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Ecological and Health Risks Assessment Due to Carbon Monoxide (CO) Exposure : Implications of Air Pollution for Parking Attendants

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Abstract

Carbon monoxide (CO) is the main pollutant from motor vehicle emissions which is dangerous if inhaled by humans. This study aims to analyze the ecological and health risks caused by carbon monoxide gas pollution to parking attendants on roads in Gorontalo City. This type of research is an observational study using the Ecological Risk Assessment (ERA) and Health Risk Assessment (HRA) approaches through field studies. The number of samples was 60 respondents and air samples were taken from 12 locations and each location consisted of 2 points. Data were analyzed descriptively through studies (ERA) and (HRA). The results showed that there were 8 locations that had CO concentrations that exceeded the threshold value. Thus the level of CO on roads in Gorontalo City is included in the unsafe category. Characterization of ecological risk due to CO exposure on roads in Gorontalo City is classified as dangerous for the environment where 4 locations are in the low hazard category (HQ 0.1-1.0) and 8 locations are in the medium hazard category (HQ 1.1-10). The highest real-time exposure CO intake was at the Jamu Solo Store location, namely 1.8501799100 mg/kg/day with an RQ value of 2.2291324200 (at risk), while the lowest was at the Extra Bakery location 0.0746788000 mg/kg/day with an RQ value of 0.0899744600 (no risk). It is recommended for parking attendants to wear masks while working and reduce smoking habits.

Keywords: carbon monoxide, ecological risk assessment, air pollution, health risks assesment, parking attendants

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INTRODUCTION

Environmental pollution and its detrimental effects on human health are among the most pressing issues that need to be addressed (Topacoglu et al., 2014). Industrial discharges, natural disasters, and construction projects are all factors that contribute to air pollution, but transportation is the main culprit (Yuliusman et al., 2020). Due to the presence of contaminants in the air, increased transportation activity has implications for declining air quality (Maksum & Tarigan, 2022). The level of carbon monoxide (CO) in the air increases as a result of vehicle exhaust emissions. About 70% of air pollution comes from motor vehicle emissions, especially in big cities (Topacoglu et al., 2014). Air

pollution levels continue to increase every year. The sharp increase in the volume of road traffic worldwide over the last 20 years (Lee et al., 2017).

In case of Gorontalo city, the average increase in the number of motorized vehicles from 2016-2020 was 2% with the highest increase occurring in 2017-2018, namely 21%. This can potentially reduce air quality due to air pollutants. This increase can cause traffic density and can increase air pollution due to transportation activities (Ibrahim, 2021). The increase in population is the main triggering factor for the increase in the number of motorized vehicles on the highway (BPS Kota Gorontalo, 2021).The 2020 Population Census recorded that the population of Gorontalo in September 2020 was 1,171,681 people. The population of Gorontalo has increased since it was founded in 2000. The results of the 2020 population census with the 2010 population census show an increase in the population of 131,517 people or an average of 13,152 people per year (Sensus Penduduk, 2020).

The dangerous impact of increased motorized vehicles for human health or the surrounding environment (Yuliusman et al., 2020). Even brief exposure to exhaust fumes results in vasoconstriction, thereby causing an increase in arterial blood pressure or a decrease in local blood flow. Also observed are increased vascular stiffness due to concomitant atherosclerosis, increased blood clotting ability and myocardial ischemia (Kobza & Geremek, 2017). In addition, long-term exposure to CO can increase mortality, exacerbate cardiovascular disease, and cause other health problems (Lee et al., 2017). People most at risk of exposure to CO gas are parking attendants (Aryagita et al., 2017). The parking attendant is responsible for managing and maintaining the security of the vehicle when it is parked in a crowded place such as a market (Devitria et al., 2018).

