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Toluene Safe Concentration for Toll Gate Keepers at Kebon Jeruk, Jakarta Indonesia

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ABSTRACT

Toluene is one of the BTX compounds with a strong and distinctive aroma. When inhaled, this can affect the nervous system and body coordination and cause headaches. At constant exposure, toluene compounds can cause more serious health risks that can cause death. This study aims to determine the safe concentration of toluene in Kebun Jeruk toll gate officers, Jakarta. The population in this study were all 20 Kebun Jeruk toll gate keepers divided into two area points of toll gate 1 and toll gate 2. This study used manually calculated quantitative data analysis through safe concentration calculation in environmental toxicology concepts. Safe concentration data in Jakarta Kebon Jeruk toll gate keepers were obtained from experimental animals' body weight (W animals), body area (BSA animals), workers' characteristics including body weight (W), height (h), body surface area (BSA), breathing rate (BR) and working duration (t). In addition, data on the concentration of benzene (C), animal km, human km, NOAEL and the safe dose of toxin were also used.

The concentration of toluene in air that enters the workers body through inhalation measured at two average points was 0.00125 mg/m^3 (0.00033 ppm). The value obtained is still far below the toluene threshold value determined by the Minister of Manpower and Transmigration Regulation Number Per.13/Men/X/2011 of 2011. The calculated safe concentration of toluene shows a result of 0.0922 mg/m^3 (0.0245 ppm) which is still in the safe category. This level must be maintained to assure its level does not increase.

Keywords: *toluene, safe concentration, toll officer*

Introduction

Toluene is one of the BTX compounds that has a strong and distinctive aroma. When inhaled, this can affect nervous system and body coordination and cause headaches. At constant exposure, toluene compounds can cause more serious health risks that can cause death.[1,2]

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Safe toluene concentration is not a reference in determining toluene threshold value that it often has an effect on workers even though the concentration is below the Threshold Limit Value. Based on the previous research, exposure of 50 ppm toluene can significantly increase lipopolisakardic (LPS-induced) induction of mouse cell proliferation (Fujimaki, 2010), decrease in antioxidant enzyme activity significantly, and increase fat peroxidation and protein damage both in vivo and in vitro (Karabulut, 2009).[3] A previous study found that toluene concentrations below the NAB had an effect on workers. Thus the revision of the Threshold Limit Value is needed regarding the safe limits of toluene concentration in the work environment.

DKI Jakarta is the capital of Indonesia. The pollution level in this city is the highest among other cities in Indonesia. The Directorate of Traffic of the Metro Jaya

Police Sub-Directorate of Vehicle Registration and Identification noted that the number of vehicles in Jakarta reached 16 million units in 2013. Air pollutants produced by motorized vehicles include carbon monoxide (CO), methane (CH4), nitrogen oxide (NO2), sulfur dioxide (SO2), and aromatic hydrocarbon compounds such as BTX (benzene, toluene, and xylene).[4]

Risk analysis research of Toluene on human activities have been mostly carried out at gas stations (Tunsaringkarn, 2012) and in urban areas (Singh, 2012).[5] The researches were mostly carried out for researchers aimed to examine effects of toluene chemicals in humans' health through inhalation. The level of pollution on highways, especially in big city toll roads such as in Jakarta and the length of exposure experienced by toll road officers makes the toll road officers have a greater risk of exposure to chemicals, especially toluene. In Eko Handoyo's (2015) study, the results of measurements of toluene concentrations at toll gate 1 and 2 of Kebun Jeruk Jakarta were 0.00121 mg/m^3 and 0.00128 mg/m^3, respectively.[6] The study was conducted on 20 toll gate guards. In the previous research, the researchers did not calculate the safe concentration of toluene.

This study aims to determine the toluene threshold value – initiated by the determination of NOAEL toluene in white rats and RfC. Calculation of safe concentration is important to ensure the health of workers.[7] The present research is beneficial as a reference in determining the toluene safe (NAB) limit in the work environment in Indonesia and the improvement of existing Threshold Value. Safe concentration was calculated using the Reference Concentration (RfC) formula with No Observed Adverse Effect Level (NOAEL) which is adjusted to the research data.

Material and Method

This study aims to determine the safe concentration of air toluene chemicals in the work area of Kebun Jeruk toll gate officers, Jakarta. The approach used was a cross sectional approach with observational descriptive research. The population in this study were 20 respondents. Population determination was carried out through total population of Kebun Jeruk toll officers, Jakarta.

The study was conducted in May 2019, initiated with the study of literature on the analysis of toxicological health risks which included calculation of intake, type of risk and value of dose response. Furthermore, secondary data from the literature study of the previous research was conducted to obtain anthropometric data of the officers of Kebun Jeruk toll gate, Jakarta. Data of supporting research was also taken which included the types of chemicals, the weight of the experimental animals, and the results of measurements of benzene in the air obtained through measurements of NIOSH 1501 (NIOSH, 2003) with activated carbon adsorbing pipes using the has Chromatography (GC) technique.

