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LITERATURE REVIEW: ANALYSIS OF EXPOSURE OF VEHICLE EMISSION GASES (CO, NO2, SO2, PM2.5, AND PM10) TO PUBLIC HEALTH RISKS

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ABSTRACT

Exhaust emissions are pollutants that pollute the air created by vehicle exhaust gases. Vehicle exhaust gas is defined as the residual gas of the combustion process which is released into the free air through the vehicle exhaust duct. People can be at risk of air pollution from various pollutants, namely people who use roads, people who live on the roadside, and people who work on highways such as traffic police, street vendors, hawkers, and street children who busk at crossroads. The purpose of this study is to discuss and analyze the stages and procedures in the process of conducting an environmental health risk analysis of pollutant pollution in the air. This writing uses the *Literature Review method* and *selection criteria for including* carried out from 2018-2023. Calculation of the amount of health risk using the Environmental Health Risk Analysis (ARKL) method. Based on the *literature review* of these articles, there are still several *risk agents* (CO, NO2, SO2, PM2.5, and PM10) sources of air pollution that have values above the specified quality standards (RQ1). This is a risk to health both carcinogenic and non-carcinogenic. The impact can occur in respiratory disorders and other body systems both in *realtime* and in *lifetime.* Based on the calculation of the RQ≥1 value, exposure to air pollutants in the community will be continued at the risk control and risk communication stages.

Keywords: *Gas Emissions, Vehicles, Society*

INTRODUCTION

Air is the most important need in the survival of all living things, especially in humans (Gita C. Ulaan et al., 2022). In general, the composition of air in the homosphere layer consists of nitrogen, oxygen, carbon dioxide, argon, neon, helium, krypton, nitrous oxide, hydrogen, xenon, ozone and other gases. Air composition has dynamic fluctuating properties, meaning that the air composition in the highlands is different from the lowlands, areas on the equator are different from polar regions, areas of much vegetation are different from industrial areas (Kurniawan et al., 2022). Air quality also experiences degradation caused by pollution in air cleanliness, or as a result of reactions to changes in normal air composition with pollutants (gases and dust particles) into it, thus disrupting the continuity of the normal respiratory system of humans, animals, and plants (Zulfiryansyah et al., 2022).

Air pollution can occur due to human activities or occur naturally due to natural events, resulting in air quality dropping to a certain level (Hidayatullah &; Mulasari, 2020). Various pollutants in the air both physical, chemical and biological can cause health problems. Air pollutants enter the body most through the respiratory tract. The first organ affected by air pollutants is the lungs. Furthermore, it affects other organs. Some diseases are associated with polluted air (Kusmiyati et al., 2022).

Exhaust emissions are pollutants that pollute the air created by vehicle exhaust gases. Vehicle exhaust gas is defined as the residual gas of the combustion process which is released into the free air through the vehicle exhaust duct. There are main emissions produced by

vehicles including: hydrocarbons (HC), Carbon Monoxide (CO), Carbon Monoxide (CO2), Nitrogen Oxides (NOx) (Dewi et al., 2022). According to Pramudya (2001) air pollutants resulting from motor vehicle pollution are known as pollutants, which consist of several types, including carbon monoxide (CO), carbon dioxide (CO2), sulfur dioxide (SO2), nitrogen dioxide (NO2), hydrocarbons (HC), lead (Pb), particulates (PM2.5 and PM10), and others (Pramudya, 2001).

People can be at risk of air pollution from various pollutants, namely people who use roads, people who live on the roadside, and people who work on highways such as traffic police, street vendors, hawkers, and street children busking at crossroads (Helmy, 2019). The dangers of pollutants in the air often go unnoticed by the public. Though air pollutants can interfere with health to cause death. Health in humans will be disrupted due to polluted air which can lead to diseases such as respiratory tract infections, lungs, heart and also as a trigger for cancer which is very dangerous (Abidin &; Artauli Hasibuan, 2019).

