Evaluation of Benzene Threshold Value in Benzene Exposed Work Environment: Case Study at Ciputat Gas Station

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Abstract

Benzene is dangerous chemical compounds from products General Fuel Filling stations (gas stations) and is one component in gasoline with 1-5% carcinogen content. The purpose of this study was to determine the limits of safe concentration for benzene in the work environment of gas stations in Ciputat. This type of research is an observational, cross-sectional and descriptive study. The population in this study were all workers at one gas station in the Ciputat region. The sampling technique is the total population, so the sample is 27 workers. The design of the study begins with the collection of secondary data related to work processes which include chemicals in the work area and the number of workers involved. Furthermore, primary data collection was carried out related to the concentration of benzene in the workplace air, length of work time, and worker weight. In addition, secondary data was collected in experimental animals, namely the weight of white mice. The type of data in this study is primary data, obtained through questionnaires and observations as well as measurements of benzene in the air of the respondent's workplace.

The measurement results of the concentration of benzene in the gas station in Ciputat in point 1 and point 2 are 0.58 mg / m3 or 0.18 ppm so that the concentration is still below the Threshold Value (TLV) according to Minister of Manpower Regulation Number 5 of 2018. Based on the manual calculation for safe limits of benzene concentration obtained 0.085 mg / m3 or 0.026 ppm. Control recommendations are to consume the CYP2E1 enzyme contained in beefliver and salmon which serves to reduce the level of benzene in the body, use the appropriate Personal Protective Equipment (PPE) in the form of half mask respirator with an organic vapor cartridge, and plant a number of ornamental plants that can absorb and reduce benzene concentrations such as Boston and Golden Photos [1].

Keywords: *Benzene, safe concentration, workers gas stations.*

Introduction

Benzene (C6H6) is an aromatic compound in the form of clear liquid at room temperature. This compound has a double bond and a saturated bond in the group with a resonating structure[2]. Benzene is one of the most applicable chemicals. Many uses of benzene are very useful for everyday life. The most important use of benzene is as a solvent and as a raw material for making other aromatic compounds which are benzene derivative compounds[3].

Benzene is widely used in the rubber industry, oil refining, shoe factories, chemical plants and other oil-related industries including age fueling stations (gas station). The General Fuel Filling Station (gas station) is a facility or place that provides and sells various types of fuel oil for all types of vehicles. According to the Agency for Toxic Substances and Disease Register (ATSDR), hazardous and toxic chemicals contained in the oil content are benzene, toluene, xylene, ethylene, TPH (Total Petroleum Hydrocarbon), and Polycyclic Aromatic Hydrocarbon (PAHs). Of the six chemicals, benzene exposure has a very serious health impact.[4]

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Individuals at risk of being exposed to benzene directly are workers at the gas station itself. Benzene exposure in gas station workers is mainly through inhalation or respiratory pathways. Gas station workers are continuously exposed to benzene because they are in the environment that emits benzene originating from the fuel pump engine when refueling, the fuel storage warehouse and the exhaust from the vehicle during the refueling queue[5].

Benzene has acute and chronic effects for exposed individuals. Acute toxic symptoms of benzene are suppression of the exposed central nervous system. While chronic and recurring chronic benzene exposure, even in low concentrations, can cause a variety of blood disorders from anemia to leukemia, a malignant disease that is irreversible and fatal. This chronic poisoning can result in non-cancerous effects and the effects of cancer[6].

In Hayat's (2012) study, the results of benzene measurements at two points in the Ciputat region gas station were 0.58 mg / m3 or 0.18 ppm. The results are still below the threshold value (TLV) of 0.5 ppm (Minister of Manpower Regulation 5 of 2018). Although the concentration of benzene in the Ciputat region gas station is below the NAV, however, gas station workers exposed to benzene will still have a carcinogenic effect. A similar study at the Pancoranmas Depok gas station by Salim (2012), benzene concentrations at these sites had yields below the TLV but the gas station workers had a risk of carcinogenic effects at the lifetime duration of exposure[4].

Saridewi and Tualeka conducted research on safe (C safe) concentrations in the gas station area[1]. The results of the study obtained a value of 0.03 as a safe concentration of benzene. Based on the research, the author will determine the limits of the safe concentration of benzene in different gas station areas, namely in the Ciputat gas station[7]. In this study also the determination of RFC was also based on the conditions of workers in the study area which included weight and height.

Material And Method

This type of research is an observational, cross-sectional and descriptive study. The population in this study were all workers at one gas station in the Ciputat region. The sampling technique is the total population, so the sample is 27 workers.

The design of the study begins with the collection of secondary data related to work processes which include chemicals in the work area and the number of workers involved. Furthermore, primary data collection was carried out related to the concentration of benzene in the workplace air, length of work time, and worker weight. In addition, secondary data was collected in experimental animals, namely the weight of white mice. The type of data in this study is primary data, obtained through questionnaires and observations as well as measurements of benzene in the air of the respondent's workplace.

