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Environmental Health Risk Analysis of Carbon Monoxide Exposure among High Activity Communities Along "X" Street, Yogyakarta

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Abstract

Background: The most exhaust-gas produced by motor vehicles consists of 71% carbon monoxide and it becomes an impact on air pollution and human health risk. This study aims to analyze the environmental health risk health of carbon monoxide exposure to high activity communities at X Street, Yogyakarta.

Method: This study was an observational study with Environmental Health Risk Analysis (EHRA) approach. This study was conducted in 2019 with 269 respondents. The respondents were chosen by using a purposive sampling method with the criteria; they had been work five years and a minimum age of nineteen years old. Besides, carbon monoxide measurement was conducted in three zones.

Findings: The average carbon monoxide concentration was 7,5035 mg/m^3,Weight (Wb) median was 60 kg,Exposure time (tE) was 11 hours/day,Exposure duration (Dt) was 10 years, and Inhalation rate (R) was 0,83 m^3/hour. Besides, the intake real-time value of non-carcinogen was 0,395 mg/kg/day with 0,329 of Risk Quotient (RQ) level. There were sixteen respondents with (RQ>1) value that might have the risk. Hence, risk management was needed by decreasing the concentration value and the inhalation rate.

Conclusion: The main risk of carbon monoxide exposure was a respiratory disorder in real-time and lifetime duration. The Technical Implementation Unit of Environmental Agency needed ISPU measurement by routinely to monitor the carbon monoxide at X Street and recommended to use the Personal Protective Equipment (PPE) or mask.

Keywords: *Air pollution, Carbon Monoxide, EHRA, Risk management.*

Introduction

Air pollution can cause poor health effect. According to the Air Quality Index (IQAir)[1] that Indonesia has first ranks in Southeast Asia and 11th ranks as the most polluted country in the world. The main source of air pollution are transportation, motor vehicles, almost 60% of the pollutants produced consist of carbon monoxide (CO)[2]. World Health Organization (WHO)[3] reported that air pollution causes the death of approximately 7 million people worldwide that 29% had lung cancer, 24% had a stroke, 25% had coronary heart disease, and 43% had lung disease.

Incomplete combustion of vehicles will produce CO gas. The inhalation path of CO gas into the human body through the respiratory and circulates throughout the body sucked into the lungs and binds to blood hemoglobin in the form of COHb. This mechanism will lack of oxygen and it can cause symptoms of poisoning to the body[4]. Long-term exposure to CO can cause headaches, dizziness, nausea, vomiting, blood vessel dilation, blurred vision,chest pain, weakness, confusion, pulmonary edema, pulmonary arrest, cardiac arrest, seizures, and coma[5].

Special Region of Yogyakarta especially X street that various vehicles crowded the road not only during rush hours but also even jammed because it is one of the tourist destinations, business or economic center[6]. Based on Environmental Agency[7] data that the quality of CO ambient air carried out in front of the Bringharjo market was 1,789.44 µg/Nm^3. Central Statistics

Agency[8] reported that the number of motorized vehicles of Yogyakarta city reached 4,616,016 vehicles. The high volume of vehicles with the small and narrow area of highway causes a high amount of vehicle density, it is inversely proportional to the speed of vehicles passing through the road and increase the concentration of pollutants. The lower speed of vehicles will result in higher concentrations of pollutants that present on road[9]. The high concentration of CO can endanger human health[10]. The communities at high risk of CO poisoning to people who have high activity along the X street likely traders and Trans Jogja bus stops officers who work more than 8 hours per day.

The research objective is examinating the magnitude of the environmental health risk of CO exposure as early dectection of health risk in high-activity communities along X Street, Yogyakarta City.

Material and Method

This study was using the Environmental Health Risk Analysis (EHRA) method to determine the magnitude of health risks due to CO exposure to the high activity communities along X Street in Yogyakarta. This study was conducted in 2019. The subjects were high-activity communities along X Street and using purposive sampling technique.

Subjects were traders and Trans Jogja bus stop officers who taken based on the length of time at the research location more than 5 years of work period and over 19 years old. The total sample amount of 269 people. The object used as the ambient air of CO along X Street that taken in 3 zones. The variables including: CO concentration (C), inhalation rate (R), respondent's body weight (Wb), exposure time (tE), frequency of exposure (fE), duration of exposure (Dt), intake (I), health risk (RQ) value, and risk management.

Results

The EHRA variable have median value i.e. body weight of 60 kg,exposure time of 11 hours/day, exposure frequency of 353 day/year, duration of exposure of 10 year. It is result complete shown in table 1.

