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Environmental Health Risk Analysis Due to Carbon Monoxide (CO) Exposure among Traders on Jalan H. Agus Salim, Bataraguru, Baubau City

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ABSTRACT : Karya Nugraha Market is one of the central shopping areas of Baubau City residents located on H. Agus Salim Street, Bataraguru Village, Baubau City. Every day the area is crowded with all types of vehicles. One of the emissions from motor vehicles is carbon monoxide (CO). This study aims to analyze carbon monoxide (CO) exposure to traders selling on H. Agus Salim Street, Karya Nugraha Market, Baubau City. Air quality measurements were carried out for three days (Saturday, Sunday and Monday) at 3 measurement points (point 1, the entrance area of Karya Nugraha Market, point 2, the parking area, and point 3, the vegetable seller area), within 8 hours, namely in the morning (06:00-09:00), noon (12:00-14:00) and in the afternoon (16:00-18:00). This research method uses descriptive observation. The sample used was 89 people . The respondent data collection technique was purposive sampling with the Environmental Health Risk Analysis (ARKL) method. For carbon monoxide (CO) concentration sampling, the AS8700A Carbon Monoxide Meter was used . The results of the research that has been carried out the concentration value on Saturday the highest value is in the afternoon of 27.207 µg / m ^{3,} on Sunday of 47.613 µg / m ^{3} and on Tuesday the highest value is 36.276 µg / m $^{3.}$ Of the 3 three sample points in the morning, afternoon and evening have an RQ value ≤ 1 so it can be said to be not at risk . Thus, it is hoped that the Baubau City Environmental Service will routinely monitor the spread of pollutant concentrations, especially carbon monoxide (CO) on Jalan H. Agus Salim, Karya Nugraha Market, Baubau City to support air pollution control.

Keywords : Carbon Monoxide, Environment, Exposure, Traders

1. Introduction

Currently, a global environmental health problem is air pollution [1] . Air is a very important substance for living things. Good air for health must be clean air without pollutants. Conversely, air pollution or air contamination occurs due to the entry of substances that are harmful to humans and other living organisms into the environment. If the air quality is polluted, it will cause bad impacts on health. Air pollution can change the air structure, causing changes in air quality. 60% of pollution from motor vehicles is *carbon monoxide (CO)* gas and 15% is *hydrocarbons* (HC) [2] .

The World Health Organization (WHO) stated that air pollution is the biggest health risk in the world [3] . The incidence was 137 per million and the risk of death was 4 .6 in a worldwide epidemiological evaluation conducted in 2019. Although there was no change in the incidence of CO poisoning between 1992 and 2017, they reported that the risk of death decreased by 36% (Mattiuzzi et al., 2020) .

In developing countries, especially in low- and middle-income countries in Southeast Asia and the Pacific, the highest burden of disease caused by air pollution (Jusuf et al., 2023) . Based on data from *the Global Alliance on Health and Pollution* (GAHP), it is stated that Indonesia is the fourth country with the highest number of deaths due to pollution in the world, approximately 232,974 premature deaths due to exposure to air pollution such as toxic air, water, soil and chemical pollution occurred in 2017 (Wıdadıo, 2019). The number of vehicles is of course a factor that greatly influences the concentration of air pollution due to motor vehicle emissions (Rambing et al., 2022) . Data from the Ministry of Environment in 2010 stated that gasoline motor vehicle pollution contributed 70% of *carbon monoxide* (CO), 100% of *Plumbum* (Pb), 60% *of hydrocarbons* (HC) and 60% of *nitrogen oxides* [4] . Motor vehicles are the main source of exhaust emissions that cause air pollution and reduce air quality [5] .

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The very high number of vehicles in Indonesia can produce high exhaust emissions . [6] The main source of CO is exhaust fumes from gasoline-powered vehicles. Inhaled CO enters the lungs and enters the bloodstream, preventing oxygen from reaching the body ·

Karya Nugraha Market is one of the central shopping areas of Baubau City residents located on Jalan H. Agus Salim, Bataraguru Village, Baubau City. Karya Nugraha Market is always busy every day in the morning at 06.00 - 09.00, noon at 11.00 - 14.00 and at night at 16.00 - 18.00 . Based on the results of observations conducted on October 21 and 22, 2024, the number of traders selling on the road was 115 stalls/traders, every day the area was crowded with all types of vehicles, various types of vehicles that passed the road such as motorbikes, cars, commercial vehicles, large cars, and others.