According to research results that all parking attendants can be at risk of exposure to CO (RQ> 1) (Aryagita et al., 2017). CO exposure can cause pain to parking attendants and the higher the concentration of CO exposure, the stronger the pain suffered by parking attendants at work (Damri et al., 2016). Another study on parking attendants stated that HbCO levels had a relationship with CO levels in the air. High CO in parking areas with minimal ventilation will increase exposure to parking attendants. CO in the air will enter the body through the respiratory tract. CO content in the body that exceeds the threshold triggers symptoms of headaches, prolonged fatigue, and even death (Purbianto & Khayan, 2022). These parking attendants will be continuously exposed because for 9 hours each day the work they are engaged in is always directly related to the condition of the parking lot which is not suitable and filled with CO gas which comes from motorized vehicle exhaust emissions (Aryagita et al., 2017).

Parking attendant is one of the jobs that has a high risk of air being polluted by vehicle exhaust gases that are released for quite a long time. Every day vehicles always cross roads in the city of Gorontalo which results in parking officers being exposed to vehicle fumes. Based on the initial survey conducted by the researchers, health data were obtained from parking attendants where visual impairment was 0.4%, headaches were 0.84%, and breathing difficulties were 0.2%, so there is a possibility that parking attendants in Gorontalo City are affected by carbon monoxide gas pollution generated by vehicle exhaust.

Based on this description, the researcher is interested to analyze the ecological and health risks caused by carbon monoxide gas pollution to parking attendants on roads in Gorontalo City. By using the Ecological Risk Assessment (ERA) and Health Risk Assessment (HRA) approaches through field studies, this research is expected to be able to provide information about the effects of carbon monoxide gas pollution and solutions for parking attendants to reduce these impacts.

METHOD

The research location was carried out on roads in the City of Gorontalo which are scattered throughout the roads in the City of Gorontalo. The time of the research was carried out from 25 May to 28 June 2022. This type of research is an observational study using the Ecological Risk Assessment (ERA) and Health Risk Assessment (HRA) approaches through field studies. The sample in this study consisted of environmental and human samples. Environmental samples are samples of ambient air with the concentration measured, namely carbon monoxide (CO). Measurement of carbon monoxide (CO) concentrations was carried out during heavy traffic hours in 12 locations at 13.00-14.00 WITA,

and each location had 2 sampling points. While the human sample is a parking attendant who is in charge of roads in the City of Gorontalo, totaling 60 respondents, obtained through purposive sampling technique.

RESULTS AND DISCUSSION

Carbon Monoxide Concentration in Ambient Air

The results of measurements of CO concentrations carried out on Jalan Gorontalo City used the Carbon Monoxide Detector AS8700A. The results show that out of the 12 measurement locations there are 8 locations that have pollutant levels that exceed the threshold value based on Government Regulation Number 22 of 2021 concerning Carbon Monoxide Ambient Air Quality Standards which is 10,000 µg/Nm3. This of course will lead to the possibility of greater health risks to parking attendants along roads in the city of Gorontalo. The 8 parking locations that have CO concentrations exceeding the Threshold Value (NAV) which can be seen in **Table 1** are Setia Budi Pharmacy (12 mg/m^3), Double Dipps (32 mg/m^3), Toko Jamu Solo (22 mg/m^3), Sumber Utama (18,5 mg/m^3), City Park Area (13 mg/m^3), Gorontalo mall Area (34 mg/m^3), Imam Bonjol Street Shops (17.5 mg/m^3) and Raja Eyato Street Shops (18.5 mg/m^3).