Table 1:The Distribution Frequency of EHRA Variables on Respondents

Variable	High activity communities				Total	
	Traders		Bus Stop Officers			
	N	%	N	%	n	%
Weight (Kg)						
>60	117	43	5	2	122	45
≤60	143	54	4	1	147	55
Total	260	97	9	3	269	100
Exposure Time (hours/day)						
>11	129	48	0	0	129	48
≤11	131	49	9	3	140	52
Total	260	97	9	3	269	100
Exposure Frequency (day/year)						
>353	116	43	8	3	124	46
≤353	144	54	1	0	145	54
Total	260	97	9	3	269	100
Duration of Exposure (year)						
>10	115	43	5	2	120	45
≤10	145	54	4	1	149	55
Total	**260**	**97**	**9**	**3**	**269**	**100**

Source: Primary Data,2019

The determination of intake rate in this study based on the default value (NAAQS) EPA[11] that is equal to 0,83 m^3/hour and the RfC value used for CO risk agents is 1,24 mg/kg/day. The results of measurements of CO in ambient air along X Street conducted in one measurement in zone I:6.15 mg/m^3,zone II:8,255 mg/m^3,and zone III:8,334 mg/m^3.With a mean value of 7,5035 mg/m^3,a median of 8,255 mg/m^3,a minimum of 6,15 mg/m^3,a maximum of 8,343 mg/m^3.

The table 1 showed that the majority respondents on traders have body weight ≤60 kg amount of 54%, exposure time ≤ 11 hours/day amount of 49%, exposure frequency ≤ 353 days/year amount of 54%, and duration of exposure ≤ 10 years amount of 54%. Based on the value of each variable in Table 1 showed that the median value of intake rate 0,395 mg/kg/day.

Table 2: The Respondents Frequency Based on Intake Rate Value In Realtime and Lifetime Exposures

Intake Rate (mg/kg/day)	High activity Communities								Total			
	Traders				Bus Stop Officers							
	Realtime		Lifetime		Realtime		Lifetime		Realtime		Lifetime	
	n	%	n	%	n	%	n	%	N	%	N	%
>0,395	131	49	259	96	3	1	9	3	134	50	268	99
≤0,395	129	48	1	1	6	2	0	0	135	50	1	1
Total	260	97	260	97	9	3	9	3	269	100	269	100

Table 3: The Respondent Frequency Based on RQ Value in Realtime and Lifetime Exposures

RQ Value	High activity Communities								Total			
	Traders				Bus Stop Officers							
	Realtime		Lifetime		Realtime		Lifetime		Realtime		Lifetime	
	n	%	n	%	n	%	n	%	N	%	N	%
>1	16	6	82	30	0	0	1	1	16	6	83	31
≤1	244	91	178	66	9	3	8	3	253	94	186	69
Total	260	97	260	96	9	3	9	4	269	100	269	100

Source: Primary Data, 2019

Based on table 3, it is known that respondents who work as traders in the realtime estimation with RQ value of >1 as much as 6% and the estimated lifetime duration with RQ value >1 amount of 30%, it means the traders is not safe for their health. The following table below is the calculation table for risk management.

Table 4: Risk Management of CO Safe Concentration in Respondents

Zone	Wb (Kg)	R (m^3/hour)	fE (day/year)	Concentration in Exposure Duration (Year)					
				5	10	15	20	25	30
I	60,23	0,83	332,531	592,609259	296,304629	197,536420	148,152315	118,521852	98,768210
II	61,72	0,83	362,073	557,721626	278,860813	185,907209	139,430406	111,544325	92,953604
III	61	0,83	352,681	565,894508	282,947254	188,631503	141,473630	113,137902	94,315751

Source: Primary Data, 2019.

Table 4 showed that the concentration of safe inhalation of air containing CO gas with average body weight, intake rate and frequency of exposure of respondents will decrease until the duration of exposure of 30 years.

Table 5: Risk Management of CO Gas Inhalation Rate in Respondents

Zone	Wb (Kg)	C (mg/m^3 /hour)	fE(day/ year)	Inhalation Rate in Exposure Duration (Year)					
				5	10	15	20	25	30
I	60,23	6,15	332,531	79,978253	39,989127	26,659418	19,994563	15,995651	13,329709
II	61,72	8,255	362,073	55,920128	27,960064	18,640043	13,980032	11,184026	9,320021
III	61	8,343	352,681	56.297811	28,148906	18,765937	14,074453	11,259562	9,382969

Source: Primary Data, 2019.

