Determination of Safe Benzene Concentration at Kebon Jeruk Toll Gate Keeper Jakarta Indonesia

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ABSTRACT

Benzene is a liquid aromatic hydrocarbon compound that is clear, colorless, flammable, and volatile. High concentrations of benzene in the body through inhalation can cause health problems. The purpose of this study is to determine the safe concentration of benzene exposure (C6H6) in Jakarta Kebon Jeruk toll gate keeper. Toll gate keepers are vulnerable to exposure to benzene compounds in the air. 20 toll gate keeper who are divided into toll gate 1 and toll gate 2 were population in the study. The sample technique used total population sampling. The present study used quantitative data analysis manually calculated through the calculation of safe concentration in the environmental toxicology concept. Safe concentration data on Jakarta Kebon Jeruk toll gate keeper were based on data from rat experimental animals, experimental body surface, workers' characteristics of body weight, body height, body surface area, breathing rate and working duration. In addition, data on benzene concentration, animal km, human km, NOAEL and safe limits for toxin doses were also used. The average measurement results of benzene concentration in the air entering the body of workers through inhalation was 0.00167 mg/m^3 (0.0052 ppm). This value is lower than benzene threshold according to the Minister of Manpower Regulation Number 5 of 2018 of 0.5 ppm.[6] The safe concentration of benzene calculated was 0.0875 mg/m^3 (0.0273 ppm). Based on the calculation of safe concentration, the concentration of benzene in the environment of the Kebon Jeruk toll gate keeper indicated safe.

Keywords: *benzena, safe concetration, toll gate keepers*

Introduction

The development of the transportation sector makes it easy for people to move and carry out their activities. On the other hand, the development of the transportation sector also has a negative impact towards the community.[1] The negative impacts include congestion and air pollution due to motor vehicle gas emissions. Air pollution can have a negative impact on public health and cause health problems such as respiratory problems, respiratory infections and even systemic diseases such as cancer.

Jakarta is one of the big cities in Indonesia with the highest pollution level. The increasing number of the volume of motor cycle is also one of the causes of increasing environmental pollution. Directorate of Metro Police Traffic Subdistrict Registration and vehicle identification reported that in 2013 the number of vehicles in Jakarta and its surrounding areas reached 16 million units.

One of the air pollutants caused by motorized activities include aromatic hydrocarbon compounds such as benzene, toluene and xylene. According to the Agency for Toxic Substances and Disease Register, chemical compounds that can cause health effects on humans and are found in petroleum content namely benzene,

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toluene, xylene, ethylene, Total Petroleum Hydrocarbon and Polycyclic Aromatic Hidrocarbon.[1] Benzene is a clear, colorless, flammable and volatile liquid aromatic hydrocarbon compound. Exposure to benzene in high concentrations that enter the body through inhalation can cause health problems and lead to death.

Toll gate keepers are prone to be exposed to benzene. Most benzene exposure received by toll gate keepers comes from inhalation exposure lines sourced from gasoline and exhaust vehicles. Toll is a state development facility that aims to facilitate traffic, improve distribution services, improve equity in development and justice outcomes.[2]

Researches on benzene risk analysis on human activities is mostly done at gas stations and workshop mechanics.[3,4] Rusdiyanto stated that workshop workers exposed to chemical substances in the form of gas exhaust motor vehicles inhaled benzene levels that exceed the Threshold Threshold Value (NAB) of 0.5 ppm.[5]

A research measured the concentration of benzene at the toll gate 1 and the toll gate 2 of the Jakarta Kebon Jeruk and produced a value of 0.00163 mg m^3 and 0.00171 mg/ m3.[6] The research was conducted on 20 respondents of Kebun Jeruk toll gate keepers who were divided into toll gate 1 keeper and toll gate 2 keeper. Based on previous research, the researchers have not calculated Safe Concentration calculation. Toll gates are one of the work environments with benzene exposure. Therefore, the calculation of safe concentration is important to ensure the health of workers. Safe concentration is calculated by using the Reference Concentration formula with No Observed Adverse Effect Level which is adjusted to the research data so that a safe value can be found on pollutant chemicals to avoid health problems. This study was conducted to calculate safe concentration through the Reference Concentration calculation with No Observed Adverse Effect Level as the safe limit of benzene concentration in the Kebun Jeruk toll gate keepers.