Table 1. Distribution of Carbon Monoxide Concentrations in the Air on Gorontalo City Roads

No	Location	Time (WITA)	Concentrations (mg/m^3)	NAV (10 mg/m^3)
1	Extra Bakery	13.00-14.00	8	Safe
2	Setia Budi Pharmacy	13.00-14.00	12	Unsafe
3	Double Dipps	13.00-14.00	32	Unsafe
4	Jamu Solo store	13.00-14.00	22	Unsafe
5	Sumber Utama	13.00-14.00	18,5	Unsafe
6	City Park Area	13.00-14.00	30	Unsafe
7	Gorontalo mall Area	13.00-14.00	34	Unsafe
8	Suprapto Street Shops	13.00-14.00	7,5	Safe
9	Imam Bonjol Street Shops	13.00-14.00	17,5	Unsafe
10	S. Parman Street Shops	13.00-14.00	8,5	Safe
11	Raja Eyato Street Shops	13.00-14.00	18,5	Unsafe
12	M.T. Haryono Street Shops	13.00-14.00	9,5	Safe

Source : Data of this study

The high concentration of CO is caused by the number of vehicles passing through the area which is more crowded than usual, hours of measurement are carried out during office breaks from 13.00-14.00 WITA so that many people carry out activities at that location, to shop at the shopping center, and as a place where people often the occurrence of gatherings, places to hang out for lunch so that there are several vehicles that cross the area such as two-wheeled, three-wheeled and four-wheeled vehicles.

This is in line with research conducted by Hamzah (2020). that the relationship between the number of vehicles and the concentration of carbon monoxide (CO) in Gorontalo City shows a pattern of positive relationship, meaning that the higher the number of vehicles means the higher the concentration of carbon monoxide (CO). Other studies also state that the density of vehicles is directly proportional to the concentration of CO, which means that the concentration of CO will increase along with the increase or increase in the number of vehicles (Sinaga et al., 2013). According to Hasairin & Siregar, (2018) traffic density and CO concentration is a positive correlation, where the higher the traffic density, the higher the CO concentration.

Locations that do not exceed the threshold value (NAV) for carbon monoxide concentrations include extra bakery (8 mg/m^3), Suprapto Street Shops (7,5 m/s^3), S. Parman Street Shops (8,5 m/s^3), and M. T. Haryono Street Shops (9,5 m/s^3). This is caused when measuring the lack of vehicles crossing the area so that the detected CO levels do not exceed the threshold (NAV). In addition, in

several research locations, such as the shopping area around Suprapto Street Shops, S Parman Street Shops, and. M. T. Haryono Street Shops, when measuring CO concentrations, road conditions were still being repaired which resulted in the road access being closed for a while and this resulted in a lack of vehicles crossing the area.

Other factors that can affect the high concentration of CO are temperature, humidity and wind speed. The results of measuring these meteorological factors can be seen in **Figure 1**, Meteorological conditions affect the high concentration of CO where the lowest temperature measurement results are 32.85^{o} with the highest CO concentration of 34 mg/m^{3}, which is Kawasan Mall Gorontalo. According to Andriani et al., (2019), there is a negative correlation between the effect of temperature on CO concentration. High air temperature causes the concentration of CO gas tends to decrease and vice versa. This is because at high air temperatures, the air expands more easily so that air dispersion will occur more quickly as a result of which the concentration of pollutant gases becomes low.

Air temperature has an effect because it is caused by chemical reactions of several pollutants which will take place faster at high temperatures, while humidity is closely related to the deposition of various types of pollutants (Risa, 2019). The air temperature on the surface of the earth will change and continue to fluctuate. Several factors cause fluctuations in air temperature, namely the intensity of sunlight, the angle of incidence of sunlight, cloud conditions, the tilt of the sun, and the condition of the earth's surface (Andriani et al., 2019).

Meanwhile, based on the results of air humidity measurements in this study, it ranged from 58.00 m/s to 66.25 m/s. Wind speed can also be one of the factors causing high and low concentrations of carbon monoxide gas in the air. The highest wind speed is at the location kawasan Mall Gorontalo, namely 3 m/s, and the lowest is at the location Imam Bonjol Suprapto Street Shops is 1.05 m/s. Strong wind speeds will carry pollutants flying everywhere because wind speed affects pollutant distribution, pollutant concentrations will decrease if wind speeds are high.

