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HEALTH RISK ANALYSIS OF EXPOSURE NO_2 AND SO_2 AT STREET VENDORS IN KAMBANG IWAK AREA PALEMBANG CITY

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Abstract

Kambang Iwak Palembang city is park the city that always is crowded passed by vehicles general nor vehicle personal with density and activity then enough traffic tall. High vehicle volume contribute give rise to various pollutant gas emissions, including NO_2 and SO_2 which can endanger health man If reach concentration certain. Objective study for analyze risk health consequence exposure to NO_2 and SO_2 to street vendors in Kambang Iwak area Palembang city. Method study apply design study descriptive with approach quantitative as well as use environmental health risk analysis. Population study that is street vendors in Kambang Iwak totaling 150 people and a sample of 109 people was counted use formula slovin and determined through technique purposive sampling. Data analysis using analysis univariate and analysis risk health environment. Average concentrations of NO_2 and SO_2 at 3 points measurement namely 0.007 mg/m^3 and 0.012 mg/m^3, concentrations the No exceed mark standard quality determined by the Regulations Government No. 22 of 2021. As many as 58.2% of respondents own NO_2 intake value > 0.00191 mg/m^3, and SO_2 intake > 0.00327 mg/m^3. Whole respondents show RQ value < 1 for non-carcinogenic exposure. No There is risk happen disturbance non-carcinogenic health consequence exposure to NO_2 and SO_2 to all over street vendors in Kambang Iwak area Palembang city.

Keywords: Environmental Health Risk Analysis, Nitrogen Dioxide, Street Vendors, Sulfur Dioxide

Introduction

Pollution air is problem environment around the world that occurs every years in various countries, especially in cities big.[1] In 2019, 99% of the world's population inhaled it air that transcends limit WHO recommendations. Pollution air estimated become cause 6.7 million death premature every the year. In 2019, pollution air outside room globally estimated cause around 4.2 million death prematurity, of which 89% occur in low income countries low and middle, regions with amount death highest found in the West Pacific and Southeast Asia. [2] Indonesia is a country with amount death early consequence pollution air highest fourth in the world, namely 232,974 people per year. [3]

Sector transportation be one contributor main pollution urban air, where about 70% of emissions vehicle motorized contribute to pollutants like Particulate Matter (PM), Nitrogen Dioxide (NO_2), Sulfur Dioxide (SO_2), and Carbon Monoxide (CO). [4] Study Alfani (2021) stated vehicle motorized as reason main pollution air moment this with contribution by 85%. [5]

The results of ambient air quality monitoring in Indonesia increased from 2015 to 2019, NO_2 concentrations ranged from 9.54 µg/m^3 to 11.55 µg/m^3. And the average concentration of SO_2 ranges from 6.90 µg/m^3 to 11.09 µg/m^3.[6] Meanwhile, in general, the concentration of NO_2 and SO_2 in South Sumatra Province still meets ambient air quality standards. However, this needs to be anticipated

because it continues to experience a significant increase. The Ministry of Environment and Forestry of the Republic of Indonesia noted that the concentration of NO_2 and SO_2 in Palembang city increased from 2017 to 2018. In 2017 the concentration of NO_2 was 43 μg/m^3 and SO_2 was 64 μg/m^3. Then, in 2018 it became 45 μg/m^3 for NO_2 concentration and 65 μg/m^3 for SO_2 concentration.[7]

Palembang city is one of the areas experiencing this enhancement amount transportation in a way significant for 3 years final from period time 2020 to 2022, BPS South Sumatra data for 2023 shows that total vehicle in 2020 there were 19.873 motorized vehicles in the city of Palembang, in 2021 there were 21.120 vehicles and in 2022 there were 550.428 million vehicles.[8] Increasing amount vehicle cause enhancement gas emissions produced, so cause enhancement pollution air. Emission from vehicle motorized is one of factor main in pollution environment and can give rise to disease in humans. [9]