The variables used in this study include the characteristics of the experimental animals in the form of weight and surface area of the experimental animals (BSA experimental animals), worker characteristics including weight (W), body surface area (BSA), and worker breathing rate (BR). In addition, toluene concentration in the workplace was also obtained from previous research literature studies. Furthermore, variables were processed by calculating factor Km in animals (Human Km), No Observed Adverse Effect Level, RfC benzene in workers and calculation of safe concentration on workers is carried out.

Result

A. Characteristics and Surface Area of Experimental Animal Bodies: Toxicity testing of compounds requires animal testing as support. This is because animal response to a toxic substance resembles a human response. The experimental animals used in this study were white mice (*Rattus norvegicus*).[8]

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)

Body Surface Area on experimental animal was 0,024165 m^2.

B. Characteristics, Body Surface Area, and Worker's Respiratory Rate: The characteristics of workers in this study include body weight, height and length of exposure in working hours per day. The total working population is 20 workers with an average body weight of 67.9 kg and height of 159 cm according to the average height of Indonesian adults. The duration of exposure is 8 hours per day according to the working hours of toll gate keepers. The body surface area and the respiratory rate of workers were calculated using the following formula.

1. **Body surface area (BSA):** The body surface area of workers was calculated by using the following formula

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

Where

BSA : Body Surface Area (m^2)

W : Weight (kg)

h : height (cm)

$$BSA = \sqrt{W.h/3600}$$
$$= \sqrt{67,9.159/3600}$$
$$= 1,73 \text{ m2}$$

2. **Breathing Rate:** The breathing rate of workers is calculated using the following formula

$$BR = 5.3 \ln W - 6.9/24$$

where

BR : Breathing Rate

W : Weight (kg)

$$BR = 5.3 \ln W - 6.9/24$$
$$= 5.3 \ln 67,9 - 6.9/24$$
$$= 0.64 \text{ m}^3/\text{hour}$$

C. Toluena Concentration: Measurement of toluene concentration is carried out in two points, i.e toll gate 1 and toll gate 2 Kebon Jeruk Jakarta. The average concentration was 0.00125 mg/m^3 (0.00033 ppm).

Table 2: Distribution of Toluene Concentration at Kebon Jeruk Toll Gate Jakarta

Location	C (mg/m^3)	Molecular weight	C (ppm)
Toll gate 1	0,00121	92,14	0,00032
Toll gate 2	0,00128	92,14	0,00034
Average			0,00033

Based on the measurements carried out, the highest toluene concentration at toll gate 2 was 0.00128 mg/m^3 (0.00034 ppm) while the lowest was at toll gate 1 at 0.00121 mg/m^3 (0.00032 ppm). The toluene concentration value is still far below the threshold value set by the Minister of Manpower and Transmigration Regulation Number Per.13/MEN/X/2011 in 2011 concerning the threshold value of physical and chemical factors in the workplace of 188 mg/m3.[9]

D. Animal Km and Human Km: Determination of safe limits for toxic doses on Kebon Jeruk Jakarta toll door officers began 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 animal

W : Weight (kg)

BSA : Body Surface Area (m^2)

Based on the Animal Km calculation, the Animal Km distribution is as follows.

Table 3: Calculation result of Animal Km on 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 average calculation of Animal Km according to the table above is 5.82.

2. **Human Km**

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

Where:

Human Km : Km factor on human

W : weigh (kg)

BSA : Body Surface Area (m^2)

Table 4: Human Km Calculation for Workers

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

The average calculation results of Human Km on Kebun Jeruk toll gate keepers is 39,42

E. No Observed Adverse Effect Level (NOAEL): To determine the safe limit of the concentration or dose of a chemical for human safety, the No Observed Adverse Effect Level (NOAEL) toxicity test was carried ou. This is the determination of the highest dose of toxin without causing effects on experimental animals.

Schäper et al. 2003, 2004, 2008; Seeber et al. 2004, 2005; Zupanic et al. 2002 states that the No Observed Adverse Effect Level (NOAEL) toluene calculation is 3.8 mg/m^3 (0.0281 mg/kg).[10] The calculation of NOAEL in he present study can be obtained using the following formula.

NOAEL toluene = 3,8 mg/m3

$$\text{NOAEL toluena} = \frac{3.8 \times 0.00013 \times 8}{0.1405}$$

$$= 0{,}0281 \text{ mg/kg}$$

F. Inhalation Reference Concentration (RfC): Shaw et al. (2007) in Saridewi and Tualeka's study (2017).[11,12] shows that the calculation of the reference concentration on workers or the Inhalation Reference Concentration (RfC) can use the following formula:

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

Where

RfC : Inhalation Reference Concentration

NOAEL : No Observed Adversed Effect Level

Animal Km : Factor Km on experimental animal

Human Km : Factor Km on human

The calculation of RfC for Kebon Jeruk toll gate keepers in Jakarta is as follows:

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

$$\text{RfC} = 0{,}0281 \frac{5{,}82}{39{,}24}$$

$$\text{RfC} = 0{,}00417 \text{ mg/kg}$$

Based on the above calculation, the reference concentration or RfC in the Kebun Jeruk Jakarta toll gate officer is 0.00417 mg/kg.

