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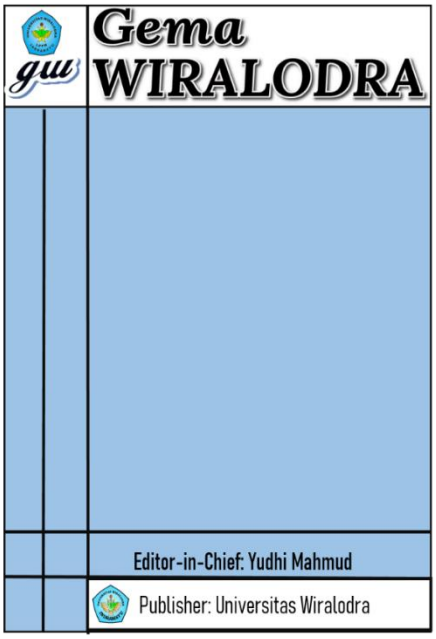

Nitrogen dioxide (NO_2) levels and health problems in street sellers around Universitas Negeri Gorontalo (UNG)

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Nitrogen dioxide (NO_2) levels and health problems in street sellers around Universitas Negeri Gorontalo (UNG)

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Abstract
Air is the most critical factor for human survival, which must and must always be maintained for quality. If the air quality changes from normal, the air has been polluted. Transportation activities are one of the contributing factors to air pollution. UNG is one of the largest campuses in Gorontalo Province, which involves students in increasing the number of residents outside the area who have an impact on campus activities and an increase in the number of vehicles. In the UNG area, street vendors sell from 6 in the morning to midnight. This makes street vendors a group at risk of experiencing health problems due to exposure to NO_2 from vehicle exhaust emissions. This type of research is observational with a descriptive study design. This research was conducted on Jalan Jendral Sudirman, around the UNG campus. The population in this study were all street vendors selling around the UNG campus, totaling 58 traders. The sampling technique uses the Total Sampling technique; the entire population is used as a sample. The results showed that the average concentration of NO_2 around the UNG campus did not exceed the quality standards set by Government Regulation No. 22 of 2021, namely 0.2 mg/m^3, and the most common health complaints experienced by respondents were coughing 43 people (74.1%), body aches and headaches 36 people (62.1%), runny nose 32 people (55.2%), sore throat 12 people (20.7%). Moreover, the least experienced was eye irritation in 2 people (3.4%). It is suggested that there should be monitoring of pollutant concentrations, and it is hoped that street vendors will use masks when selling and reduce selling time.
Keywords: Nitrogen dioxide (NO_2), health problems, Gorontalo

1. Introduction

Air is the most critical factor for human survival, and its quality must always be maintained. If the air quality changes from normal conditions and disrupts the lives of humans, animals, and plants, the air will be polluted. Air pollution is a critical environmental problem, especially in developing countries (Hikmiyah, 2018; Xu et al., 2023). One technology that causes air pollution is motorized vehicles. Transportation activities are one of the contributing factors to air pollution (Darmawan et al., 2018). WHO data for 2016 shows that in Indonesia, an average of 25 people died per 100 thousand per capita or up to 61 thousand people due to air pollution. WHO estimates that 70% of city residents have breathed dirty air due to motor vehicle emissions, while the remaining 10% have breathed marginal air (WHO, 2017). Air pollutants that are dangerous to public health, such as Sulfur Dioxide (SO_2), Nitrogen Dioxide (NO_2), particulates containing particles, and hydrocarbons, are all emitted by motorized vehicles (Wenas et al., 2016).

In recent years, nitrogen oxide (NOx) pollution due to vehicle emissions has become an essential issue in several countries in the world because the proportion of NOx in the form of NO_2 gas from vehicle exhaust has been shown to increase (Dwirahmawati et al., 2018). Nitrogen Dioxide (NO_2) is a pollutant that has a very high level of toxicity. Research shows a link between short-term exposure to Nitrogen Dioxide, ranging from thirty minutes to twenty-four hours, with respiratory side effects, including inflammation of the respiratory tract in

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healthy people and increased respiratory symptoms in people with asthma. NO_2 can stimulate the lungs and reduce resistance to respiratory infections such as influenza (Rahmatika, 2017). The source of Nitrogen Dioxide (NO_2) pollution is mostly produced from the transportation zone. The increasing number of motorized vehicles every year also greatly influences the release of vehicle exhaust emissions into the air. The more exhaust emissions there are, the more polluted the air will be if it is not accompanied by efforts to reduce pollutants. The growth rate of motorized vehicles makes a major contribution to air pollution. Various research results show that motorized vehicles are vehicles that contribute greatly to air pollution (Darmawan et al., 2018).