According to Alchamdani (2019) exhaust vehicle motorized emit various type substance pollutants, including NO_2 and SO_2. [10] Nitrogen Dioxide (NO_2) and Sulfur Dioxide (SO_2) are substance possible pollutants endanger health man. [11] Exposure to NO_2 and SO_2 from exhaust vehicle motorized Can enter to lungs and irritates system Respiratory. [10] Besides that, Nitrogen Dioxide (NO_2) can result cough, decline function lungs, bronchitis chronic, irritation of the eyes, nose and throat, difficulty breathing, chest pain and pulmonary edema. [12] Impact negative Sulfur Dioxide (SO_2) for body man is lower function lungs, and irritation channel Respiratory so that give rise to symptom like cough, trouble breathing and improvement disease asthma. [13]

Relevant research conducted by Nuzela (2021) regarding risk health exposure to NO_2 and SO_2 on Ki Kemas Rindo street, the city of Palembang stated that all over public own RQ value > 1.[14] Furthermore study Mulyati et al. (2019) related Exposure to Nitrogen Dioxide (NO_2) and Sulfur Dioxide (SO_2) at 26 Ilir Market, Palembang city states based on calculation risk NO_2 exposure all over trader not yet there are risks exposed to NO_2, meanwhile calculation risk SO_2 exposure state that There are 7 street vendors exposed to SO_2 with non-carcinogenic risk RQ > 1. [15] And research Sunarsih et al. (2019) shows that exposure to NO_2, SO_2, PM10 and TSP in bus drivers in Palembang city causes risk non-cancer health. [16]

Kambang Iwak Palembang city is a park the city already there is since 1900s. Based on the initial survey, activities then traffic around area the always crowded with vehicles general nor vehicle personal with sufficient density tall. That matter happen because Kambang Iwak always crowded visited public for exercising, hunting snacks culinary, or just relax and enjoy beauty garden, besides it's around area this there is several cafes or place busy eating visited by the public. With condition it and its height opportunity economics, then around area This there is existing street vendors trade many years. Therefore there it is possibility happen impact resulting health consequence pollution air from activity vehicle. Objective from study This is for analyze risk health caused by exposure to NO_2 and SO_2 to street vendors in Kambang Iwak area Palembang city.

Method

This research applies a research design descriptive with a quantitative approach as well as using Environmental Health Risk Analysis (EHRA). Implementation location study is in Kambang Iwak area Palembang City, which was carried out from November – December 2023. The population that is the focus of the study is all street vendors who trade around Kambang Iwak area, with a total of 150 people and as many as 109 people as calculated samples use formula slovin and determined through technique purposive sampling, with criteria inclusion that is is trader regulars and traders who work mainly as street vendors in Kambang Iwak area Palembang city.

Instrument questionnaires and tools Impinger used as tool data collector. Impinger tool used for measure NO_2 concentration and SO_2. NO_2 measurement follow provisions of SNI 7119-2-2017 and SO_2 SNI 7119-7-2017 which regulate procedure testing Nitrogen Dioxide (NO_2) and Sulfur Dioxide (SO_2), i.e. measurement use spectrophotometer with method analysis Griess Saltzman for NO_2 and

Pararosanilin for SO_2. Measurement done together air sampling officer from UPTD Laboratory DLHP South Sumatra Province. Data analysis was carried out with Analysis Univariate and Environmental Health Risks Analysis (EHRA) include stages hazard identification, dose-response assessment, exposure assessment, and risk characterization. For count intake exposure to NO_2 and SO_2 street vendors, you can use the following formula: [17]

$$C_{adj-air} = \frac{C \times ET \times EF \times ED}{AT}$$

Where:

$C_{adj-air}$: The adjusted air concentration (mg/m^3)
C : Concentration of contaminants in the media (mg/m^3)
ET : Exposure time (hours/day)
EF : Exposure frequency (days/year)
ED : Exposure duration (years)
AT : Average time, non-carcinogen risk AT = ED x 24 hours/day x 365 days/year

After obtain intake value, Risk Qutient (RQ) can calculated use the equality following:

$$RQ = \frac{C_{adj-air}}{RfC}$$

Where:

RQ : Risk Quotient
$C_{adj-air}$: The adjusted air concentration (mg/m^3)
RfC : Reference Concentration NO_2 100 ppb = 0,188 mg/m^3 and SO_2 75 ppb = 0,197 mg/m^3