G. Toluene Safe Concentration: In a study conducted by Saridewi and Tualeka (2017), the calculation of safe (C safe) concentration is calculated using a formula obtained from William (1985), Davis (1991) and Soemirat (2003).[12] The value of Inhalation Reference Concentration (RfC), No Observed Adverse Effect Level (NOAEL), average duration of work, average body weight and breathing rate of workers were calculated by the following formula:

$$\text{C safe} = \frac{\text{R}f \text{ C} \times \text{W}b}{a \times \text{BR}xt} \text{ Mg/m3}$$

Where.

C safe : The safe concentration of ctoxin in the air to workers (mg/m^3 or ppm)

RfC : Inhalation Reference Concentration (mg/kg)

W : Workers' weight (kg)

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

BR : Breathing Rate (m3/jam)

T : Time (hour)

Calculation of toluene safe C for Kebun Jeruk toll officers is calculated by the following formula.

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

$$= \frac{0{,}00417 \times 67{,}9}{60\% \times 0{,}64x8} \text{ mg/m}^3$$

$$= \frac{0{,}283143}{3{,}072} \text{ mg/m}^3$$

$$= 0{,}0922 \text{ mg/m3}$$

$$\text{Concentration (ppm)} = \frac{\text{C} \times 24{,}45}{\text{W Molekul}}$$

$$= \frac{0{,}0922 \times 24{,}45}{92{,}14}$$

$$= 0{,}0245 \text{ ppm}$$

Discussion

The toluene concentration at Kebon Jeruk toll gate is divided into 2 points, i.e toll gate 1 at 0.00121 mg/m^3 and toll gate point 2 at 0.00128 mg/m^3. According to the Minister of Manpower and Transmigration Regulation Number Per.13/Men/X/2011 of 2011 concerning the Threshold Value of Physical Factors and Chemical Factors at Work, Threshold value of toluene concentration is 188 mg/m3.[9] This shows that toluene concentration at Jakarta Kebon Jeruk toll gate is still far below the Threshold Value. Calculation of safe concentration at the Kebon Jeruk Jakarta toll gate is based on the calculation of Refrence Concentration (RfC), and No Observed Adverse Effect Level (NOAEL). Test of experimental animals is used to calculate No Observed Adverse Level (NOAEL) or the highest dose of toxin without causing an effect. The No Observed Adverse Effect Level (NOAEL) is 0.0281 mg/kg. According to the Agency of Toxic and Substances, the NOAEL for exposure through inhalation is 3 ppm.[13] Therefore, the value of toluene NOAEL is safe for workers.

Reference Concentration (RfC) of toluene through inhalation can be calculated through NOAEL, Animal Km, and Human Km values. The calculation results of Reference Concentration (RfC) value through inhalation on Kebon Jeruk toll gate keepers is 0.00417 mg/kg. Toluene Reference Concentration (RfC) value limit through inhalation based on U.S Environmental Protection Agency National Center for Environmental Assessment (2003) is 0.03 mg/m^3. This shows that the value of RfC for Kebon Jeruk toll keepers is lower than that of Integrated Risk Information System Chemical Assessment Summary (2003).

The toluene safe concentration of officers of the Kebon Jeruk toll is to 0.0922 mg/m^3 (0.0245 ppm). According to Minister of Manpower and Transmigration Regulation No. Per.13/Men/X/2011 of 2011 concerning the Threshold Value of Physical Factors and Chemical Factors in the Workplace, NAB from toluene concentration is 188 mg/m3.[9] This shows that safe concentration is still below the NAB and is safe. In conclusion, the value of toluene safe concentration in Jakarta Kebun Jeruk toll gate keepers is considered safe and can be maintained.

Conclusion

Measurement of toluene concentration entering the body through inhalation at toll gate keepers at Kebun Jeruk is 0.00125 mg/m^3 (0,00033 ppm).[8] This level is safe and far from the Threshold Value set by the Minister of Manpower and Transmigration Regulation Number Per.13/Men/X/2011 in 2011 by 188 mg/m3.[9]

The safe concentration of toluene of workers is 0.0922 mg/m^3 (0.0245 ppm), meaning that air condition of Kebon Jeruk Jakarta toll gate is in a safe category. This condition must be maintained that the level of toluene in the air around the workplace does not increase.[14] The control effort that must be carried out in addition to maintaining the environment is by using Personal Protective Equipment (PPE) on toll gate keepers that workers are not directly exposed to hazardous toluene substances.[11]

Conflict of Interest: All authors have no conflicts of interest to declare.

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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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