METHOD

The method used in this literature study is by way of literature *review* in research that uses Environmental Health Risk Analysis (ARKL) research design. In its implementation, ARKL is carried out with four stages, namely hazard identification, response dose analysis, exposure analysis and determination of risk characteristics. Article search is carried out using *an online research journal* database. The literature used in this literature study is in the form of a National Journal published from 2018 to 2023. Literature collection is done through *google scholar databases* and other journal sources.

The selection of literature to be *reviewed* is determined using inclusion and exclusion criteria. The selection of inclusion and exclusion criteria, among others:

Inclusion Criteria:

1. The literature taken has a distance of 2018-2023.
2. Articles can be accessed thoroughly.
3. Articles according to the topic of literature study.
4. Discusses air pollution due to vehicle emission gases in Indonesia.
5. Discusses health risks due to air pollution from motor vehicle emission gases.
6. The study respondents worked as street vendors.

Exclusion Criteria:

1. Literature published below in 2018.
2. The article is not fully accessible to researchers.
3. Discusses air pollution in general.

Respondents did not work as street vendors.

RESULTS AND DISCUSSION

Researchers	Research Title	Result
(A. Lestari et al., 2021)	Environmental Health Risk Analysis Due to CO Exposure to Traders in Malang City Market	The results of this study showed that the concentration of CO in the Immune Market was 26,063 mg/m3. The RfC value is 1.207

		mg/kg/day. Intake value of 1,614 mg/kg/day. The RQ value is 1,337 mg/kg/day. It was concluded that the concentration of CO in the Immune Market exceeded the value of quality standards. A total of 19 respondents were declared not at risk and 40 respondents were declared at risk.
(Wahyuni et al., 2018)	Environmental Health Risk Analysis of Carbon Monoxide Gas in Street Vendors (Case Study of Jalan Setiabudi Semarang)	The average risk characterization value (RQ) is 0.037 (realtime) and 0.104 (lifetime) indicating that the risk characterization value (RQ) of 46 respondents of street vendors on Jalan Setiabudi, both realtime and lifetime, namely RQ≤1, means that it is still in the category of non-carcinogenic health risks.
(Darmawan, 2018)	*Environmental Health Risk Assessment of NO2 Ambient Level and Toll Collectors Officer'S Health Complaints*.	The results of ARKL show that toll ticket collectors with an average body weight of 62 kg are not safe to work at Dupak 1 Surabaya Toll Gate if the air intake rate is 0.83 m3 / hour, work 8 hours / day in 350 days / year for the next 30 years if the maximum NO2 concentration value is 0.1183 ppm (RQ>1).
(Prasetyo et al., 2020)	Risk Analysis of Epe Banana Traders Due to NO2 Gas Exposure on Jalan Penghibur Kota Makassar	The results showed that the concentration of NO2 in the comfort street was still below the established quality standard value with a maximum value of 28.98 µg /Nm3. No Risk Quotient (RQ) value exceeds 1 with a maximum value of 0.25, the Target Hazard Quotient (THQ) value also does not exceed 1 with a maximum value of 0.00002
(Wenas et al., 2020)	Environmental Health Risk Analysis of Sulfur Dioxide (SO2) and Nitrogen Dioxide (NO2) Exposure Around	The realtime RQ SO2 value was not found by at-risk respondents (RQ value>1). The RQ SO2 lifetime value was found to be 12 respondents (24.0%) who were at