Material and Method

This study aims to determine the safe concentration of benzene in the work area of the Kebun Jeruk toll gate in Jakarta. The approach used in this study is a cross-sectional approach and is in the form of observational descriptive research. The population in this study was 20 respondents of toll gate keepers who were exposed to benzene chemicals. Population determination was carried out through total working population of Kebun Jeruk toll gate keepers, Jakarta.

The study was conducted in May 2019. It begins with literature study on the analysis of toxicological health risks which included calculation of intake, type of risk and value of dose-response. Secondary data collection was carried out by conducting a literature study of previous research. Supporting research data were also used such as the type of chemical, weight of the experimental animal and results of the measurement of benzene in the air obtained through measurements of NIOSH1501 with activated carbon adsorbing pipe using Chromatography technique.

The variables used in this study were the characteristics of the experimental animals which included weight and surface area, worker characteristics including weight, body surface area, and worker breathing rate. The concentration of benzene in the workplace is also obtained through previous research literature studies. Processing variables by calculating factor Km in animals, No Observed Adverse Effect Level, RfC benzene in workers and calculation of safe concentration on workers is carried out. Data analysis was carried out using the Environmental Health Risk Analysis method.

Results

A. Characteristics of Experimental Animals: Measuring the level of toxicity of chemical compounds using experimental animals is the process of supporting testing. The experimental animals used were white rats.

Table 1: Distribution of Characteristics of White Mice

Experimental animal	W (kg)	BSA (m2)
1	0,1405	0,024165
2	0,1405	0,024165
3	0,1410	0,024223
4	0,1410	0,024223
5	0,1395	0,024050
6	0,1415	0,024165

Where:

BSA: Body Surface Area (m^2)

W: Weight (kg)

The body surface area calculated was 0,024165 m2.

B. Workers' Characteristics: The characteristics of workers used were body weight, height, and exposure duration. The population of 15 workers Kebon Jeruk toll gate keepers with an average weight of 67.9 kg and an average height of 159 cm. The duration of occupational exposure is 8 hours per day.

1. **Workers' Body Surface Area:** This is calculated with the following formula

   $BSA = \sqrt{W.H./3600}$

   Where

   BSA: Body Surface Area (m2)

   W: Weight (kg)

   H: Height (cm)

   $BSA = \sqrt{W.H./3600} = \sqrt{67,9.159/3600}$

   = 1,73 m2

2. **Workers' Respiratory Rate:** Breathing rate calculations can be done using the following formula

   BR = 5.3 ln W - 6.9/24

   Where

   BR : Breathing Rate

   W : Weight

   BR = 5.3 ln W − 6.9/24

   = 5.3 ln 67,9 – 6.9/24 = 0.64 m^3/hour

C. Benzena Concentration: Measurement of benzene concentrations inhaled by workers was carried out at two different toll gate points. The concentration of benzene at the door of Kebon Jeruk toll, Jakarta has an average of 0.00167 mg/m^3 (0,00052 ppm).

Table 2: Distribution of Benzene Concentration

Location	C (mg/m3)	Berat Molekul	C (ppm)
Toll gate 1	0,00163	78,11	0,00051
Toll gate 2	0,00171	78,11	0,00054
Average			0,00052

Based on the results of the above measurements the highest benzene concentration was 0.00171 mg m3 (0.00054 ppm) at toll gate 2, while the lowest concentration was 0,000163 mg/m^3 (0,00051 ppm) at toll booth 1. The value of benzene concentration is lower than Threshold Value by 0.5 ppm.[5]

D. Animal Km and Human Km: Determination of safe dosage limits or safe concentration on workers begins with the calculation of Animal km and human km

