

Determination Reference of Concentration (RfC) Xylen Exposure Based on Xylen NOAEL in White Rats and Workers' Body Weight and Height in Surabaya Car Painting Area, Indonesia

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Abstract

This study aims to calculate the value of RfC from xylen exposure around the car painting area of Surabaya, Indonesia. This is an observational cross-sectional study with quantitative data analysis methods conducted manually. The population in this study was groups of car painting workers and groups of car repairer on Jalan Pengenal Kota Surabaya. The sampling technique was proportionate stratified random sampling to take 51 people. The measurement of xylen concentration around the car painting area was 635.98 mg/m³ (146.47 ppm). This value is above the threshold value according to Minister of Manpower and Transmigration Regulation Number 13 of 2011 and Minister of Manpower Regulation Number. 5 of 2018 is 434 mg/m³ (100 ppm). RfC of car painting workers with NOAEL 50 mg/kg was 7.76 mg/kg.

Keywords: Xylen, RfC, car painting worker

Introduction

Xylen is an aromatic hydrocarbon which is often used as a solvent namely cleaning agents, diluents for paints, and varnishes. Xylene is colorless, flammable, and volatile. It is often used in the printing, rubber and leather industries. The chemical industry produces xylene from petroleum (ATSDR, 2007)¹.

In the process of painting the car by spraying, workera are constantly exposed to xylen when the paint is sprayed. Workers are exposed not only to the vapor, but also from a collection of fine particles (mist). This form is easily absorbed by workers or into the skin, especially if workers do not wear proper personal protective equipment (WWAC, 2009)². The main exposure pathway occurs through inhalation, yet dermal exposure (through skin contact) and oral can also occur (IPCS, 2004)³. Individuals who routinely work on conditions that are periodically exposed to high levels of solvent vapors can be acutely affected such as intoxication, fatigue, poor endurance, headache, nausea, tremor, balance complaints to mild depression (Spurgeon et al., 1994)⁴.

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Kurnianto (2016) stated that the results of measuring xylen concentrations in the car painting area of Surabaya at 5 painting locations showed an average yield of 146.47 ppm which was above the threshold according to Minister of Manpower and Transmigration Regulation No. 13 of 20116 and Minister of Manpower Regulation Number. 5 of 20187. The set threshold value is not much different, namely 434 mg/m³ (100 ppm). While it does not cause a carcinogenic effect, it has an impact on health if one is continuously exposed.

Research conducted by Ilhan in 2004 on workers in Turkey showed that as many as 131 workers exposed to organic solvents with a noise of 85 dB in the workplace experienced increased hearing damage in the paint-making industry and painting workers with higher xylen organic solvents than workers who were only exposed to noise with the same level (Ilhan et al., 2014)⁸. Exposure to 10,000 ppm xylene inhaled shows complaints of kidney function characterized by increased levels of β -glucuronidase and albumin and the excretion of red blood cells and white blood cells in the urine (Malathi, 2014)⁹.

Based on the previous research, calculations of xylen Reference of Concentracion (RfC) on workers around the car painting area of Surabaya by using anthropometric data of Indonesian people has not been made. RfC as a safe concentration of xylen which is recommended for car painting workers in Indonesia still uses research references from America and Europe so that it is not accurately used as a reference in determining risk for Indonesian people. The xylene response dose was obtained from IRIS (2003) in US EPA10 which stated an inhalation reference dose (RfC) for non-xylene carcinogen exposure in the air by 0.1 mg/m³. The RfC number is multiplied by the default value of the adult inhalation rate by 20 m³/day (Kolluru, 1996) 11 and divided by the default value of adult body weight 70 kg (EPA, 1991) 12 resulting in 0.03 mg/kg.

In this study, the calculation of RfC was derived from experimental doses of NOAEL (No Observed Adverse Effect Level) using the characteristics of the experimental animals of white rats (*Rattus Novergicus*) from Indonesia and anthropometric factors (Wb, tE, fE, and Dt) car painting workers. The value of NOAEL xylene average body weight, the average height of Indonesian people is then obtained. The purpose of this article is to determine the xylen RfC for workers around the car painting area of Surabaya, Indonesia so that the

results can be used as a reference to estimate the amount of exposure each day that workers can receive without causing harmful effects during their lifetime.

Material and Method

This is an analytic observational study conducted in a cross sectional manner. The study population consisted of 2 strata of groups of workers namely car painting workers on Jalan Pengenal Kota Surabaya and group of car wreckers. The sampling technique was proportionate stratified random sampling which produced 51 samples consisting of 36 painters and 15 repairer.

The research design starts from secondary data collection related to the general description of the location, number of workers, and work schedule obtained from the chairman of the Welding and Painting Employers Association (PPLDC) Surabaya. Literature studies are carried out by studying scientific books, research reports, research journals related to xylene toxicology. Furthermore, primary data collection related to xylene content in the air was carried out by collaborating with the Prodia laboratory and UPT K3 East Java Province.