	Manado Shopping Center Area in 2020	risk (RQ>1 value) of SO2 gas exposure. The RQ value of NO2 was found to be 1 respondent (2%) who was at risk (RQ value>1). The RQ NO2 lifetime value was found by 28 respondents (56.0%) who were at risk (RQ>1 value) of NO2 gas exposure.
(Maherdyta et al., 2022)	Environmental Health Risk Analysis of Nitrogen Dioxide (NO2) and Sulfur Dioxide (SO2) Gas Exposure to People in Yogyakarta Area	The results of this study show that for SO2 exposure, there are still 3 locations with RQ calculation results > 1. This shows that SO2 exposure has the potential to endanger health in all three locations, namely at Wonosari GunungKidul Terminal, north of PT Madu Baru, and south of PC. GKBI Medar. From the results of this study, the results of the calculation of RQ ≤ 1 for NO2 exposure were also obtained. The level of risk obtained is RQ < 1, meaning that it does not have a risk that can cause health problems.
(Sembiring, 2020)	Health Risks of PM2.5 Exposure in Ambient Air to Street Vendors Under Pasar Pagi Asemka Jakarta Flyover	Based on calculations, *realtime* RQ values at average concentrations showed RQ<1 or safe exposure for street vendors, which was 0.603 with 58 respondents. The value of RQ>1 is shown in the maximum condition at the pollutant concentration, which is RQ of 1.25 with the number of respondents as many as 2 people.
(Septian Maksum & Flora Ninta Tarigan, 2022)	Health Risk Analysis Due to Exposure to Dust Particles (PM2.5) from Transport Activities	The results showed that the average concentration of $PM_{2.5}$ in four locations, namely the front area of the UNG campus 0.01116 mg / m3,

		the Madina Baru Store area 0.02664 mg / m3, intersection five Jalan Agus Salim 0.03682 mg / m3, and the Central Market 0.0144 mg / m3. *Non-carcinogenic* realtime intake values were 1.43e-4 mg/kg/day, 9.49e-4 mg/kg/day, 6.44e-4 mg/kg/day, and 8.62e-4 mg/kg/day, respectively. The risk level of street vendors due to PM2.5 exposure is not risky (RQ ≤1).
(Wahyuningsih, 2020)	Environmental Health Risk Analysis (ARKL) of *Particulate Matter (*PM10) Exposure to Traffic Volunteers Due to Transportation (Case Study Jl. Abdullah Daeng Sirua Makassar City)	Based on the results of the calculation of PM10 intake in volunteers, traffic is still far below standard. Risk Characteristics Traffic volunteers who are active on Jl. Abdullah daeng sirua on RQ < 1, this means that traffic volunteers on Jl. Abdullah daeng sirua are not at risk.
(Gusti et al., 2018)	Decreased Degree of Trader Health Due to PM10 Dust Exposure	The *intake lifetime* value of PM10 exposure by inhalation at the Siteba Kodam Simpang and Siteba Perumnas Simpang has an RQ>1 value, indicating that the exposure is not safe for traders so it is necessary to control and the realtime intake *value of PM10 exposure by inhalation at the three sampling locations shows that the exposure is still safe or not risky to traders with an RQ<1 value* . The results of *the lifetime* risk calculation show that there are two risk sampling locations, namely at the Siteba Kodam Simpang and Siteba Perumnas Simpang with a value of RQ>1, which shows that traders are at risk of respiratory tract disorders in the next 30 years.

DISCUSSION

CO Gas Exposure

Car fumes contain 9% carbon monoxide. In traffic jams, the level of danger is quite high for poisoning cases. The presence of CO gas can be very dangerous if inhaled by humans because it will replace the position of oxygen (O2) to bind to hemoglobin in red blood cells. CO gas will flow into the heart, brain, and vital organs. The result can be very fatal. First, oxygen will be unable to compete with CO when it binds to hemoglobin molecules. This means that oxygen levels in the blood will decrease. Though as is known oxygen is needed by the cells and tissues of the body to perform metabolic functions. Second, CO gas will inhibit cytochrome oxidation activity.

This causes intracellular respiration to be less effective. Lastly, CO can bind directly to heart muscle and bone cells. The most serious effect is direct poisoning of these cells, also causing disruption of the nervous system. The main danger to health is resulting in blood disorders, the limit of exposure to carbon monoxide allowed by OSHA (*Occupational Safety and Health Administration*) is 35 ppm for 8 hours / working day, while that is 25 ppm for 8 hours. Levels considered directly hazardous to life or health are 1500 ppm (0.15%). Exposure of 1000 ppm (0.1%) for several minutes can cause 50% of hemoglobin to become carboxy hemoglobin and can be fatal (Irianti et al., 2017).