1. **Animal Km**

   $$\text{Animal Km} = \frac{\text{W animal}}{\text{BSA animal}}$$

   Where

   Animal Km: Km factor on experimental animal

   W: Weight (kg)

   BSA: Body Surface Area (m^2)

   The distribution of Animal Km is as follows:

Table 3: Calculation of Animal Km in White Mice

Experimental animal	W (kg)	BSA (M2)	Animal Km
1	0,1405	0,024165	5,814194082
2	0,1405	0,024165	5,814194082
3	0,1410	0,024223	5,820914007
4	0,1410	0,024223	5,820914007
5	0,1395	0,024050	5,8004158
6	0,1415	0,024165	5,855576247
Average	0,1407	0,024165	5,82

The calculation results of Animal Km are shown by the table above with an average of 5.82 in white rats.

2. **Human Km:** Human Km calculations are also needed for workers to support risk analysis

   $$\text{Human Km} = \frac{\text{W human}}{\text{BSA human}}$$

   Where:

   Human Km: Km factor on human

   W: Weight (kg)

   BSA: Body Surface Area (m2)

Table 4: Human Km calculations for workers

Number of worker	W avg (kg)	BSA avg (m^2)	Human KM avg
20	67,9	1.73	39,24

Based on the calculation of human km above, the average human km value is 39.24.

E. No Observed Adverse Effect Level (NOAEL): Toxicity test was performed by determining

the highest dose without causing effects on experimental animals or No Observed Adverse Effect Level.

Saridewi and Tualeka stated that the calculation of the highest toxins without causing effects on experimental animals was 3.0 mg/m3 (0.022 mg/kg).[7] NOAEL calculations in this study can be obtained from the following formula:

NOAEL benzene = 3,0 mg/kg

$$\text{NOAEL benzene} = \frac{3 \times 0.00013 \times 8}{0.1405}$$

NOAEL benzene = 0,022 mg/kg

F. Inhalation Reference Concentration (RfC): Shaw et al. in a study conducted by Saridewi and Tualeka, show that the calculation of the reference concentration on workers or the Inhalation Reference Concentration can use the following formula.[8]

$$\text{RfC} = \text{NOAEL} \frac{\text{Animal KM}}{\text{Human KM}}$$

Where

RfC: Inhalation Reference Concentration

NOAEL: No Observed Adverse Effect Level

Animal Km: Km factor on animal

Human Km: Km factor on human

Based on the calculation of reference concentration on toll gate keepers obtained from the NOAEL value, the average Animal Km and the Human Km average are as follows.

$$\text{RfC} = \text{NOAEL} \frac{\text{Animal KM}}{\text{Human KM}}$$

$$\text{RfC} = 0{,}022 \frac{5{,}82}{39{,}24}$$

RfC = 0,0033 mg/kg

The reference concentration value of the Jakarta Kebon Jeruk toll gate keepers is 0.0033 mg/kg.

G. Safe Concentration (C safe) of Benzene: In Saridewi and Tualeka, it is shown that the calculation of safe concentration on benzene substances can be calculated using a formula obtained from William, Davis and Soemirat.[7] Calculation of safe concentration using the value of Inhalation Reference Concentration, No Observed Adverse Effect Level (NOAEL), average length of work, average body weight and breathing rate of the Kebun Jeruk Jakarta toll gate keepers are as follows.

$$\text{C Safe (mg/m3)} = \frac{\text{R}f\text{C} \times \text{W}b}{a \times \text{BR}xt} \text{ Mg/m}^3$$

Where.