RQ calculation produces two category level risk that is if RQ value > 1 then stated no safe and risky cause disturbance health and if RQ < 1 is stated still classified safe and not risky cause disturbance health. [18]

The following sampling location layout is in Figure 1:

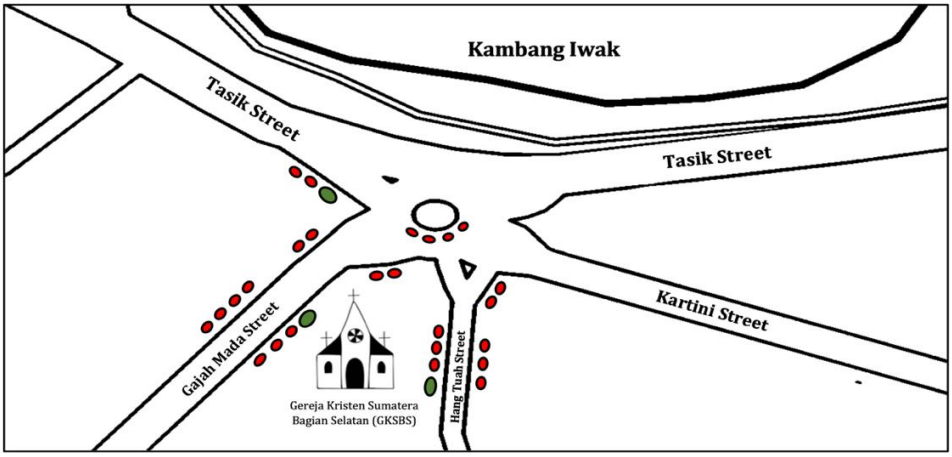

Figure 1. Sampling Location Layout

Where:

- : Sampling Point
- : Street vendors

Results

Hazard Identification

NO_2 and SO_2 concentrations

Measurement results concentration NO_2 and SO_2 at 3 points measurements in Kambang Iwak area Palembang City is listed in Table 1 follows this:

Table 1. Results of NO_2 and SO_2 Concentration Measurements in Kambang Iwak Area Palembang City

No	Sampling Point	Measurement Time (WIB)	Measurement Results	
			NO_2 (mg/m^3)	SO_2 (mg/m^3)
1	Gajah Mada Street Next to GKSBS	13.20 – 14.20	0,0038	0,0054
2	Side of Tasik Street	14.45 – 15.45	0,0089	0,0054
3	Hang Tuah Street Next to GKSBS	17.10 – 18.10	0,0092	0,0266
Average			**0,007**	**0,012**

Source: Primary Data, 2023

Based on the data in Table 1, the measurement results show an average concentration of Nitrogen Dioxide (NO_2) of 0,007 mg/m^3 and Sulfur Dioxide (SO_2) 0,012 mg/m^3. The highest NO_2 concentration measurement was at point 3, namely 0,0092 mg/m^3, and the lowest was at point 1, namely 0,0038 mg/m^3. Meanwhile, the highest SO_2 concentration measurement was at point 3, reaching 0,0266 mg/m^3, while points 1 and 2 showed the lowest concentration with a value of 0,0054 mg/m^3.

Dose-Response Assessment

Dose Response is expressed as Reference Concentration (RfC). RfC numbers for Risk Agent NO_2 and SO_2 in this study used quality standard values regulated in NAAQS (National Ambient Air Quality Standards), namely 100 ppb (0,188 mg/m^3) for NO_2 and 75 ppb (0,197 mg/m^3) for SO_2, respectively. [19]

Exposure Assessment

Activity Patterns and Analysis of Street Vendors Intake in Kambang Iwak Area Palembang City

Exposure Time (ET), Exposure Frequency (EF), and Exposure Duration (ED) are aspects of activity patterns. The following is a data analysis table of activity patterns and intake of street vendors in Kambang Iwak area Palembang city

Table 2. Results of Univariate Analysis of Activity Patterns and Intake of NO_2 and SO_2 Street Vendors in the Kambang Iwak area of Palembang City