Gorontalo City is one of the regions that has an average annual increase in the number of motorized vehicles reaching 19.04% (BPS, 2020). Data on the number of motorized vehicles in 2020 was 122,559, increasing in 2021 to 125,437 vehicles. The increase in the number of vehicles each year can affect the release of vehicle exhaust emissions into the air. Gorontalo State University (UNG) is a state university located in Gorontalo City and is one of the largest campuses in Gorontalo Province which involves students in increasing the number of residents from outside the area who live and has an impact on campus activities as well as increasing the number of vehicles. Meanwhile, in the UNG area there are many street vendors selling, starting from 6 am to 12 pm. This makes street vendors a group at risk of experiencing health problems caused by exposure to NO_2 which comes from vehicle exhaust emissions.

2. Method

Location of air sampling on Jl. Jln. Jendral Sudirman, Wumialo Village, Kota Tengah, Gorontalo around the UNG campus, at three points, namely point 1 in front of the UNG Sabiilurrasyaad Mosque where traffic jams often occur because there are many three-wheeled vehicles parked on the road, point 2 around the Gorontalo State University (UNG) campus), point 3 near the turnoff on Jl.Ir.Hi. Joesoef Dalie Dalie, where there are also people selling and passing by, both students and buyers who are not students, there are often traffic jams on the road. Then the air samples were tested at BTKLPP Class I Manado. The type of research used is descriptive research. The population in this study were all street vendors around the UNG campus, totaling 58 people. A map of the research location can be seen in Figure 1.

Figure 1
Map of research locations

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3. Results and Discussion

a) Characteristics Respondent

Table 1

Frequency Distribution of Street Vendors by Age Around the UNG Campus In 2023

Age (Years)				
n	Mean	Median	Min	Max
58	33.19	30.50	18	59

Table 1 shows the average age of street vendors around the UNG campus, namely 33.19. The oldest age is 59 years and the youngest age is 18 years.

Table 2

Frequency Distribution of Street Vendors by Gender Around the UNG Campus in 2023

Gender	n	%
Man	32	55.2
Woman	26	44.8
Total	58	100.0

Table 2 shows that of the 58 respondents, 32 people (55.2%) were male and 26 people (44.8%) were female.

Table 3

Frequency Distribution of Street Vendors based on Body Weight Around the UNG Campus in 2023

Body Weight (Kg)				
n	Mean	Median	Min	Max
58	57.0	55.0	37	85

Table 3 shows the average body weight of street vendors around the UNG campus, namely 57.0 kg. The highest body weight is 85 kg and the lowest body weight is 37 kg.

b) Results of Nitrogen Dioxide (NO_2) Concentration Measurements and Meteorological Parameters

Table 4

Results of measurements of nitrogen dioxide (NO_2) concentrations and meteorological parameters in ambient air around the UNG campus in 2023

Location	NO_2 (mg/m^3)	Quality Standard NO_2 (mg/m^3)	Temperature (^0C)	Air pressure (hpa)	Air humidity (%)	Wind Speed (m/s)
Point 1 Sabilurrasyad UNG Mosque	0.025	0.2	31.3	1006.35	68.75	1.0
Point 2 Around the UNG Campus	0.02707	0.2	31.6	1002.25	63.325	1.4
Point 3 near the turnoff on Jl.Ir.Hi. Joesoef Dalie	0.01649	0.2	33.7	1007.125	58.35	0.7

Table 4 shows the results of measuring Nitrogen Dioxide concentrations around the UNG campus at different points. The highest concentration of Nitrogen Dioxide is at point 2 with a value of (0.02707 mg/m^3). Meanwhile, the lowest concentration of Nitrogen Dioxide is at point 3, namely (0.01649 mg/m^3). The Quality Standard Value set by Government Regulation No.22 of 2021 for Nitrogen Dioxide (NO_2) Concentration is 200µg/Nm^3 or 0.2 mg/m^3. So, it

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can be seen that the results of Nitrogen Dioxide concentrations at all points around the UNG campus do not exceed the specified quality standard limits.

c) Vehicle Density Measurement Results

Table 5

Results of Vehicle Distribution When Measuring Nitrogen Dioxide (NO_2) Concentrations around the UNG Campus in 2023