C safe: The safe concentration (mg/m3 or ppm)

RfC: Inhalation Reference Concentration (mg/kg)

W: Weight (kg)

Δ: Percentage of substances absorbed by workers' lungs (%)

BR: Breathing Rate (m^3/hour)

T: Time

Calculation of safe Concentration can be seen in the formula as follows.

$$\text{C safe (Mg/m}^3\text{)} = \frac{\text{R}f\text{C} \times \text{W}b}{a \times \text{BR}xt} \text{ Mg/m}^3$$

$$= \frac{0,0033 \times 67,9}{50\% \times 0{,}64x8} \text{ Mg/m}^3$$

$$= \frac{0,224}{2,56} \text{ Mg/m}^3$$

$$= 0{,}0875 \text{ Mg/m}^3$$

$$\text{C safe (ppm)} = \frac{\text{C} \times 24.45}{\text{Berat Molekul}}$$

$$= \frac{0{,}0875 \times 24.45}{78{,}11} \text{ ppm}$$

$$= 0{,}0273 \text{ ppm}$$

Discussion

Benzene concentrations in Kebon Jeruk toll gates was 0.00163 mg/m^3 (0.00051) on toll gates 1 and 0.00171 mg/m3 (0.00054) on toll gate 2. Benzema concentration at toll gate 2 concentration is higher than benzene concentration at toll gate 1. Based on the regulation of the Minister of Manpower Number 5 of 2018 concerning the Threshold Limit Value, benzene concentration is 0.5 ppm.[5] The concentration of benzene in the gate of Jakarta Kebon Jeruk toll was below the threshold value. Calculation of safe concentration at the Jakarta Kebon Jeruk toll gate is based on calculations of Reference

Concentration and No Observed Adverse Effect Level. The result of No Observed Adverse Effect Level is 0.022 mg/kg. This result is comparable with study by Swaen et al. which states that NOAEL benzene compounds are 3.0 mg/m^3 or equivalent to 0.022 mg/kg.[8] According to the Agency of Toxic and Substances, the value of No Observed Adverse Effect Level for exposure through inhalation of 3 ppm through the respiratory system.[1] Thus, the value of No Observed Adverse Effect Level benzene is safe for workers.

Reference Concentration through the inhalation pathway for benzene can be calculated through the value of NOAEL, Animal Km, Human Km for Jakarta Kebon Jeruk toll gate keepers. The results show that the Reference Concentration value through inhalation is 0.0033 mg/kg. These results were considered the same as the study by Kartikasari which had an RfC value of 0.0039 in workers exposed to benzene in the petroleum processing laboratory.[9] In addition, based on the Reference Concentration value through inhalation based on U.S EPA National Center for Environmental Assessment, RfC value is 0.03 mg/m^3. This shows that the value of RfC for Kebon Jeruk toll gate keepers is still smaller than Integrated Risk Information System Chemical Assessment Summary.[10]

Reference Concentration through the inhalation pathway for benzene can be calculated through the value of NOAEL, Animal Km, Human Km for Jakarta kebon Jeruk toll gate keepers. The results show that the Reference Concentration value through inhalation is 0.0033 mg/kg. These results reconsidered similar to the study by Kartikasari which had an RfC value of 0.0039 in workers exposed to benzene in the petroleum processing laboratory.[9] In addition, based on the determination of the Reference Concentration value through inhalation based on U.S EPA National Center for Environmental Assessment, RfC value is 0.03 mg/m^3. This shows that the value of RfC for Kebon Jeruk toll gate keeper is still lower than that of Integrated Risk Information System Chemical Assessment Summary.[10]

Conclusion

Benzene concentration in the air that entering the body of workers through inhalation on average was 0.00167 mg/m^3 (0.0052 ppm). This value is still below the Benzene Threshold Value according to the Minister of Manpower Regulation Number 5 of 2018 of 0.5 ppm.[5] Calculation of safe concentration on workers shows the safe level by 0.0875 mg/m^3 (0.0273 ppm). Through the results of the calculation of safe concentration, benzene in the work environment of Kebon Jeruk toll gate keepers is in the safe category.

Control measures and efforts to minimize health effects can be in the form of the use of personal protective equipment for workers and work shift arrangements. Personal protective equipment can be in the form of respiratory masks to protect workers from direct benzene exposure.

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Ethical Clearance: The study was approved by the institutional Ethical Board of Health Ministry of Tangerang City

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