Based on data from the Bataraguru Community Health Center (Puskesmas), there has been a recent increase in cases due to air pollution, one of which is Acute Respiratory Tract Infections (ARI). Between January and September 2024, there were 426 cases of ARI at the Bataraguru Community Health Center. Interviews with the Community Health Center indicated that the number of ARI cases is quite high, as in recent years, ARI cases have been among the 10 most common diseases at the Bataraguru Community Health Center in Baubau City. This is suspected to be due to a decline in environmental quality in the Bataraguru area.

Smoke from motor vehicle exhausts can reduce air quality and cause *carbon monoxide* (CO) pollution which can harm the health of traders on the Karya Nugraha Market Road, thus becoming the main problem in the research entitled "Analysis of Environmental Health Risks Due to *Carbon Monoxide* (CO) Exposure in Traders Selling on the H. Agus Salim Road, Karya Nugraha Market, Baubau City".

2. Methodology

This research was conducted on Jalan H. Agus Salim, Karya Nugraha Market, Baubau City, Southeast Sulawesi Province, in December 2024 with sampling points determined based on SNI 19-7119.6-2005 concerning the determination of sampling locations for ambient air quality monitoring tests. The research design used was descriptive observational with an environmental health risk analysis (ARKL) approach. The ARKL method is implemented through four stages, namely hazard identification, dose-response analysis, exposure analysis, and risk characteristics. Hazard identification was carried out on risk agents in the form of carbon monoxide (CO) by measuring CO concentrations in the ambient air around Karya Nugraha Market. Dose-response analysis was obtained from the literature, especially the IRIS-US EPA study, because there is no RfC value for CO particulates. Exposure analysis was calculated based on CO concentration, exposure frequency, exposure duration, exposure duration, and respondent body weight. Meanwhile, risk characteristics are calculated using the Risk Quotient (RQ) formula, where RQ > 1 indicates the existence of a health risk that needs to be controlled, while RQ ≤ 1 means the risk can be tolerated.

The population in this study was 115 traders/stalls selling on Jalan H. Agus Salim, based on the results of observations on October 21–22, 2024. The research sample was determined using purposive sampling techniques and Slovin calculations at a 5% error rate, resulting in 89 respondents as research samples. In addition, air samples were taken using a Carbon Monoxide Meter AS8700A at three locations, namely the entrance to Jalan H. Agus Salim, the parking area, and the vegetable seller area, with a measurement duration of 8 hours per day for three consecutive days (Friday, Saturday, and Sunday), carried out in the morning (06.00–09.00), afternoon (11.00–14.00), and evening (16.00–18.00)

The research variables included respondent characteristics (age, weight, duration, frequency, and time of exposure) and CO concentration. Primary data were obtained through questionnaires, interviews, and direct measurements of CO concentration, while secondary data were obtained from relevant agencies such as market managers and the BMKG of Baubau City. The research instruments used included informed consent, questionnaires, an AS8700A CO meter, scales, GPS, and a camera. Data were collected through licensing stages, preliminary surveys, questionnaire distribution, air quality measurements, and field documentation.

Data processing was carried out through editing, coding, processing, cleaning, and tabulating stages. Data analysis included univariate analysis to describe the research variables, while the calculation of health risk analysis was carried out using the formula intake (Ink) = C × R × tE × fE × dE / (Wb × tAVG). The intake value was then used to calculate the Risk Quotient (RQ = Ink/RfC) as an indicator of the health risk of traders due to carbon monoxide exposure.

3. Results And Discussion

1. Univariate Analysis

a. Characteristics of Individual Traders on Jalan H. Agus Salim, Karya Nugraha Market

Gender

Respondents were divided into two groups: male and female. The distribution of respondents by gender can be seen in Table 6 below.