Measurement Location	Location Point	Vehicle Distribution Results at the Time of Measurement					
		Type of Vehicle					
		Wheels 4	Wheels 3	Wheels 2	Others	Total	Mean
Around the UNG Campus	Point 1	2.300	930	2.120	92	5.442	1.361
	Point 2	2.120	1.210	2.214	110	5.654	1.414
	Point 3	2.390	1.189	2.440	154	6.173	1.543

Table 5 shows that the results of vehicle distribution when measuring the concentration of Nitrogen Dioxide (NO_2) at each point during 1 hour of measurement around the UNG campus obtained different results. The highest vehicle density distribution results were at point 3 with the number of 4-wheeled vehicles, namely 2,390, 3-wheeled vehicles with a total of 1,189, 2-wheeled vehicles with a total of 2,440 vehicles and others 154 vehicles with a total of all types of vehicles, namely 6,173 and an average of 1,543. Meanwhile, the lowest vehicle distribution results were at point 1 with the number of 4-wheeled vehicles, namely 2,300, 3-wheeled vehicles with a total of 930, 2-wheeled vehicles with a total of 2,120 and others 92 and the total of all types of vehicles was 5,442 with an average of 1,361 vehicles.

d) Health problems of street vendors

Table 6

Frequency Distribution of Respondents based on Health Problems Data from Street Vendors Around the UNG Campus in 2023

Health Problems	Quantity			
	Yes		No	
	N	%	n	%
Fever	36	62.1	22	37.9
Cough	43	74.1	15	25.9
Cold	32	55.2	26	44.8
Throat Pain	12	20.7	46	79.3
Eye irritation	2	3.4	56	96.6
Headache	36	62.1	22	37.9

Based on data on health problems due to exposure to Nitrogen Dioxide (NO_2), the most common complaints were coughs by 43 people (74.1%), fever and headaches by 36 people (62.1%), colds by 32 people (55.2%) and most 12 people (20.7%) complained of sore throat and eye irritation in 2 people (3.4%).

Discussion

Nitrogen Dioxide (NO_2) Concentration in Ambient Air

Measurement of the Nitrogen Dioxide (NO_2) concentration around the UNG campus at point I was taken from 15.00 to 16.00, at point II the sample was taken from 16.00 to 17.00 and at point III the sample was taken from 17.00 to 18.00. sampling at this location in sunny weather conditions. The results of measuring NO_2 concentrations around the UNG campus showed

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that the average NO_2 concentration at 3 location points did not exceed the quality standard based on Government Regulation No. 22 of 2021, namely 0.2 mg/m^3. The highest NO_2 concentration was at location point 2 with measurement results of 0.02707 mg/m3, temperature 31.60C, humidity 63.325 % and wind speed 1.4 m/s. The NO2 concentration at point 1 obtained a measurement result of 0.025 mg/m^3, with a temperature of 31.3^{0}C, humidity of 68.75% and wind speed of 1.0 m/s. Meanwhile, at point 3, the lowest measurement results were obtained, namely 0.01649 mg/m3, temperature 33.7^{0}C, humidity 58.35% and wind speed 0.7 m/s. This is directly proportional to the measurement results above because the NO_2 concentration will decrease as the wind speed increases and if the wind speed is low then the pollutant concentration will increase. The concentration of Nitrogen Dioxide in Gorontalo City in January 2023 got an average value of 0.08398 mg/m^3 and in February 2023 it got an average value of 0.07179 mg/m^3. Based on the results of measuring NO_2 concentrations in Gorontalo City, the results showed that the average NO_2 concentration in January and February did not exceed the quality standards set by Government Regulation No. 22 of 2021, namely 0.2 mg/m^3 (Dinas Lingkungan Hidup dan Kehutanan, 2023).

The high and low concentrations are also influenced by several things, such as meteorological factors, which can act as inhibitors or triggers for the formation of pollutants. Meteorological factors that can influence air pollution include air temperature, which can influence atmospheric turbulence and the occurrence of chemical reactions. Meteorological factors including temperature, relative air humidity, rainfall, wind speed influence the measured NO_2 concentration. Humidity can affect the high and low concentrations, the lower the humidity, the drier the air, resulting in an increase in the distribution of NO_2 gas in the air. High air humidity indicates that there is a lot of water vapor in the air, thereby inhibiting the spread of polluting gases in the air (Serlina, 2020). Besides air temperature, wind speed and direction are also factors that influence NO2 concentrations. Wind speed and direction can determine certain directions and radius that are potentially exposed to these pollutant sources. Varying wind directions will affect the dispersion process, if the wind spreads in various directions continuously, then the distribution area of air pollutants will be wider, whereas if the wind direction only moves in one particular direction, the area will be exposed to high concentrations of air pollutants (Regia et al., 2021).