Research by Lestari et al. (2021) resulted in RQ>1 values of CO exposure in 19 street vendors, while 21 others had no health risks due to CO gas exposure. However, Wahyuni's research (2018) shows the risk characterization (RQ) of 46 respondents of street vendors on Jalan Setiabudi, both *realtime* and *lifetime*, namely RQ≤1, meaning that it is still in the category of not yet at non-carcinogenic health risk.

NO2 exposure

The organ most sensitive to NO2 gas pollution is the lungs. High concentrations of NO gas can cause disruption of the nervous system resulting in convulsions. Air pollution by NOx gas can also cause *Peroxi Acetil Nitrates* (PAN). Can cause irritation to the eyes which causes the eyes to feel sore and watery (Sabrina &; Ridho Pratama, 2022). The main source of NO2 due to human activities is produced from the combustion of fossil fuels (coal, gas, oil), especially motor vehicle gasoline. In urban areas, 80% of NO2 is produced by motor vehicles. This gas is also produced from the process of making nitric acid, welding, and the use of explosives. According to Madl and Yip (2000), acutely, nitrogen oxide can cause irritation of the airway, poisoning in edema, and difficulty breathing, so it can have an impact on death. Chronically, toxicity due to nitrogen oxide causes fibrosis, bacterial infections, damage to elastin, and damage to collagen fibers (Irianti et al., 2017)

Darmawan's research (2018) shows that exposure to NO2 gas has a risk value for health problems for toll road officials, this is evidenced by the calculation of the ARKL value which shows the value of RQ≥1. However, research by Prasetyo et al. (2020) shows that exposure to NO2 gas does not have a risk of health problems for traders with RQ<1 values.

SO2 Exposure

SO2 has a characteristic odor that is sharp, colorless and does not burn in air. SO2 gas enters the human body through the nose and mouth by breathing deeply. Because the solubility of SO2 gas is quite high, it can quickly cause irritation of bronchus, bronchioles and alveoli so

that the production of membranes and lenders (mucosa) increases. This will cause respiratory airway resistance to increase and will cause bronchus constriction (Wijiarti et al., 2016).

Sulfur Dioxide can cause irritation to the eyes, throat and other respiratory tracts. The condition of patients with asthma, bronchitis, and emphysema can become more severe in the presence of sulfur oxide. In addition, SO2 is converted in the air into secondary pollutants such as sulfate aerosols. Aerosols generally have a very fine size so that they can be sucked into the lower respiratory system. Sulfate aerosols when they enter the respiratory tract can cause more severe health effects than other particles because they have corrosive and carcinogenic properties. In gas form, SO2 can cause irritation to the lungs and cause difficulty breathing, especially in sensitive groups of people such as people with asthma, children and the elderly (Irianti et al., 2017).

Research by Wenas et al. (2020) shows that the RQ SO2 value in *realtime* is not found by respondents who are at risk (RQ value ≥1). The RQ SO2 *lifetime* value was found to be 12 respondents (24.0%) who were at risk (RQ>1 value) of SO2 gas exposure. RQ≥1 means that people exposed to SO2 gas have a risk of health problems. Research by Maherdyta et al. (2022) also shows that exposure to SO2 gas has a risk of health problems to health, this is indicated by the RQ≥1 value in the study.