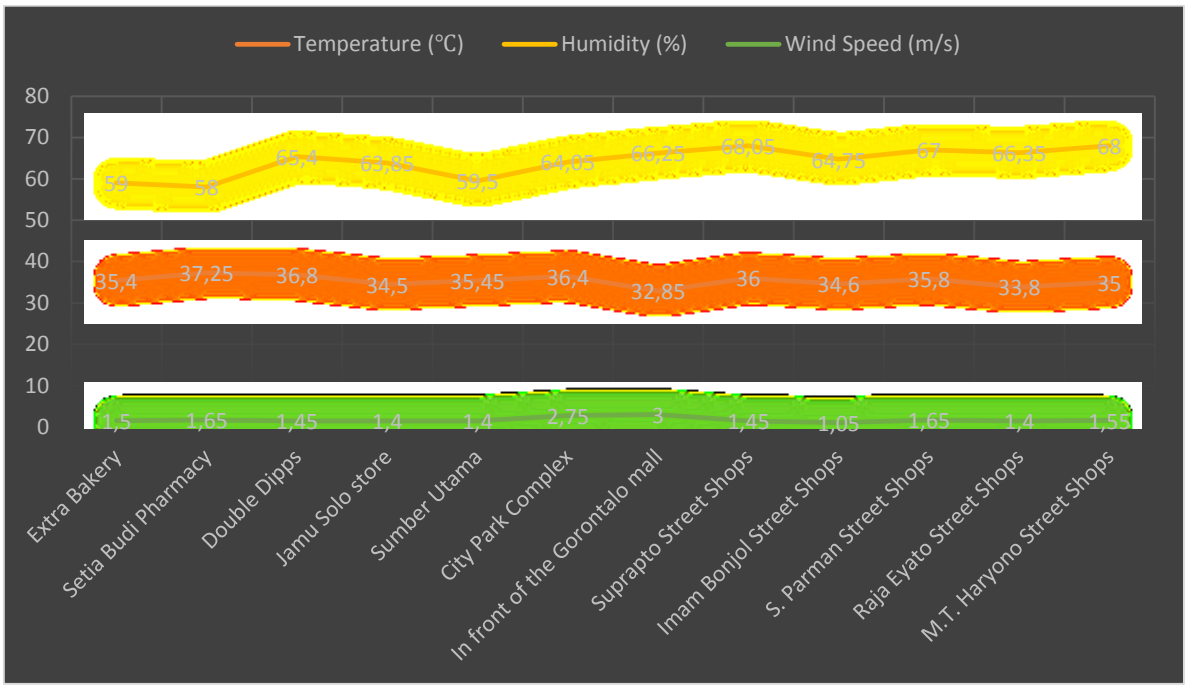

Figure 1. Distribution of Meteorological Parameters on Gorontalo City Road Section

Ecological Risk Characterization

The results of the study in **Table 2** show that the CO concentrations at the 4 study sites have HQ values <1, which means that each location has potential ecological risks that are acceptable. The average ecological risk due to exposure to carbon monoxide at each location has an HQ value of 0.1-1.0 with low hazard criteria, namely the Extra Bakery location with an HQ value of 0.8, a location Suprapto Suprapto Street Shops with an HQ value of 0.75, a location at S. Parman Street Shops with an HQ value of 0.85 and a location at M. T. Haryono Suprapto Street Shops with an HQ value of 0.95,

which means that the ecological risk of exposure to carbon monoxide in the ambient air around the location of parking attendants is at an acceptable level.