The activity of vehicles passing around campus is one of the causes of high and low NO_2 concentrations. The results of vehicle distribution when measuring the concentration of Nitrogen Dioxide (NO_2) at each point during 1 hour of measurement around the UNG campus obtained different results. The highest vehicle density distribution results were at point 3 with the number of 4-wheeled vehicles, that is 2,390, 3-wheeled vehicles with a total of 1,189, 2-wheeled vehicles with a total of 2,440 vehicles and others 154 vehicles with a total of all types of vehicles, that is 6,173 and an average of 1,543. Meanwhile, the lowest vehicle distribution results were at point 1 with the number of 4-wheeled vehicles, that is 2,300, 3-wheeled vehicles with a total of 930, 2-wheeled vehicles with a total of 2,120 and others 92 and the total of all types of vehicles was 5,442 with an average of 1,361 vehicles. Based on the results of vehicle distribution and the results of measurements of Nitrogen Dioxide concentration, there is a relationship between the number of vehicles passing at the time of measurement and the resulting high and low concentrations, because the large number of vehicles affects the high and low concentrations of NO_2. Vehicle speed, vehicle age, engine maintenance, traffic flow, driving style, and differences in fuel usage can affect the concentration of NO_2 produced. In petrol vehicles, the change in NO_2 gas concentration increases clearly when the vehicle starts driving at medium speed (40-60 km/hour), whereas diesel fueled vehicles produce

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relatively high concentrations of NO_2 gas when stationary, but this increases with variations in speed. vehicle is not that significant (Agustina et al., 2020).

The results of Sa'adah, 2019 regarding efforts to increase Indonesian vehicle emission standards related to the automotive market within the AEC framework explained that low concentrations in the air were influenced by vehicle emission standards, from 1992 to 2014 there were six levels recorded in the euro emission standard, namely euro 1, euro 2, euro 3, euro 4, euro 5 and euro 6. The higher the level in the euro emission standard, the lower the level of exhaust gas pollutants produced by a vehicle. Increasing vehicle emission standards will result in increasingly stringent reductions in emission thresholds. If this limit is reduced sufficiently, the resulting air concentration will be cleaner, thereby reducing the creation of air pollution which can have an impact on health and the environment. Bearing in mind the importance of implementing strict emission standards for a country, in terms of energy efficiency as well as to encourage the competitiveness of vehicle products, especially cars. In 2017 Indonesia decided to ratify regulations regarding minimum vehicle emission standards at the Euro 4 level in the ASEAN MRA. And the results of Angelia tahun 2019 research on Carbon Monoxide and Nitrogen Dioxide Air Quality Analysis at several traffic jam points in Manado City explain that currently many vehicles, both four-wheeled and two-wheeled, use fuel with a high octane value such as Pertamax and Pertalite, which makes it possible The combustion process in a vehicle engine is more efficient so that the exhaust gas emissions released are smaller.

Health Problems Due to NO_2 Exposure

ir can be a medium for disease transmission, especially air that has been polluted by particles and pollutants such as NO_2. Air polluted with NO_2 can cause different health problems, depending on its size, type and chemical composition. Health problems that often occur include dysfunction of body organs such as blood vessels and lungs, which can cause irritation to the eyes and skin. Apart from that, it can also stimulate the respiratory tract and cause irritation and inflammation (Adriana, 2021; Hidayatullah & Mulasari, 2020). The research results showed that of the 58 respondents, there were 43 respondents who experienced health problems and 15 respondents who did not experience health problems. The types of complaints felt by respondents were fever, cough, cold, sore throat, shortness of breath and eye irritation. Air pollutants affect the entire body, from the beginning of intrauterine development to the end of life, causing premature death mainly through lung and heart disease. Nitrogen Dioxide is an irritant gas that also causes oxidative stress and inflammatory reactions in the lungs. Nitrogen Dioxide also worsens asthma symptoms and causes airway disease (Ritz et al., 2019).