PM2.5 and PM10 exposure

Large particulates can be retained in the upper respiratory tract, while small-sized particulates can reach the lungs, after which contaminants are absorbed by the circulatory system and spread throughout the body. Studies have shown that particle pollution is linked to threatened lung function in the form of respiratory disorders. The health impact caused is Acute Respiratory Infection (ARI), including asthma, bronchitis, and other respiratory disorders. Short-term and chronic exposure to PM10 plays a role in increasing the risk of cardiovascular disease and respiratory diseases including lung cancer (Gusti et al., 2018)

PM2.5 and PM_{10} are particles composed of various sulfate compounds, nitrate compounds, hydrogen ions, organic compounds, carbon compounds, ammonium, and particles bound to water. The main source of PM2.5 and PM10 particles is fossil fuels which are the result of public and private transportation. PM2.5 and PM10 negatively impact health by means of large dust particles that can enter the human respiratory tract can cause basic symptoms such as nausea, vomiting and headaches in addition to respiratory problems with coughing and sneezing characters and difficulty breathing at first exposure (Inaku &; Novianus, 2020).

PM2.5 is a particulate matter that has a diameter of <2.5 μm. This makes PM2.5 very difficult to filter by the respiratory system so that these particles will directly enter the smallest part of the human lung. PM2.5 contains various types of metals in it that can endanger human health both carcinogenic and non-carcinogenic (R. A. Lestari et al., 2021). PM2.5 has a high level of toxicity. When entering the body, PM2.5 will be able to penetrate into the lung system. Various studies have found a correlation between air pollution and certain diseases. One of them is proven that PM2.5 exposure affects the incidence of Chronic Obstructive Pulmonary Disease (COPD) (Riski &; Haryanto, 2020)

PM10 is a particle less than or equal to 10 micrometers in size, this size is so small that it can enter the lungs, potentially causing serious health problems. Numerous scientific studies link exposure to particle pollution with a variety of health problems, including eye, nose and throat irritation, coughing, chest tightness and shortness of breath, reduced lung function,

irregular heartbeat, asthma attacks, heart attacks, and premature death in people with heart disease or lung disease. PM10 exposure and its toxicity are related to geographic location and sampling season and correspond to chemical components of various PM10 fractions. If inhaled, PM10 will disrupt the respiratory system, because it tends to accumulate in the respiratory tract. The dose of PM10 exposure depends on the concentration of PM10 in the air, aerodynamic diameter, rate of deposition in the air, and the mechanism of particle cleaning and retention within the respiratory tract (Suryatia et al., 2019).

Sembiring's research (2020) obtained *realtime* RQ values at average concentrations showing RQ<1 or safe exposure for street vendors, which is 0.603 with 58 respondents. In the study, Septian Maksum &; Flora Ninta Tarigan (2022) also stated that exposure to PM2.5 has no health risks. In the Wahyuningsih Research research (2020) resulted that there is an RQ<1 value for the PM10 parameter so that the risk level is still safe. In the study of Gusti et al. (2018) showed that exposure to PM10 in realtime intake values *does not indicate health risks, but* in lifetime intake assessors *that people are at risk of having health problems in the respiratory tract in the next 30 years.*

CONCLUSION

Based on the results of a literature review in ten journals on the effect of air pollution on public health, five journals were found that indicate each pollutant that has a public health risk (RQ≥1). The calculation of *the lifetime* intake value will show whether exposure to pollutants will have an impact on health or not even though the calculation of the *real-time intake* value has no health risks. The RQ≥1 value will be continued at the risk control stage due to exposure to air pollutants (CO, NO2, SO2, PM2.5, and PM10). Negative impacts on health are in the form of dust particles that disturb the surrounding community, air pollution has an impact on respiratory diseases and air pollution does not pose a carcinogenic risk to the surrounding community.

REFERENCES

Abidin, J., & Artauli Hasibuan, F. (2019). Pengaruh Dampak Pencemaran Udara Terhadap Kesehatan Untuk Menambah Pemahaman Masyarakat Awam Tentang Bahaya Dari Polusi Udara. *Prosiding Seminar Nasional Fisika Universitas Riau IV (SNFUR-4), September*, 1–7.

Darmawan, R. (2018). Environmental Health Risk Assessment of NO2 Ambient Level and Toll Collectors Officer'S Health Complaints. *Jurnal Kesehatan Lingkungan*, *10*(1), 116–126.