Table 2. Ecological Risk Levels at Each Location Point on the Gorontalo City Road Section

Location	CO concentration (mg/m^3)	Screening Benchmarks (mg/m^3)	HQ	Criteria
Extra Bakery	8	10	0,8	Low Danger
Setia Budi Pharmacy	12	10	1,2	Moderate Danger
Double Dipps	32	10	3,2	Moderate Danger
Jamu Solo store	22	10	2,2	Moderate Danger
Sumber Utama	18,5	10	1,85	Moderate Danger
City Park Area	30	10	3	Moderate Danger
Gorontalo mall Area	34	10	3,4	Moderate Danger
Suprapto Street Shops	7,5	10	0,75	Low Danger
Imam Bonjol Street Shops	17,5	10	1,75	Moderate Danger
S. Parman Street Shops	8,5	10	0,85	Low Danger
Raja Eyato Street Shops	18,5	10	1,85	Moderate Danger
M.T. Haryono Street Shops	9,5	10	0,95	Low Danger

HQ : Hazard Quotient/Ecological Risk Level
EEC : Estimated airborne contaminant concentration (maximum) at site, how much contaminant is in the air (mg/m^3).
Screening Benchmarks: Standard no-adverse-effect concentration for CO (10000 $\mu g/Nm^3$ atau 10 mg/m^3).
Source : Data of this study

There are 8 research locations with a value of HQ> 1, which means that each location has the potential to pose an ecological risk. The average HQ value is 1.0-10 with moderate hazard criteria, namely the location of Setia Budi Pharmacy with an HQ value of 1.2, Double Dipps with an HQ value of 3.2, Jamu Solo store with an HQ value of 2.2, Sumber Utama location with a HQ 1.85, the location of the City Park Area with an HQ value of 3, the location Gorontalo mall Area with an HQ value of 3.4, a shopping location Imam Bonjol Suprapto Street Shops with an HQ value of 1.75 and Raja Eyato Suprapto Street Shops with an HQ value of 1.85, which means that carbon monoxide exposure has the potential to pose an ecological risk to the ambient air around the parking attendant's location.

The same research that examined ecological risk was conducted by Al-Zboon, Matalqah, & Ammary (2021) showed the hazard quotient (HQ) value for carbon monoxide (CO) exposure at 4 study locations ranged from 0.0032-0.036, meaning HQ< 1 indicating that no significant potential health effects are to be expected from each pollutant individually. This is in line with research conducted by Mitmark & Jinsart (2016) showing the concentration of carbon monoxide (CO) in Northern Thailand has an HQ value <1, which means there is no potential for adverse health effects from carbon monoxide (CO).

Ecological risk can be estimated using the Hazard Quotient (HQ) approach. If HQ < 0.1, there is no danger. HQ 0.1 – 1.0 low hazard. HQ 1.1 – 10, medium hazard and if HQ >10, high hazard (Mallongi et al., 2015).The health risk analysis (HRA) method is used in order to provide an estimate of public health risks based on the concentration of carbon monoxide (CO).

The magnitude of the value of potential ecological risk is a comparison between the concentration of environmental contaminants at the site (EEC) and the concentration of the level of harmless effects (Scrineeng benchmarks). The Scrineeng benchmarks values used in this study were taken based on Government Regulation Number 22 of 2021 for Carbon Monoxide 10,000 $\mu g/Nm^3$ or 10 mg/m^3.

Analysis of Exposure (Intake) and Characterization of Health Risks

CO exposure intake in the air is calculated in real-time. Realtime exposure intake aims to describe the amount of exposure that has been received by respondents from the beginning of being a parking attendant until the time the research was carried out. The magnitude of the intake value is directly proportional to the concentration of contaminants, the rate of intake, the duration of exposure, the exposure frequency , and the duration of exposure, which means that the greater the

value, the greater the intake received by the individual. While the value of intake is inversely proportional to the value of body weight and the average time period, meaning that the greater the weight ate, the smaller the health risk (Risa, 2019).

The calculation of the risk level is one part of the ARKL study conducted on at-risk populations at 12 location points in the city of Gorontalo. The magnitude of the risk level is obtained from the results of a comparison between the intake value and the Reference Dosage Value (RfC) which is obtained from calculations using the intake formula with the concentration value taken based on the quality standard according to Government Regulation Number 22 of 2021, namely 10,000 µg/Nm^3 (10 mg/m^3) .