Based on the research results, the average health complaints most frequently experienced by respondents were coughs for 43 people (74.1%), body heat and headaches for 36 people (62.1%), colds for 32 people (55.2%), sore throat for 12 people (20.7%). And the least experienced was eye irritation in 2 people (3.4%). Several epidemiological studies suggest ambient nitrogen dioxide (NO_2) exposure is associated with health effects. Research result Zhang et al., 2022, Ambient air pollution is one of the factors that influences lung health, the effect of which is the incidence of coughing in adults. Research result Xu et al., 2023 in Wuhan China, demonstrated a 10-µg/m3 increase in NO_2 in ambient air led to a 3.64% increase in neurology clinic visits for headaches (95% CI: 1.02%, 6.32%, P=0.006). This study concluded short-term exposure to ambient NO_2 was positively correlated with NCV for headache.

The results of research by Chung et al., 2021 in Taiwan show that exposure to high levels of NO_2 in women significantly increases the risk of dry eye syndrome (DES). Based on

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the research results of Faustini et al., 2014, the combined effect on mortality was 1.04 (95% CI 1.02-1.06) with an increase of 10 µg·m-3 in annual NO_2 concentration. The effect on cardiovascular mortality was 1.13 (95% CI 1.09–1.18) for NO_2 and respiratory mortality was 1.03 (95% CI 1.02–1.03). Four analyzes of bipollutants with particulate matter and NO_2 in the same model showed minimal changes in the estimated effects of NO_2. In Amrullah's 2020 research on environmental health risk analysis of exposure to Nitrogen Dioxide (NO_2) gas among traders at the Simpang Aur Kuning Terminal, Bukittinggi City, he explained that of the 60 respondents the most common health complaints were coughs (71.7%), headaches (56 .7%), eye irritation (51.7%), runny nose (50%), body heat (43.3%), sore throat (31.7%), shortness of breath (20%), and the least experienced namely shortness of breath accompanied by chest pain (3.3%), and asthma (1.7%).

4. Conclusion

The results of measuring the concentration of Nitrogen Dioxide around the UNG campus do not exceed the quality standards set based on PP No.22 of 2021, namely 0.2 mg/m^3. The number of respondents in this study was 58 people, the largest gender was 32 men and 26 women. The health complaints most frequently experienced by respondents were coughing for 43 people (74.1%), body heat and headaches for 36 people (62.1%), colds for 32 people (55.2%), sore throat for 12 people (20.7%). The least experienced was eye irritation in 2 people (3.4%). From this conclusion, it is suggested that traders are expected to be able to reduce their exposure time while selling and maintain their health when selling until the early hours of the morning and use masks when selling. Supervision and monitoring of vehicle emission levels around the UNG campus, considering that around the campus there are many people selling on the road and traffic jams on the road often occur.

5. References

Adriana. (2021). *Analisis kualitas udara serta keluhan pernapasan pada pemulung di sekitar TPA Tamangapa Kota Makassar*. 9–47. http://repository.unhas.ac.id/id/eprint/16355/2/K011171024_skripsi_bab 1-2.pdf

Agustina, D. P., Annisa, N., & Prasetia, H. (2020). Konsentrasi karbon monoksida dan nitrogen dioksida pada ruas Jalan Kuin Utara dan Kuin Selatan Kota Banjarmasin. *Jernih: Jurnal Tugas Akhir Mahasiswa*, *3*(1), 37–48. https://doi.org/10.20527/jernih.v3i1.480

Angelia, G. C., Akili, R. H., & Maddusa, S. S. (2019). Analisis kualitas udara ambien Karbon Monoksida (CO) dan Nitrogen Dioksida (NO_2) dibeberapa titik kemacetan di Kota Manado. *Kesmas*, *8*(6), 378–387.

BPS. (2021). *Perkembangan Jumlah Kendaraan Bermotor Menurut Jenis*. https://www.bps.go.id/Linktabledinamis/View/id/1133

Chung, C. J., Hsia, N. Y., Wu, C. Da, Lai, T. J., Chen, J. W., & Hsu, H. T. (2021). Exposure to ambient no2 increases the risk of dry eye syndrome in females: An 11-year population-based study. *International Journal of Environmental Research and Public Health*, *18*(13), 1–14. https://doi.org/10.3390/ijerph18136860

Darmawan, R., Kesehatan, D., Fakultas, L., & Masyarakat, K. (2018). Analisis Risiko Kesehatan Lingkungan Kadar NO_2 Serta Keluhan Kesehatan Petugas Pemungut Karcis Tol Environmental Health Risk Assessment of NO_2 Ambient Level and Toll Collectors Officer'S Health Complaints. *Jurnal Kesehatan Lingkungan*, *10*(1), 116–128.