Variable	Mean	Median	SD	Min	Max	p-value Kolmogorov - Smirnov
Exposure Time	6,7	7,0	0,4	6	7	0,000
Exposure Frequency	345,9	353,0	13,8	269	359	0,000
Exposure Duration	3,8	3,0	1,9	1	8	0,000
Intake NO_2	0,00186	0,00191	0,00015	0,00150	0,00201	0,000
Intake SO_2	0,00318	0,00327	0,00025	0,00258	0,00344	0,000

Source: Primary Data, 2023

Based on table 2, the average value of exposure time is 7 hours/day, the frequency of exposure reaches 353 days/year, the duration of exposure is 3 years, the average intake of NO_2 is 0,00191 mg/m^3 and the average intake of SO_2 0,00327 mg/m^3. The data normality test shows that all variables are not normally distributed because of the p-value less than 0,05 so the middle value (median) becomes the

benchmark. Below is a table of distribution of activity patterns and intake of NO_2 and SO_2 for street vendors in the Kambang Iwak area Palembang city, based on category from the test Kolmogorov-Smirnov:

Table 3. Distribution of Activity Patterns and Intake of NO_2 and SO_2 Street Vendors in Kambang Iwak Area Palembang City

Variable	Frequency	Percentage
Exposure Time (hours/day)		
≤ 7	109	100
> 7	0	0
Frequency Exposure (days/year)		
≤ 353	86	78,9
> 353	23	21,1
Duration Exposure (years)		
≤ 3	59	54,1
> 3	50	45,9
Intake NO_2 (mg/m^3)		
≤ 0,00191	58	53,2
> 0,00191	51	46,8
Intake SO_2 (mg/m^3)		
≤ 0,00327	58	53,2
> 0,00327	51	46,8

Source: Primary Data, 2023

Based on the data information listed in Table 3, it shows that the majority of respondents had exposure time ≤ 7 hours/day (100%), with exposure frequency ≤ 353 days/year (78,9%), and exposure duration ≤ 3 years (54,1%), and has an intake NO_2 ≤ 0,00191 (53,2%) and intake SO_2 ≤ 0,00327 (53,2%).

Intake calculation NO_2 and SO_2 can be exemplified by one of the respondents in serial number 02 below:

Realtime intake calculation of NO_2 concentration:

$$C_{adj-air} = \frac{0{,}007\,\frac{mg}{m^3} \times 7\,\frac{hours}{days} \times 359\,\frac{days}{years} \times 6\ years}{24\,\frac{hours}{days} \times 365\,\frac{days}{years} \times 6\ years}$$

$$= 0{,}00201\ mg/m^3$$

Realtime intake calculation of SO_2 concentration:

$$C_{adj-air} = \frac{0{,}012\,\frac{mg}{m^3} \times 7\,\frac{hours}{days} \times 359\,\frac{days}{years} \times 6\ years}{24\,\frac{hours}{days} \times 365\,\frac{days}{years} \times 6\ years}$$

$$= 0{,}00341\ mg/m^3$$

Risk Characterization

Risk characterization are calculated by comparing the results of the intake analysis with the reference concentration value (RfC), which is generally referred to as Risk Quotient (RQ) or big risk. Below is an example of RQ calculation based on intake values NO_2 and SO_2 for respondent number 02:

Realtime RQ calculation of NO_2 concentration:

$$RQ = \frac{0{,}00201\ mg/m^3}{0{,}188\ mg/m^3} = 0{,}0107$$

Realtime RQ calculation of SO_2 concentration:

$$RQ = \frac{0{,}0034\ mg/m^3}{0{,}197\ mg/m^3} = 0{,}0173$$

Real time RQ calculation for respondent number 02 above show that RQ < 1 so that the risk level of exposure to NO_2 and SO_2 in real time street vendors are still classified as safe. The following is analysis table Risk Quotient (RQ) of exposure to NO_2 and SO_2 in street vendors in Kambang Iwak area Palembang city:

Table 4. Results of Univariate Analysis of Risk Quotient (RQ) Street vendors in Kambang Iwak area Palembang City

Variable	Mean	Median	SD	Min	Max
RQ NO_2	0,00987	0,01016	0,000799	0,00798	0,01069
RQ SO_2	0,01613	0,0166	0,001286	0,01310	0,01746

The results of the RQ calculation of exposure to NO_2 and SO_2 in street vendors show the lowest values of 0,00798 and 0,01310 respectively. And the largest RQ values are 0,01069 and 0,01746 respectively. With an average RQ NO_2 value of 0,00987 and RQ SO_2 0,01613.