If you look at the comparison of each study location in **Table 3**, there is a significant difference in intake values both at location 1 to location 12. If you look at the largest intake value it is at location 4, namely the Jamu Solo store of 1.8501799100 mg/kg/day. The high intake value at the Jamu Solo store location was influenced by the high concentration of CO, which was 22 mg/m^3, even though the CO concentration was still relatively low compared to other locations, the activity patterns of parking attendants greatly influenced the intake value.

Table 3. Analysis of Carbon Monoxide Exposure and Risk Characterization

Location	Value							
	BW	ED	ET	EF	IR	*Intake realtine* (mg/kg/day)	RQ	Risk Characterization
Extra Bakery	59	3.5	12	173	0.83	0,0746788000	0,0899744600	no risk
Setia Budi Pharmacy	63	3	9	317	0.83	0,1235741700	0,1488845400	no risk
Double Dipps	59.5	7.5	10.5	269	0.83	0,8635745400	1,0404512490	at risk
Jamu Solo store	60	15	14	317	0.83	1,8501799100	2,2291324200	at risk
Sumber Utama	66	5	15	317	0.83	0,5051406200	0,6086031550	no risk
City Park Area	46.75	6	9.25	233	0.83	0,6290027100	0,7578345910	no risk
Gorontalo mall Areaa	62.6	7.5	12.2	242.6	0.83	0,8944392544	1,0776376559	at risk
Suprapto Street Shops	59.5	9.5	10.5	305	0.83	0,2906839200	0,3777800160	no risk
Imam Bonjol Street Shops	55.67	6	9.67	221	0.83	0,3054408200	0,4212861950	no risk
S. Parman Street Shops	62.86	9.43	9.29	275.86	0.83	0,2475561400	0,3427446180	no risk
Raja Eyato Street Shops	65.36	8.91	7.27	242.82	0.83	0,3375292300	0,4212777970	no risk
M.T. Haryono Street Shops	68	8.5	6.5	197	0.83	0,1152596200	0,1896204340	no risk

Body Weight (BW), Exposure Duration (ED), Exposure Time (ET), Exposure Frequency (EF), Inhalation Rate (IR)
Source : Data of this study

This is in line with research conducted by Wahyuni et al., (2018) Although the concentration of carbon monoxide gas on the Setia Budi road is still below the established quality standard, continuous exposure will affect the amount intake of carbon monoxide gas that is inhaled into the trader's body.

For the exposure duration to parking attendants at the Jamu Solo shop location, the average value is higher than other locations, namely for 15 years, followed by the exposure frequency in one year for 317 days, then for parking attendants working time at Jamu Solo an average of 14 hours/ day, this greatly affects the high intake value at that location.

While the lowest intake value of all locations is at the location of Extra Bakery 0.0746788000 mg/kg/day. This is influenced by the low concentration of CO, which is 8 mg/m3. The average age of parking attendants at the Ektra Bakery location is 41.25 years with an average body weight of 59 kg, besides that the average exposure time for parking attendants is 12 hours/day and the average exposure duration is 3.5 years . When compared to other locations, Extra Bakery is the location that has the lowest average value, so it is unlikely that the parking attendants at the Extra Bakery location have an unsafe risk of CO exposure.

The results of research conducted by Lestari et al., (2021) traders with low intake results occur in traders with high body weight and little exposure time. The results of the intake of traders with a

body weight of 124.35 kg show that the intake value received is 0.665 mg/kg/day, indicating that the higher the trader's weight, the smaller the intake value received. This is in line with research conducted by Falahdina, (2017) which states that the amount of intake received by people with excess body weight results in a smaller intake value.