Dinas Lingkungan Hidup dan Kehutanan. (2023). *Data Pemantauan Kualitas Udara Ambien (AQMS) SPKUA Kota Gorontalo*.

Dwirahmawati, F., Nasrullah, N., & Sulistyantara, B. (2018). Analisis perubahan konsentrasi

p-ISSN: **1693 - 7945**
e –ISSN: **2622 - 1969**

Original Article

nitrogen dioksida (NO2) pada area bervegetasi dan tidak bervegetasi di Jalan Simpang Susun. *Jurnal Lanskap Indonesia*, *10*(1), 13-18.

Faustini, A., Rapp, R., & Forastiere, F. (2014). Nitrogen dioxide and mortality: Review and meta-analysis of long-term studies. *European Respiratory Journal*, *44*(3), 744–753. https://doi.org/10.1183/09031936.00114713

Hidayatullah, F., & Mulasari, S. A. (2020). Literature Review: Gangguan Saluran Penapasan Akibat Pencemaran Udara di Lingkungan Tempat Pembuangan Akhir (TPA). *Jurnal Kesehatan*, *13*(2), 119-130.

Hikmiyah, A. F. (2018). Analysis of dust and NO_2 level in the ambient air and sweeper's respiratory complaints in purabaya bus station Sidoarjo. *Jurnal Kesehatan Lingkungan*, *10*(2), 138. https://doi.org/10.20473/jkl.v10i2.2018.138-148

Rahmatika, N. I. (2017). Analisis risiko paparan nitrogen dioksida dari polutan ambien terhadap kesehatan masyarakat di kabupaten Magelang tahun 2015 (Bachelor's thesis, UIN Syarif Hidayatullah Jakarta: Fakultas Kedokteran dan Ilmu Kesehatan, 2017).

Regia, R. A., Bachtiar, V. S., & Solihin, R. (2021). Analisis risiko kesehatan akibat paparan particulate matter 2,5 (PM2,5) dalam rumah tinggal di perumahan X kawasan industri semen. *Jurnal Ilmu Lingkungan*, *19*(3), 531–540. https://doi.org/10.14710/jil.19.3.531-540

Ritz, B., Hoffmann, B., & Peters, A. (2019). The effects of fine dust, ozone, and nitrogen dioxide on health. *Deutsches Arzteblatt International*, *116*(51–52), 881–886. https://doi.org/10.3238/arztebl.2019.0881

Sa'adah, N. (2019). Upaya peningkatan standar emisi kendaraan indonesia terkait pasar otomotif dalam kerangka AEC. *EJournal Ilmu Hubungan Internasional*, *7*(1), 055–068. www.menlh.go.id,

Serlina, Y. (2020). Pengaruh faktor meteorologi terhadap konsentrasi NO_2 di udara ambien (Studi kasus bundaran hotel indonesia DKI Jakarta). *Jurnal Serambi Engineering*, *5*(3). https://doi.org/10.32672/jse.v5i3.2146

Wenas, R. A., Pinontoan, O. R., & Sumampouw, O.J. (2020). Analisis risiko kesehatan lingkungan pajanan Sulfur Dioksida (SO_2) dan Nitrogen Dioksida (NO_2) di Sekitar Kawasan Shopping Center Manado tahun 2020. *Indonesian Journal of Public Health and Community Medicine*, *1*(2), 053-058.

WHO. (2016). *World Polution Report 2017*.

Xu, H., Xu, M., Jc, Z., Ye, F., Liu, X., Liu, Y., & Jin, X. (2023). Short-term environmental nitrogen dioxide exposure and neurology clinic visits for headaches, a time-series study in Wuhan, China. *BMC Public Health*, *23*(1), 1–10. https://doi.org/10.1186/s12889-023-15770-0

Zhang, J., Lodge, C., Chang, A., Knibbs, L., Abramson, M., Walters, E. H., Bui, D., Erbas, B., Frith, P., Perret, J., Dharmage, S., & Idrose, S. (2022). Associations between ambient air pollution and chronic cough in middle-aged adults. *European Respiratory Journal*, *60*(suppl 66), 3357. https://doi.org/10.1183/13993003.congress-2022.3357