Table 6. Gender Distribution of Street Vendors on H. Agus Salim Bataraguru Street, Baubau City

Gender	Permanent Traders on Karya Nugraha Bataraguru Market Road	
	N	%
man	19	21.3
Woman	70	78.7
Total	89	100.0

Source : Primary Data 2024

Based on table 6, the number of female permanent trader respondents is greater with a total of 70 respondents or 78.7% compared to the number of male respondents of 19 or 21.3% of respondents.

b. **Individual Characteristics Activity Patterns**

The individual characteristics and description of activity patterns (length of exposure, frequency and duration of exposure) of regular traders on Jalan H. Agus Salim Bataraguru, Baubau City can be seen in Table 6.

Table 7. Distribution of Individual Characteristics and Activity Patterns of Traders on Jalan H. Agus Salim Bataraguru, Baubau City

Variables	N	Mean	Median	Elementary School	Min	Max	P *Value*
Respondent's age	89	42.51	41.00	13,851	16	80	0.200
Weight	89	58.08	59.00	9,754	39	81	0.197
Duration of Exposure	89	6.64	7.00	2,497	2	12	0,000
Exposure Time	89	9.35	9.00	2,079	5	14	0,000
Exposure Frequency	89	361.46	365.00	19,057	260	365	0,000

Source: Primary Data 2024

Kolmogorov-Smirnov test that has been conducted, the respondent's age variable was obtained with a P value = 0.200 which means that the respondent's age data is normally distributed, so the average age of the respondents is 42.51 years . The oldest age is 80 years and the youngest age is 16 years. Body weight obtained a p value = 0.197 which means that the respondent's weight data is normally distributed, so the average value of the respondent's weight is 58.08 kilograms (kg). The largest weight is 81 kilograms (kg) and the smallest weight is 39 kilograms (kg). The duration of exposure obtained a P result = 0.000 which means that the exposure duration data is not normally distributed, so the median value is used, namely 7 years with a standard deviation of 2.497. The average permanent trader is 6.64 years, the highest exposure duration is 12 years and the lowest is 2 years. The exposure time obtained a p value = 0.000 which means that the respondents were not normally distributed, so the median value was used, namely 9.00 hours / day with a standard deviation of 2.079, with an average value of permanent traders of 9.35 hours / day, the highest exposure time of 14 hours / day and the lowest was 5 hours / day. The frequency of exposure was obtained with a p value = 0.000 which means that the respondents were not normally distributed, so the median value was used, namely 365 days with a standard deviation of 19.057, the average of permanent traders was 361.46 days, with the highest exposure frequency of 365 days and the lowest was 260 days. The Median value will be entered into the CO intake formula and risk level.

2. Dose Response Analysis

Dose-response analysis is used to determine the quantitative toxicity of a risk agent, which aims to determine whether it has the potential to cause adverse health effects in an at-risk population. In respiratory (inhalation) risk analysis, *the Reference Concentration* (RfC) is expressed. The RfC is the daily exposure dose of a non-carcinogenic agent that does not pose a potential health risk even if the exposure occurs over a lifetime.

Reference dose data is generally issued from the EPA's *National Ambient Quality Standard* (NAAQS), because there is no reference dose for CO, the following equation applies:

$$RfC = \frac{CxRxtExfExDt}{Wbxtavg}$$

Substitute the EPA default value, C = Ambient CO air quality standard based on PP RI Number 22 of 2021, namely 10,000 µg/m ^{3} which is converted to 10 mg/m ^{3}, R = 0.83 m ^{3} /hour, tE = 24 hours/day, fE = 365 days/year, Wb = 55 kg, obtained:

1. CO Reference Concentration on Saturday

$$RfCco = \frac{27,207x14,571x9x365x7}{58,08\ x\ 10950} = \frac{9115981.36501}{635.976}$$

$$RfCco = 14,333 \text{mg/kg/day}$$

2. CO Reference Concentration on Sunday

$$RfCco = \frac{47,613x14,571x9x365x7}{5808\ x\ 10950} = \frac{15953218.6839}{635.976}$$

$$RfCco = 25,084 \text{ mg/kg/day}$$

3. CO Reference Concentration on Tuesday

$$RfCco = \frac{36,276x14,571x10x365x8}{58,08\ x\ 10950} = \frac{12154641.82}{635.976}$$

$$RfCco = 19,111 \text{mg/kg/day}$$

Discussion

a. Characteristics of Individual Traders at Karya Nugraha Market, Bataraguru, Baubau City

1. Gender Distribution

Based on the results of the study, 70 female respondents (78.7%) were found, while fewer were male, namely 19 respondents (21.3%). Gender was the variable studied. According to (Lestari, 2021) regarding CO elimination in men and women, there are differences in alveolar ventilation and hemoglobin levels in women and men. Research conducted by Sihombing (2022) explains that gender can affect the process of CO elimination from the lungs and it is said that the half-life of CO in women is faster than in men due to differences in hemoglobin levels and differences in alveolar ventilation between men and women. with the difference in the amount of hemoglobin owned, there is also a difference in the function of hemoglobin to transport oxygen to all organs of the human body, so that women are more susceptible to having high levels of COHb in the blood because women's hemoglobin levels are lower than men's hemoglobin levels . The difference in the half-life response of the body's respiratory system between men and women is the basis for the importance of respondent characteristics in research. The direct interview process can make it easier for researchers to determine whether respondents are male or female [8] .

2. Age Distribution of Traders

Age is one of the variables studied because it can potentially influence the level of COHb in the blood of respondents. Based on the results of the study, which used a questionnaire and interview method with respondents, namely the age of the traders, the average age of all traders was 42.51 . years. The oldest respondent was 80 years old and the youngest was 16 years old. This is supported by research conducted by Sihombing (2022) which explains that COHb levels are obtained from exposure to CO gas in the air which is then inhaled by humans through the respiratory tract then enters the blood and binds to hemoglobin, thereby inhibiting the transfer of oxygen to all organs of the body because CO gas binds more easily to hemoglobin than oxygen. As humans age, they will experience a physiological decline in all organ functions including a decrease in bone marrow which produces red blood cells with reduced red blood cell production meaning the ability of hemoglobin to transport oxygen to all organs of the body is reduced. In addition, research conducted by Wulansari (2013) states that COHb levels are directly proportional to age, the older a person is, the higher the COHb levels in the blood. This is because people of productive age do more activities outside the home, one of which is working as market traders [9] .

3. Trader Weight Distribution

Market traders' weight data was measured using a digital scale with a maximum weight capacity of 180 kg. The measurements were taken on 89 respondents. The results of the study showed that the average measured weight was 58.08 kg, with a range of 39 kg to 81 kg. In this study, the trader's weight variable is likely at risk due to carbon monoxide exposure in the market. Karya Nugraha Market. In environmental health risk analysis, body weight is used to determine whether an individual is within the risk threshold. Traders with higher body weight and shorter exposure time tend to have lower CO2 intake than those with lower body weight.

In this study, the respondents were all adults with a *default* body weight value of 55 kg (EPA , 2011).

Research conducted by Chairunnisa (2022) explains that the risk of exposure to hazardous substances can be influenced by body weight. The greater a person's weight , the greater their lung capacity, which allows for more air to enter the body. Therefore, the greater the person's air volume . This research aligns with that conducted by Wahyuni (2018) , who stated that the greater the

respondent's weight, the lower their carbon monoxide intake , and this affects the *risk quotient* (RQ).

The presence of a body weight variable is very useful in environmental health risk analysis. Body weight is used to determine intake values and RQ values, or risk characteristics. Body weight was determined by weighing the vendors using a digital scale. Each respondent weighed themselves, which was then recorded by the researcher. The weight results were used as part of the calculation to determine the extent of the vendors' risk from carbon monoxide exposure in the area. Karya Nugraha Market.