Intake is directly proportional to the RQ value so that if the intake is high, the RQ will also be high (Indriyani et al., 2017). The RQ value for the Jamu Solo store location is 2.2291324200. From the results of this study it can be seen that the value of RQ> 1. As research Aryagita et al., (2017), which analyzed the level of risk of CO gas to parking attendants at Pasar Kapasan Surabaya, the RQ value of all respondents was obtained, namely RQ > 1, therefore all parking attendants at Pasar Kapasan Surabaya are at risk of CO gas exposure and can cause health effects Aryagita et al., (2017). While the low intake value at the Extra Bakery location causes the RQ value ≤ 1, the RQ value obtained from the research results is 0.0899744600. If RQ> 1 then the value of carbon monoxide exposure has a risk of health problems, whereas if the value of RQ ≤ 1 then carbon monoxide exposure is considered safe (Lestari et al., 2021).

An overview of health complaints (**Table 4**) for each parking attendant on a road in the city of Gorontalo can be used to see the effect of the level of risk due to carbon monoxide exposure. From the results of the questionnaire it was found that 29 respondents (48.33%) complained of headaches, 9 respondents (15.00%) felt weak, 15 respondents (25.00%) experienced visual disturbances and 7 respondents (11.67%) experienced difficulty breathing.

Table 4. Health Complaints to Parking Attendants on Roads in Gorontalo City

No.	Health Complaints	Once		Never		Total	
		n	%	n	%	n	%
1	Headache	29	48.33	31	17.22	60	100.00
2	Weak	9	15.00	51	28.33	60	100.00
3	Visual disturbances	15	25.00	45	25.00	60	100.00
4	Hard to breath	7	11.67	53	29.44	60	100.00

Source : Data of this study

The results of research conducted by Asrini Zendrato (2020) found that the most common health complaints experienced by traders in Pajus were complaints of dizziness, namely 26 people (83.9%), complaints of headaches as many as 23 people (74.2%) , visual disturbances in 6 people (19.4%), then breathing complaints and nausea each in 4 people (10%). This is in line with research conducted by Mentari et al., (2021) where health problems caused by exposure to carbon monoxide in traders with fatigue 36 people (53.7%), blurred vision and coughing 35 people (52, 2%), lightheadedness 34 people (50.7%) and dizziness 33 people (49.3%).

In addition, the behavior of parking attendants also affects the level of risk of CO exposure, one of which is smoking habits. The data obtained by researchers through interviews using questionnaires from 60 parking attendants, 7 parking officers did not smoke (11.66%) and as many as 53 respondents smoked (88.33%). This is directly proportional to research conducted by Rifaza, (2018) as many as 50% of parking attendants have the habit of smoking. In this study, respondents who smoked were still used by researchers, bearing in mind that if respondents who smoked were not included, the sample obtained would only be 7 out of 60 respondents.

CONCLUSION

The results of measuring CO concentrations at several points on roads in Gorontalo City, from 12 locations, there were 8 locations that exceeded the threshold value. Based on these results, it can be seen that CO levels in Gorontalo City are included in the unsafe category because 66.67% of the location sampling points exceed the Threshold Limit Value (NAV). Characterization of ecological risk due to CO exposure on roads in Gorontalo City is classified as dangerous for the environment where 4 locations are in the low hazard category (HQ 0.1-1.0) and 8 locations are in the moderate hazard category (HQ 1.1-10). CO intake realtime exposure to the greatest health risk from all locations was

at the Jamu Solo store location, namely 1.8501799100 mg/kg/day with an RQ value of 2.2291324200 (at risk). Meanwhile, the lowest realtime intake value of all locations is at the Extra Bakery location 0.0746788000 mg/kg/day with an RQ value of 0.0899744600 (not at risk). Parking attendants are expected to care more about health and take precautions such as getting used to wearing masks while working and reducing smoking habits and for the Environment Service it is hoped that they can carry out routine monitoring of CO concentrations. In addition, based on the concept of natural recycling, planting trees around city streets to reduce air pollution. It is known that trees can reduce the impact of air pollution such as carbon monoxide gas and carbon dioxide gas.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest concerning the publication of this article. The authors also confirm that the data and the article are free of plagiarism.

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