The research variables were xylen concentration, body weight, height, respiratory rate, exposure time in a day, body surface area of workers, weight of white rats, body surface of white rats, highest dose of toxin without effect on experimental animals (NOAEL), Km factor in animals (Animal Km), factor Km in society (Human Km), RfC. Data analysis in this study was carried out by using quantitative data analysis manually to determine the xylen Rfc.

Findings

A. *Characteristics and Body Surface Area of Experimental Animal*

The experimental animals used in this study were white rats (*Rattus norvegicus*). The properties of white rats are perfectly known, easy to maintain, and are relatively healthy and suitable for various studies¹⁴. In general, human response to toxicity is qualitatively similar to that of animals. This fact is the basis of extrapolation of animal data to humans¹⁵.

Table 1. Distribution of Characteristics of Experimental Animals (White Rats)

Research Object (White Rats)	W (kg)	BSA (m ²)
1	0,1405	0,024165
2	0,1405	0,024165
3	0,141	0,024223
4	0,141	0,024223
5	0,1395	0,02405
6	0,1415	0,024165
Total	0,844	0,144991
Average	0,140666667	0,024165167

Based on data from table 1, body surface area of white rats is calculated using the following formula.

$$BSA = 0,09 W^{0,67} W^{0,67}$$

Where

BSA : Body Surface Area (m²)

W : Weight (kg)

B. Characteristics, Worker's Body Surface Area and Worker's Respiratory Rate

The characteristics of workers in this study included weight and exposure time of 51 respondents who settled around the fertilizer industry. The average body weight is 62.14 kg and the average exposure time is 6.67 hours. Community height uses the average value of Indonesian adult height of 159 cm.

Based on data on body weight and height, people's body surface area and respiratory rate were calculated using the following formula.

Worker's body Surface Area

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

WHERE

BSA : Body Surface Area (m²)

W : Weight (kg)

H : Height (cm)

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

$$= \sqrt{61,42 \cdot 159 / 3600}$$

$$= \sqrt{61,42 \cdot 159 / 3600} \sqrt{57,65 \cdot 159 / 3600} = 1,65 \text{ m}^2$$

1. Workers' breathing rate

$$BR = (5,3 \ln W - 6,9) / 24$$

$$= (5,3 \ln 61,42 - 6,9) / 24 = \frac{5,3 \ln 57,65 - 6,9}{24}$$

$$= 0,62 \text{ m}^3/\text{hour}$$

Table 2. Characteristics, Body Surface Area and Respiratory Rate of Workers around the Surabaya Car Painting Area

Workers	Wb (Kg)	h (Cm)	BSA (m ²)	t (hour/day)	BR = (m ³ /hour)
1	50.1	159	1.48	6	0.57
2	50.1	159	1.48	6	0.57
3	50.1	159	1.48	6	0.57
4	50.1	159	1.48	6	0.57
5	50.1	159	1.48	6.5	0.57
6	50.1	159	1.48	6.5	0.57
7	50.1	159	1.48	6.5	0.57
8	50.1	159	1.48	6.5	0.57
9	50.1	159	1.48	6.5	0.57
10	50.1	159	1.48	6.5	0.57
11	50.1	159	1.48	6.5	0.57
12	50.1	159	1.48	6.5	0.57
13	58.7	159	1.61	6.5	0.61
14	58.7	159	1.61	6.5	0.61
15	58.7	159	1.61	6.5	0.61
And so on					
51	73.64	159	1.8034504	7	0.66
Average	62.14	159	1.65	6.67	0.62

Based on the calculation results of the average body surface area of the worker is 1.65 m² and the average respiratory rate is 0.62 m³/hour.

B. Xylene Concentration

The results of xylen concentration measurements in the car painting area showed different results at 5 workshop locations. The workshops at this location consist of open and semi-closed workshops.

Table 3. Distribution of Xylen Concentrations around Surabaya Car Painting Area

Radius	Xylene Concentration (mg/m ³)
Workshop A (Open)	137.64
Workshop B (Open)	263.46
Workshop C (Open)	286.26
Workshop D (Semi Closed)	1176.66
Workshop E (Semi Closed)	1480.59
Average	635.98

Based on the results of measurements, the xylen concentration around the car painting area was 635.98 mg/m³ (146.47 ppm) with the highest concentration of 1480.59 mg/m³ (341 ppm) and the lowest concentration of 137.64 mg/m³ (31.7 ppm).

C. Animal Km and Human Km

Determination of safe dosage of toxin for the community begins with the calculation of Animal Km and Human Km.

1. Animal Km

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

Where :

Animal Km : Km factor on human

W : Wight of Experimental Animal (white rats)

BSA : Body Surface Area of Experimental Animal (white rats)

The results of the Animal Km calculation are shown in table 4 with an average Animal Km in experimental white rats of 5.81.