Dewi, S. P., Alsakinah, R., Sara, S. A., & Amrina, D. H. (2022). Pajak Lingkungan Sebagai Upaya Pengendalian Pencemaran Udara Dari Gas Buang Kendaraan Bermotor Di Indonesia. *Jurnal Ilmiah Ekonomi Dan Pajak*, *2*(1), 7–13. https://ojs-ejak.id/index.php/Ejak

Gita C. Ulaan, Poekoel, V. C., & Ontowirjo, A. H. J. (2022). Indoor Air Quality Monitoring Systems. *Jurnal Teknik Informatika*, *17*(1), 93–104. https://doi.org/10.4018/ijkbo.2021070101

Gusti, A., Arlesia, A., & Anshari, L. H. (2018). Penurunan Derajat Kesehatan Pedagang Akibat Pajanan Debu PM 10 Decreasing the Degrees of Health Due to PM 10 Exposure on Traders. *Jurnal MKMI, 14*(3), 233–240.

Helmy, R. (2019). Hubungan Paparan Debu dan Karakteristik Individu dengan Status Faal Paru Pedagang di Sekitar Kawasan Industri Gresik. *Jurnal Kesehatan Lingkungan, 11*(2), 132–140. https://doi.org/10.20473/jkl.v11i2.2019.150-157

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. http://dx.doi.org/10.1016/j.pbi.201

Inaku, A. H. R., & Novianus, C. (2020). Pengaruh Pencemaran Udara PM 2,5 dan PM 10 Terhadap Keluhan Pernapasan Anak di Ruang Terbuka Anak di DKI Jakarta. *ARKESMAS (Arsip Kesehatan Masyarakat), 5*(2), 9–16. https://doi.org/10.22236/arkesmas.v5i2.4990

Irianti, T. T., Sugiyanto, Kuswandi, & Nuranto, S. (2017). *Toksikologi Lingkungan*. UGM. Yogyakarta.

Kurniawan, D., Eko Prastiyo, E., & Alfatih, M. F. (2022). Rancangan Purwarupa Pendeteksi Gas Karbon Monoksida (CO) Pada Pesawat Tanpa Awak Secara Nirkabel Berbasis Mikrokontroler. *Teknika STTKD: Jurnal Teknik, Elektronik, Engine*, *8*(2), 224–229. https://doi.org/10.56521/teknika.v8i2.626

Kusmiyati, Kambuno, N. T., Selasa, P., & Waangsir, F. W. F. (2022). Pengaruh Paparan Pencemar Udara Terhadap Stres Oksidatif: Sistematik Review. *Jurnal Ilmu Lingkungan*, *20*(3), 628–636. https://doi.org/10.14710/jil.20.3.628-636

Lestari, A., Misbahul, S., & Tiwi, Y. (2021). Analisis Kesehatan Lingkungan Akibat Pajanan CO Pada Pedagang. *Media Husada Journal of Environtmental Healrh, 1*(1), 1–6.

Lestari, R. A., Shadiq, F. A., Regia, R. A., Goembira, F., & Akbar, F. (2021). Potensi risiko pajanan PM2,5 pada pekerja tambang batu kapur di PT.X Kab. 50 Kota. *Riset Informasi Kesehatan*, *10*(2), 123. https://doi.org/10.30644/rik.v10i2.581

Maherdyta, N., Syafitri, A., Septywantoro, F., Kejora, P., Gulo, S., & Sulistiyorini, D. (2022). Analisis Risiko Kesehatan Lingkungan Paparan Gas Nitrogen Dioksida (NO2) Dan Sulfur Diokida (SO2) Pada Masyarakat Di Wilayah Yogyakarta. *Jurnal Sanitasi Lingkungan*, *2*(1), 51–59. https://doi.org/10.36086/jsl.v2i1.1040

Pramudya, S. (2001). *Melindungi Lingkungan Dengan Menerapkan ISO 1400*. Jakarta: Grasindo.

