^3$ (0.01 ppm) into the ambient air. By looking at the results of the calculation of the number of vehicles, the location with the most vehicle congestion was point III. The results of measurements of Nitrogen Dioxide (NO_2) levels that have been carried out from each point obtained results below $400 \mu\text{g}/\text{Nm}^3$ (0.4 ppm) had met the requirements according to the Decree of the Governor of South Sulawesi No. 69/2010 Ambient Quality Standards for South Sulawesi Province) that the air quality standard ambient Nitrogen Dioxide (NO_2) is $400 \mu\text{g}/\text{Nm}^3$ (0.4 ppm).⁷

The results of measurement of NO_2 levels both in the first, second, and third measurements do not exceed the established quality standard, which is 3 ppm based on the Indonesian Government's regulation concerning the threshold value of physical factors and chemical factors in the work environment.⁸

The results obtained vary widely. These results couldn't be separated from various factors such as the biggest contributing factor, namely the density of the vehicle and the fuel used by the vehicle, such as premium type fuels that can produce relatively large amounts of NO_x and contain heavy metal lead (Pb), while the fuel type of pertalite gas exhaust NO_x in a relatively very small amount compared to premium and free from heavy metal (Pb) content while in fuel type Pertamina fuel is not much different from pertalite but better because it has the better capability and more perfect combustion resulting in exhaust gas very few. NO_x exhaust in one vehicle for premium with octane 88 can produce 15.10% NO_x , while pertalite with octane 90 produces 14.9% and for pertamax with octane 92% produces 14.53%.

The high level of NO_2 was caused by the number of vehicles at certain hours at each measurement point.

The Previous research on basement and upper ground parking, it was explained that the number of vehicles affects the amount of NO_2 concentration because the emissions emitted by vehicles were the main source, the more the number of vehicles, the more NO_2 levels will increase.⁹

Meteorological data can be seen if there is an increase in air temperature, based on the previous research¹⁰, when the air temperature was high, gases and air particles on the surface rise due to heating. So there is a tendency if the air temperature increases, it will increase the levels of gas and particles, including NO_2 levels. When the humidity of the air increases, the temperature of the air decreases as well as having an impact on the measured NO_2 levels.

The weather conditions at the time of the first measurement were cloudy and during the second and third measurements, the weather was sunny with a northward wind direction. Wind speed has a negative correlation. When the wind speed is high, the NO_2 level is measured to the low level.

Nitrogen dioxide (NO_2) is one of the pollutants that arise as a result of the combustion process. Whenever NO appears, NO_2 is always found, because NO, which is emitted in the combustion process, will immediately react with oxygen in the air to form Nitrogen Dioxide (NO_2) as a more stable nitrogen oxidation compound.

NO_2 gas can damage the human body and the environment. If NO_2 meets water vapor in the air or the human body, HNO_3 will form immediately, which is very damaging to the body. That's why NO_2 hurts when it comes to the eyes, nose, respiratory tract, and heart. High concentrations can cause death.¹¹

High NO_2 concentrations can affect respiration. NO_2 is a dangerous gas that can interfere with the respiratory system by reducing lung function, and weaken the pulmonary respiratory system.¹² The number of motorized vehicles that increase every year also greatly affects the emission of vehicle exhaust gases into the air. The more exhaust emissions, the more polluted the air will be if it is not accompanied by efforts to reduce pollutants. The increase in motorized vehicles is projected to continue in line with the increasing mobility

of people who need vehicles.¹³

Conclusion

Based on the research that has been done, it can be concluded that there was no effect of vehicle density with levels of nitrogen dioxide (NO₂) on the S. Alauddin Street, Makassar, namely 2.51 µg/Nm³ (0.02 ppm). There was no influence on vehicle density with Nitrogen Dioxide (NO₂) levels on Sudirman Street Makassar, namely 1.45 µg/Nm³ (0.01 ppm). There was no effect of vehicle density with levels of nitrogen dioxide (NO₂) on Independence Pioneer Street Makassar, namely 1.71 µg/Nm³ (0.07 ppm).

For people who work on the highway as well as people who use motorized vehicles to always use Personal Protective Equipment (PPE) such as masks. For the next researcher, it is expected to add CO gas measurement parameters by taking three sampling locations.

Conflict of Interest: There was no conflict of interest regarding this study and publication.

Ethical Clearance: This study has been ethically approved and allowed by the Regional Investment and Coordination Board of South Sulawesi in Makassar.

Source of Funding: This research was funded by the Health Polytechnic of Ministry of Health in Makassar Budget Year in 2020.

References

- [1] Mukono. Air pollution and its effects on respiratory tract disorders. 3rd ed. Surabaya: Airlangga University Press; 2000. 150 p.
- [2] Indonesia B-S. Indonesian Statistics 2019. Statistical Year Book of Indonesia 2019. 2019.
- [3] Thakur A. Study of ambient air quality trends and analysis of contributing factors in Bangalore, India. *Orient J Chem.* 2017;33(2).
- [4] Zainal A, Sukoco. *Vehicle Pollution Control.* Bandung: Alfabeta; 2009. 144 p.
- [5] Budiyo A. Air pollution: Impact of Air Pollution on the Environment. *Dirgantara.* 2010;2(1).
- [6] Prayudi T, Susanto JP. Quality of Dust in the Air as an Impact of the Flat Metal Casting Industry. *J Environmental Technology.* 2001;2(2).
- [7] Ahmad H, Rifai M. Noise Level at Higher Education Institutions Health Polytechnic Ministry of Health Makassar in 2016. *Sulolipu Media Komun Sivitas Akad dan Masy.* 2019;17(1).
- [8] Permenakertrans. Minister of Manpower and Transmigration Regulation Number Per.13/Men/X/2011 Concerning the Threshold Value of Physical and Chemical Factors in the Workplace in 2011. Reg. Minister of Manpower and Transm. 2011;
- [9] Binu Soesanto QM, Huboyo HS, Sutrisno E. Analysis of Indoor No₂ Quality at Basement and Upper Ground Parking (Case study : Mall X, Semarang). *J Environmental Technology.* 2014;3(2):1–6.
- [10] Adi K, Bimo, Saraswati, Nadira, Nurfienna, Ricardo L, et al. Simulation of the Spread of NO₂ and Motor Vehicle Emissions in Bandung Using TAQM. Paper. 2011;
- [11] Darmawan R (Universitas AS. Environmental Health Risk Assessment of NO₂ Ambient Level and Toll Collectors Officer's Health Complaints. *J Environmental Health*[Internet]. Available from: <https://e-journal.unair.ac.id/JKL/article/download/9394/5259>
- [12] Hadiwododo M, Hubayo HS. The Pattern of NO₂ Gas Spread in Ambient Air in the Northern Area of Semarang City in the Dry Season Using the ISCST3 Program. *J Presipitasi* [Internet]. 2006;1(1). Available from: <https://ejournal.undip.ac.id/index.php/presipitasi/article/view/10979>
- [13] Pamungkas RK. Kadar NO₂ di Udara Ambien Hubungannya dengan Keluhan Pernafasan Penduduk berdasarkan Kajian ARKL dan Sebaran Tanaman. 2012;(Skripsi thesis). Available from: <http://repository.unair.ac.id/23636/>