At Karya Nugraha Market, traders' weight was measured using digital scales. For environmental health risk analysis, traders' weight is used to compare the inhaled carbon monoxide concentration (mg/kg/day). A trader's weight can influence the risk of inhaled carbon monoxide. Carbon monoxide in the blood can displace oxygen, forming COHb, which can cause poisoning. High body weight can increase health risks, influenced by several factors such as diet, lifestyle, and medical history (Lestari, 2021) .

b. Environmental Health Risk Analysis

1. Exposure Analysis

Based on the results of the calculation of the intake value that has been carried out, on Saturday, point 2 of the highest sampling location was in the afternoon at (16:00-18:00) with a value of 14.333 mg/kg/day, on Sunday the highest intake value was at point 2 of location in the afternoon at (16:00-18:00) with a value of 25.085 mg/kg/day and on Tuesday the highest intake value was at point 2 of location in the morning (16:00-18:00) with a value of 19.111 mg/kg/day.

The CO concentration value will be directly proportional to the intake value. Therefore, the higher the CO concentration, the greater the intake (Putri *et al* ., 2022) . Calculation of the risk level is also part of the ARKL conducted at three sample points in the H. Agus Salim Street area, Karya Nugraha Market. To determine the level of risk, a comparison was made between the intake value and the reference dose (RfC). In this study, the RfC determined by IRIS EPA through a decrease in the intake value was used. Thus, the reference dose (RfC) value for CO on Saturday was 14.333 mg/kg/day, on Sunday 25.084 mg/kg/day, and on Tuesday 19.111 mg/kg/day.

2. Risk Characteristics

Risk characteristics (RQ) aims to determine the level of risk from exposure that enters the human body. The determination of RQ is calculated by comparing the intake value of each sample point with the RfC value. If the RQ shows RQ > 1, then exposure to CO has a risk of health problems, while for RQ ≤ 1, it is still considered safe for health.

Based on the calculation results, in this study it was found that in 3 days and at 3 sample points the RQ value was ≤ 1 or could be said to be non-risky, so no risk management was needed. On Saturday's air sampling, the highest RQ value was at sample point 2 in the afternoon (16:00-18:00) with a value of 1. On Sunday's air sampling, the highest RQ value was at sample point 2 in the afternoon (16:00-18:00) with a value of 1, and on Tuesday's air sampling day, the highest RQ value was at sample point 2 in the morning of 1. Several factors that can cause a difference between the high concentration of carbon monoxide (CO) in the air and the results of the risk analysis which indicate no risk for traders in the Karya Nugraha market, one of which is **Duration of Exposure** Traders may not be exposed to CO long enough to reach a dangerous dose. According to my research, exposure duration of 7 years yielded an RQ of ≤ 1. These results indicate that exposure to CO at Karya Nugraha Market is considered safe, even though CO levels in the air exceed the safe threshold. Several studies have found that Lestari (2021) duration of exposure for 15.5 years. obtained an RQ value > 1. These results indicate that as many as 40 respondents have these characteristics at risk of health problems . Research conducted by Risna (2024) namely the duration of exposure for 10 years with 3 days of measurement, the RQ value is obtained > 1. So it is said that carbon monoxide (CO) exposure is risky and research conducted by Dini (2022) Analysis of the risk of CO exposure in satay traders is predicted to occur at the 10th year of exposure which is influenced by the increasing duration of exposure. Therefore, the difference between the high concentration of carbon monoxide (CO) in the air and the results of the risk analysis for traders at the Karya Nugraha market is the duration of exposure, it can be interpreted that if the duration of exposure is long, the level of CO exposure also increases and is risky (unsafe).

Considering the RQ concentration ≤ 1, risk management is not necessary. The risk value is greater when compared to research conducted by Wahyuni (2017). on the Analysis of the Risk of Exposure to CO for School Children at Kakatua State Elementary School, Makassar City, that the community has a risk level in the range of 0.20 – 0.80. This study is in line with Ode (2024) on the analysis of environmental health risks due to exposure to carbon monoxide (CO) in durian traders on Jalan Buburanda, Kendari City. The results The results of the research that has been carried out show that the three sample point locations during the day and evening have an RQ value ≤ 1, so it can be said that there is no risk. This research is in line with Aprilia (2017) The average *real-time RQ value* of non-carcinogenic CO gas in toll collectors in Semarang is 0.520. The lowest *real-time RQ value* is 0.007 and the highest reaches 0.191. The highest reaches 0.352. The results of mathematical risk value calculations show that the risk level of Carbon Monoxide (CO) gas exposure at this time *(real time)* and for 30 years *(lifetime)* in Semarang toll collectors has not shown a non-carcinogenic risk due to

CO gas exposure (RQ ≤ 1).