Table 5. Distribution of Analysis Risk Quotient (RQ) Street vendors in Kambang Iwak area Palembang City

Variable	Frequency	Percentage
RQ NO_2		
≤ 1	109	100
> 1	0	0
RQ SO_2		
≤ 1	109	100
> 1	0	0

Based on table 5, it is known that there are no street vendors who are exposed to concentrations of Nitrogen Dioxide (NO_2) and Sulfur Dioxide (SO_2).

Discussion

Hazard Identification

NO_2 and SO_2 concentrations

NO_2 concentration measurements show that the highest concentration of 0,0092 mg/m^3 came from the third measurement point at 17.10 – 18.10 WIB. And the average value of the NO_2 concentration measurement results at the three measurement points was 0,007 mg/m^3. Sourced from Government Regulation no. 22 of 202, the results of NO_2 concentration measurements, both the highest concentration and the average concentration, do not exceed the established quality standards, namely 200 μg/m^3 or equal to 0,2 mg/m^3 within a 1 hour measurement time span. [20] Meanwhile, the results of measuring the SO_2 concentration showed that the highest concentration was 0,0266 mg/m^3 from the third measurement point at 17.10 – 18.10 WIB. And the average value of SO_2 concentration at three measurement points is 0,012 mg/m^3. Sourced from Government Regulation no. 22 of 2021 SO_2 measurement results, both the highest concentration and average concentration, do not exceed the established quality standards, namely 150 μg/m^3 or equal to 0,15 mg/m^3 within a measurement time span of 1 hour. [20]

Based on the results of measuring the concentrations of NO_2 and SO_2 At three measurement points, it was found that the highest concentration of these two gases was at the third point, namely on Hang Tuah street next to the Gereja Kristen Sumatera Bagian Selatan (GKSBS). The high concentration of NO_2 and SO_2 at the third point is influenced by the high volume of vehicles at the time of measurement, namely in the afternoon at 17.10 – 18.10 WIB. The high volume of vehicles causes the NO_2 and SO_2 emissions produced to also increase. Study Gasmi et al. (2017) stated that NO_2 concentration is closely related to traffic activity, as traffic density increases, the amount of NO_2 gas

produced also increases.[21]And research by Rosa et al. (2015) stated that an increase in the number of motorized vehicles causes an increase in SO_2 gas emissions.[22]

Dose-Response Assessment

In this study, the agents at risk are non-carcinogenic agents via the inhalation exposure route. RfC values for NO_2 and SO_2 are not yet available in Integrated Risk Information System (IRIS) US EPA, so the RfC values used are based on literature from the National Ambient Air Quality Standards (NAAQS). The RfC value of Nitrogen Dioxide (NO_2) is 100 ppb or 0,188 mg/m^3 and Sulfur Dioxide (SO_2) is 75 ppb or 0,197 mg /m^3. [19] The Director General of PP&PL stated that dose-response analysis can be carried out without having to carry out experimental research yourself, but can refer to existing literature.[18]

Exposure Assessment

Activity Patterns and Analysis of Street Vendors Intake in Kambang Iwak area Palembang City

Based on the data analysis carried out, the median exposure time was 7 hours/day. The results of the exposure time analysis in this study were compared with the Republic of Indonesia Minister of Manpower Regulation No. 5 of 2018 concerning Occupational Safety and Health in the Work Environment, the maximum time for workers to do work is 8 hours/day[23] so that the average exposure time does not exceed predetermined regulations. Masito (2018) stated in his research that exposure to ambient air pollutant gases continuously and over a long period of time, this can have a greater impact on the respiratory complaints experienced by a person.[24] Study Fatimah et al. (2018) stated that the majority of street vendors are exposed to dust for less than 8 hours (55%) per day along Brigjen Sudiarto street.[25] The researcher's assumption in this study is that the condition of street vendors who are continuously in the location for a long period of time could potentially cause health problems.