Table 4. Results of Calculation of Animal Km in White Rice

Experimental Animal (White rats)	Animal Km
1	5.814209516
2	5.814209516
3	5.821029467
4	5.821029467
5	5.800520675
6	5.827833234
Averages	5.816471979

2. Human Km

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

Where

Human Km : Km factor on human

W : Workers' weight

BSA : Workers' Body Surface Area

The results of the Human Km calculation are shown in table 5 with Human Km average for workers of 37.41.

Table 5. Results of Human Km Calculation for Workers around the Surabaya Car Painting Area

Citizen	Human Km
1	33.67
2	33.67
3	33.67
4	33.67
5	33.67
6	33.67
7	33.67
8	33.67
9	33.67
10	33.67
11	33.67
12	33.67
13	36.45
14	36.45
15	36.45
dst	
51	40.83
Average	37.41

D. No Observed Adverse Effect Level (NOAEL)

One of the objectives of research activities in the field of toxicology is to evaluate the safety of a substance. The safe limit of the concentration of a chemical begins with the toxicity test for determining the highest dose without causing effects on experimental animals or No Observed Adverse Effect Level (NOAEL). Korsak et al. (1994) in U.S. The 2003 Environmental Protection Agency¹⁰ stated that NOAEL xylene is 50 ppm (mg / kg: ppm is 1: 1).

E. Reference of Concentration (RfC)

Saridewi and Tualeka (2017) ¹⁶ suggest RfC calculations using the formula from Shaw et al. (2007) ¹⁴.

$$RfC = NOAEL \frac{Animal\ Km\ Animal\ Km\ Animal\ Km}{Human\ Km\ Human\ Km\ Human\ Km}$$

where:

RfC : Reference of Concentration

Animal Km : Km factor on animal

Human Km : Km faktor on human

Results of Calculation of Reference of Concentration (RfC) obtained from NOAEL, Animal km averages, and Human Km averages are as follows.

$$RfC = NOAEL \frac{Animal\ Km\ Animal\ Km}{Human\ Km\ Human\ Km}$$

$$= 50 \frac{5,81\ 5,81\ 5,81}{37,41\ 37,41\ 35,96}$$

$$= 7,76\ mg/kg$$

Based on the results of calculations, the inhalation Reference Concentration (Rfc) for workers around car painting area of Surabaya is 7.76 mg/kg.

Discussion

Based on the measurement results, the average xylen concentration around the car painting area of Surabaya was 635.98 mg / m³ (146.47 ppm) with the highest concentration of 1480.59 mg/m³ (341 ppm) and the lowest concentration of 137.64 mg/ m³ (31.7 ppm). The value of xylem concentration is higher than the results of a study conducted by Irawati (2010)¹⁷ on shoe shop workers in the small industrial area of Jakarta with an average value of 0.05 mg / m³ with the highest concentration in the section 0.18 mg/m³. This is in line with the research conducted by Cahyana et al (2015)¹⁸ in informal car painting workers in Bandung with xylene values between 0.042 and 4.447 ppm. The significant difference in concentration between this study and other studies was caused by differences in sources of xylen exposure. For research conducted in the car painting area in Bandung, there are 3 types of workshops of open, semi-open, and closed that the results are smaller. In this study there were only 2 types of open and semi-closed workshops.

RfC in the oresent study is 7.76 mg/kg. Calculation of RfC xylene in this study is greater than that of RfC according to IRIS (2003) in US EPA 1991 of 0.03 mg/ kg. There were significant differences in RfC results because the calculations were carried out using relatively

different data on Indonesian body weight and height. In addition, the concentration of xylene in the air of the car painting area of Surabaya, Indonesia is also high. The greater the RfC, the greater the safe concentration so that it becomes less stringent and less safe for workers. Thus, control measures are still needed to reduce xylen exposure.

Control measures that can be taken are the provision of air vents (local exhaust) especially for semi-closed workshops, the use of paint containing safer organic solvents, the use of appropriate personal protective equipment in the form of half mask respirators with organic vapor cartridges to minimize xylen vapor exposure (ATSDR, 2007)¹.

Conclusion

The average xylen concentration around the car painting area of Surabaya, Indonesia is 635.98 mg/m³ (146.47 ppm). This level of concentration is above the threshold value according to Minister of Manpower and Transmigration Regulation Number 13 of 2011 and Minister of Manpower Regulation Number. 5 of 2018 is 434 mg/m³ (100 ppm). The average body weight is 62.14 kg and the average exposure time is 6.67 hours. For community height data, the researchers used the average value of Indonesian adult height of 159 cm.

The results of RfC car painting workers with NOAEL 50 mg/kg is 7.76 mg/kg.

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Ethical Clearance: The study was approved by the institutional Ethical Board of the Public Health, Airlangga University

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