The RQ value is influenced by each respondent's *intake based on their exposure pattern and anthropometric data. Differences in exposure patterns in terms of concentration and duration affect the intake received by respondents. Based on the RQ calculation, the longer the duration of exposure, the greater* their *intake* .

As a result, the health risk due to exposure to CO gas received by respondents is also greater. Although in mathematical calculations it has not yet caused a risk, if seen from the respondent's characteristics data there are several factors that can cause CO gas exposure to be a risk to health based on research conducted by Jusuf (2023) the results of the calculations obtained, the concentration of PM_{10} with real-time RQ in three locations recorded the risk level (RQ) results, namely ≤ 1. This is also influenced by body weight, namely the greater the individual's weight, the smaller the health risk, so this shows that there is no health risk for each individual if exposed to the risk agent $PM_{10\ Concentration}$. Risk characterization is measuring the level of exposure suffered by the body of the high population risk agent on Monday can be done for 3.8 years, on Thursday the highest risk management control can be done for 2 years, and on Sunday management control the highest risk can be done for 1.9 years.

4. Conclusion

Based on the results of carbon monoxide (CO) concentration measurements carried out for 3 days and 3 times, the highest concentration value was obtained on Monday at 35.514 - 108.833 μg/Nm ^{3} , which means that the Kedondong Street area of Anduonohu Market, Kendari City has the highest carbon monoxide (CO) concentration level. The average weight of traders remains the same. Kedondong Anduonohu Market is 62.65 kg . The median value of exposure time in this study was 10 hours/day. Mark The median frequency of exposure was 365 days/year. The median value of the duration of exposure was 365 days/year. namely 10 years, while the average value of inhalation rate for traders remains in the Anduonohu Market Roadside Section, namely 14,800 m ^{3} /hour. Mark C O *intake* of street vendor population Ambarella Market Anduonohu the highest there is on day Monday with mark 17,140 - 85,699 mg/kg/day so it can be said that traders on Jalan Kedondong Pasar Anduonohu are at risk. The risk level (RQ) of the population of traders on Jalan Kedondong Pasar Anduonohu was carried out on 3 day measurement, The RQ value obtained on Monday was 2-9,999, the RQ value on Thursday was 3,637-10,000, and on Sunday the RQ value obtained was 4,516-10,000. Therefore, it is said that carbon monoxide (CO) exposure is risky. Controlling the duration exposure carbon monoxide (CO) for traders on Jalan Kedondong, Anduonohu Market, which was carried out for 3 days of air sampling, then control management risk .

Suggestion

For the Baubau City Environmental Agency (DLH), the results of this study are expected to be used as a consideration in conducting routine monitoring of pollutant concentrations, particularly carbon monoxide (CO), in urban areas. Regular monitoring is crucial for assessing air quality in high-traffic areas, such as Jalan H. Agus Salim and Pasar Karya Nugraha, which are influenced by high transportation mobility as a primary source of CO emissions. With measurable monitoring data, the DLH can formulate strategic steps to control air pollution, including mitigation policies and traffic management in market areas, to maintain air quality and minimize public health risks. For regular vendors operating along these roads, awareness of maintaining personal health also needs to be increased, for example by making it a habit to wear masks during activities. This is crucial because their location directly on the roadside makes vendors more vulnerable to exposure to air pollution, particularly CO gas, which is harmful to the lungs and respiratory system. Therefore, preventive efforts, both from the government through supervision and from vendors through self-protection, are expected to go hand in hand in reducing the negative impacts of pollution. air on public health.

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