The table 5 shown that the higher concentration of CO in the air correlate with the decrease of inhalation rate which become safe for repondents to the health risk of noncarcinogenic diseases and the inhalation rate will decrease according to increases the duration of exposure.

Discussions

CO gas potentially as toxic from the presence of air pollution from vehicle exhaust fumes, especially those which using gasoline fuel. The air pollution will cause the decrease of air quality level and human health[12]. CO gas concentration compared with the CO quality standard according to Governor Decree[13] which amounted to 30000 µg/m^3 or 30,000 mg/m^3, it means that CO concentration levels along X street were still below the predetermined quality standard. The different CO concentration in the ambient air obtained is due to several factors including temperature, humidity, wind speed and air pressure[14].

The calculation of the intake value is influenced by the concentration of the risk agent in the air, the inhalation rate, exposure time, duration of exposure, and body weight. Based on the intake calculation it is known that the daily exposure time and annual exposure frequency is directly proportional to the intake value. It means that the annual frequency of exposure to the respondent caused by risk agent correlate with intake value that against health problems due to risk agent exposure[15]. Other factors that influence the amount of intake are age, working period, smoking habits and use of personal protective equipment (PPE)[16].

RQ value is obtained from the comparison between the intake rate with RfC value[21] and it has a relationship that intake compared with the RfC value, becomes the risk characteristics value. The RfC value used in this study was 1,24 mg/kg/day. It is obtained from calculations using the intake formula with default values for each variable, which is the difference in the concentration value. The concentration value is obtained from the RfC of CO in mg/m ^{3} which is the standard in NAAQS[10].

CO compounds can be toxic to the human body because the reaction between CO and hemoglobin (Hb) in the blood. Hb in humans functions as a transport system to carry oxygen in the form of oxyhemoglobin from the lungs to the body's cells and carry CO_2 in the form CO_2 Hb from the body's cells to the lungs. Hb can form carboxyhemoglobin with the presence of CO. If the reaction occurs, the blood's ability to transport oxygen is reduced. The affinity of CO to hemoglobin is 200 times higher than in affinity of oxygen to hemoglobin, as a result of CO and O_2 together in the air and is formed as COHb in the number of far more than the O_2Hb[11]. The highest percentage of hemoglobin bound in the form of COHb is getting worse, the effect on human health[17].

The first risk management is a decrease in CO concentrations so that all populations are safe from the health problems of CO exposure the concentrations must be reduced below the average concentration. To reduce the concentration of CO gas risk agents along X Street, it can reduce the capacity of the main pollutant source likely motor vehicles. Reducing the capacity of motorized vehicles can be done with the existence of a car-free day action weekly routine action along X Street, Yogyakarta City. This will affect the reduction of pollutants due to motorized vehicles. The previos study related to the reduction of CO concentration with the car-free day was conducted by other study[18] reported that air quality monitoring of CO generated from motor vehicle emissions has been decreased by car-free day action at the intersection of Semarang City. The subsequent reduction in ambient air concentration by planting trees or phytoremediation. Phytoremediation is a method by using forage plants to move, accumulate and change harmful contaminants into harmless substances. The yellow palm (Chrysalidocarpus lutescens) can be

planted, it is very effective for absorbing toxic gases into the stomata from vehicle fumes, besides plants that have broad hairy leaves and rough surfaces[19].

The second risk management is reduction of inhalation by using PPE to minimize the possibility of exposure to inhaled CO gas from ambient air. This study in line with previous study[20] to reduce the amount of exposure to security guards and parking attendants at Campus X Yogyakarta can be done with preventive measures by using a PPE.

The high concentration of CO in the ambient air will affect a health risk to CO intake into the body. So, the higher concentration of CO positive correlates with a higher intake value and it can be prevented by using PPE such as masks. Previous studies reported that the average COHb levels of respondents who use masks are lower than respondents who do not use masks[21].

The socialization was held by Technical Management Unit (UPT) in collaboration with the Department of Yogyakarta Tourism, the Environment Agency, and Academic Higher Education to educate the use of PPE and provide information related to health risks due to CO gas emissions. The socialization is expected to reduce the magnitude of risks arising from motor vehicle emissions, especially in CO gas, for high-activity communities along X Street,Yogyakarta City.

Conclusion

CO exposure to high activity communities will impact their health because respondents have RQ >1. Risk management through the reduction of concentration and decrease of the inhalation rate in high activity communities along X Street, Yogyakarta City.

Conflict of Interest: The authors declare that there are no conflict of interest regarding the publication.

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Ethical Clearance: The research has been approved ethical clearance from Ethical Review Committees of Universitas Ahmad Dahlan Number 01905055.

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