Prasetyo, M., Mallongi, A., & Amqam, H. (2020). Analisis Risiko pada Pedagang Pisang Epe Akibat Pajanan Gas NO2 di Jalan Penghibur Kota Makassar. *Hasanuddin Journal of Public Health, 1*(1), 71–82. https://doi.org/10.30597/hjph.v1i1.9514

Riski, M., & Haryanto, B. (2020). Hubungan pajanan PM2.5 terhadap Penyakit Paru Obstruktif Kronik (PPOK) pada pekerja di pintu gerbang pelabuhan tanjung priok tahun 2018. *Jurnal Nasional Kesehatan Lingkungan Global, 1*(3), 222–232.

Sabrina, A. P., & Ridho Pratama. (2022). Gambaran Kualitas Udara serta Analisis Risiko Nitrogen Dioksida (NO2) dan Sulfur Dioksida (SO2) di Kabupaten Bekasi. *Journal of Engineering Environtmental Energy and Science*, *1*(2), 63–70. https://doi.org/10.31599/joes.v1i2.1289

Sembiring, E. T. J. (2020). Risiko Kesehatan Pajanan PM2,5 Di Udara Ambien Pada Pedagang Kaki Lima Di Bawah Flyover Pasar Pagi Asemka Jakarta. *Jurnal Teknik Lingkungan*, *26*(1), 101–120. https://doi.org/10.5614/j.tl.2020.26.1.7

Septian Maksum, T., & Flora Ninta Tarigan, S. (2022). Analisis Risiko Kesehatan Akibat Paparan Partikel Debu (PM 2.5) Dari Aktivitas Transportasi. *Jambura Health and Sport Journal*, *4*(1), 19–28.

Suryatia, I., Akbara, M. N., & Latifaha, N. (2019). Studi Kandungan Logam Berat (As, Cd, Cr, Pb Dan Hg) dalam Particulate Matter 10 Mikron (PM10) di Beberapa Ruas Jalan Kota Medan. *Dampak: Jurnal Teknik Lingkungan Universitas Andalas*, *16*(2), 77–85. https://doi.org/10.25105/pwkb.v1i1.5256

Wahyuni, E., D, Y. H., & Setiani, O. (2018). Analisis Risiko Kesehatan Lingkungan Gas Karbon Monoksida Pada Pedagang Kaki Lima (Studi Kasus Jalan Setiabudi Semarang). *Jurnal Kesehatan Masyarakat (e-Journal)*, *6*(6), 87–93.

Wahyuningsih, S. (2020). Analisis Risiko Kesehatan Lingkungan (ARKL) Pajanan Partikulat Matter (PM10) Pada Relawan Lalu Lintas Akibat Transportasi (Studi Kasus Jl. Abdullah Daeng Sirua Kota Makassar). *Jurnal Sanitasi Dan Lingkungan*, *1*(1), 47–51. https://e-journal.sttl-mataram.ac.id/index.php/jsl/article/view/2

Wenas, R. A., Pinontoan, O. R., Sumampouw, O. J., Studi, P., Kesehatan, I., Universitas, P., & Ratulangi, S. (2020). Analisis Risiko Kesehatan Lingkungan Pajanan Sulfur Dioksida (SO2) dan Nitrogen Dioksida (NO2) di Sekitar Kawasan Shopping Center Manado. *Indonesian Journal of Public Health and Community Medicine*, *1*(2), 53–58.

Wijiarti, K., D, Y. H., & D, N. A. Y. (2016). Analisis Risiko Kesehatan Lingkungan Paparan Sulfur Dioksida (SO2) Udara Ambien Pada Pedagang Kaki Lima Di Terminal Bus Pulogadung, Jakarta Timur. *Jurnal Kesehatan Masyarakat*, *4*(4), 983–991.

Zulfiryansyah, F., Syahrorini, S., & Habibi, M. N. (2022). Air Quality Monitoring System using Unmanned Aerial Vehicle (UAV) Quadcopter Type. *Procedia of Engineering and Life Science*, *2*(2), 2–8. https://doi.org/10.21070/pels.v2i2.1244