The average frequency of exposure to street vendors in the Kambang Iwak area Palembang city is 353 days/year. Meanwhile, the default value for exposure to the work environment that has been set by the US-EPA is 250 days/year. Study Harjanti et al. (2016) stated that the greater the frequency of a person's exposure to ambient air pollutants, the higher the health risk.[26] Based on research conducted by Mulyati et al. (2019) found that the average frequency of exposure to street vendors at 26 Ilir Market, Palembang city reached 357 days/year, thus the frequency value obtained was quite high and had the potential to influence the risk of health problems in respondents exposed to NO_2 and SO_2. [15] In this study, respondents experienced a fairly high exposure frequency, this is because some of the street vendors in Kambang Iwak area work almost every day and the work of street vendors is informal so they are not bound by the rules of daily working hours set by certain institutions or agencies. The longer the frequency of exposure will have an impact on the respondent's health.

The results of the exposure duration analysis show a median value of 3 years which is the benchmark in this study. The lowest duration of exposure was 1 year and the highest was 8 years. There were 59 street vendors who had exposure duration ≤ 3 years and 50 people had exposure duration > 3 years. Research conducted Maksum et al. (2022) found that the average duration of exposure to street vendors was 4,06 years. [27] The longer the work period, the risk to a trader's health may increase. A longer duration of exposure will provide a higher risk of contaminants. As explained by Riviwanto et al. (2017) stated that a long duration of exposure will have an impact on the possibility of various health problems occurring through the respiratory route (inhalation) and the greater the effects that can be obtained on the body. [28]

From the research results, 58,2% of street vendors obtained NO_2 intake values > 0,00191 mg/m^3, while 58,2% of them also had SO_2 intake values > 0,00327 mg/m^3. Rahmawati, (2023) stated in her research that the amount of intake value has a directly proportional relationship with the value of exposure frequency, exposure time, exposure duration, concentration of risk agents and intake rate.[29]

In other words, the higher the value, the greater the intake consumed by the individual and vice versa. According to the results of research conducted by Arista et al. (2015) 50% of street vendors at Ampera Terminal, Palembang city have an intake value > 0,00132 mg/kg/day and 50% of street vendors have an intake value SO_2 > 0,00677 mg/kg/day.[30] The intake value obtained in this study is quite low because the concentration of NO_2 and SO_2 from the measurement results is still below the quality standard value and the exposure time is less than the same as ≤ 7 hours/day. In research Alchmadani (2019), the intake value at gas station operators obtained is still quite low due to the measurement results of NO_2 and SO_2 concentrations are still below the quality standard value and the average exposure is still below 8 hour /day.[10] Therefore, it is considered normal if the intake value obtained is low enough. However, it should be noted that in the long term and as the number of vehicles increases, this will have an impact on the intake value of street vendors.

Risk Characterization

Based on the calculation results, it shows that the risk level of NO_2 and SO_2 concentrations in all street vendors in Kambang Iwak area Palembang city has an RQ value < 1, which means that all street vendors are still classified as safe from non-carcinogenic effects due to exposure to NO_2 and SO_2 in the workplace. The magnitude of the RQ value is influenced by the intake value, the number of variables such as exposure frequency, exposure time, exposure duration, risk agent concentration and intake rate can affect it.[29] Research conducted by Mulyati et al., (2019) shows that all street vendors at 26 Ilir Market, Palembang City are not at risk of exposure to NO_2 because the RQ value is < 1 with the intake value > 0,00123.[15] And research by Silvana (2016) states that all street vendors at Raya Padang Market are not at risk of experiencing health problems due to exposure to SO_2 with RQ < 1 and intake value SO_2 realtime is 0,0011596 mg/kg/day.[31] The magnitude of the RQ value of < 1 in street vendors is influenced by the low intake received by street vendors.

Conclusion

Level of health risk from exposure to NO_2 and SO_2 real time for street vendors in Kambang Iwak area Palembang city, it does not pose a non-carcinogenic risk or is still in the safe category. No risk management is needed to control the impact of exposure to NO_2 and SO_2 on street vendors. However, the Palembang city government must always regularly monitor the concentration levels of pollutants in the air so that they do not exceed the recommended limits.

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