The research variables were benzene concentration in the workplace, worker body weight, worker height, respiration rate of workers, length of day working, body surface area, weight of white mice, body surface of white mice, highest dose of toxin without effect on experimental animals (NOAEL), Km factor in animals (Animal Km), Km factor for workers (Human Km), safe dose limit for workers (SHD), and benzene concentration in safe air for workers (C is safe).

Data analysis in this study was carried out by using quantitative data analysis manually to determine the safe concentration of benzene for workers in the Ciputat region gas station.

Findings Experimental

A. *Characteristics of Try Animals and Surface Area of Animals (White Mice)*

Toxicity is the ability of a chemical substance or compound to cause damage when it comes to sensitive internal parts or surfaces. According to Saridewi and Tualeka, the implementation of a toxicity test using experimental animals is a white mouse[1]. In general, the human response to toxicity is qualitatively similar to that of animals, so this fact forms the basis of extrapolation from animal to human data[8].

In table 1, the characteristics of experimental animals in the form of white rat body weight are displayed.

Table 1. Distribution of Characteristics of Try Animals (White Mice)

Try Animals (White Rat)	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

Based on the data of white rat body weight, it can be calculated the body surface area of white mice using the following formula

BSA animal= $0.09\ W^{0.67}$

Description:

BSA : Body Surface Area / body surface area (m^2)

W : Weight / weight (kg)

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

The characteristics of workers in this study include body weight and working time from 27 workers in the area Ciputat regional gas station. Based on Table 2, it is known that the highest body weight of workers in the Ciputat area gas station area is 80 kg, the lowest weight is 44 kg, and the average body weight is 57.73 kg. The duration of work in a day is 8 hours. Whereas for height use the average value of Indonesian adult male height which is 159 cm.

Based on data on workers' body weight and worker height, the body surface area and the respiratory rate of workers can be calculated using the following formula.

1. The surface area of the worker body

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

Description:

BSA : Body surface area (m^2)

W : Weight (kg)

h : Height (cm)

2. Worker's respiratory rate

BR = 5.3 ln - 6.9 / 24

Description:

BR : Breathing rate (m^3/ hour)

W : Weight (kg)

Table 2. Distribution of Characteristics of Characteristics of Workers, Employee Respiratory Rate and Length of Working Time at Ciputat Regional Gas Station

Worker	W (kg)	H (cm)	BSA (m2)	BR (m3/ hour)	t (hour / day)
1	45	159	1.41	0.55	8
2	80	159	1.88	0.68	8
3	44	159	1.39	0.55	8
4	60	159	1.63	0.62	8
5	70	159	1.76	0.65	8
6	71	159	1.77	0.65	8
7	60	159	1.63	0.62	8
8	50	159	1.49	0.58	8
9	70	159	1.76	0.65	8
10	49	159	1.47	0.57	8
11	70	159	1.76	0.65	8
12	50	159	1.49	0.58	8
13	64	159	1.68	0.63	8
14	60	159	1.63	0.62	8
15	67	159	1.72	0.64	8
16	48	159	1.46	0.57	8
17	54	159	1.54	0.59	8
18	50	159	1.49	0.58	8
19	63	159	1.67	0.63	8
20	70	159	1.76	0.65	8
21	55	159	1.56	0.60	8
22	74	159	1.81	0.66	8
23	65	159	1.69	0.63	8
24	57	159	1.59	0.61	8
25	55	159	1.56	0,60	8
26	47	159	1.44	0.56	8
27	69	159	1.75	0.65	8
Average	59.89	159	1.62	0.61	8

The results of the analysis of the calculation of body surface area and worker respiratory rate according to table 2 shows that the average body surface area of workers is 1.62 m^2 and the average respiration rate of workers is 0.61 $m^{3/}$ hour.

C. *Benzene Concentration*

The results of the measurement of benzene concentration at both points in the Ciputat region gas station showed the same results, namely 0.58 mg / m^3 (0.18 ppm)

Table 3. Distribution of Benzene Concentration in Ciputat Regional Gas Station

Benzene Concentration (ppm)	Location Measurement of
0.18	Point 1
0.18	Point 2

Based on the results of measurements carried out, the concentration of benzene in the working environment of the Ciputat gas station is 0.58 mg / m^3 or 0.18 ppm. This benzene concentration is below the threshold value of 0.5 ppm in accordance with the provisions of the Minister of Manpower Regulation Number 5 of 2018 concerning Occupational Safety and Health at the Work Environment. However, the concentration of benzene is above the Minimum Risk Level (MRL), the level of benzene inhalation exposure determined by ATSDR, ie for acute exposure (≤14 days) = 0.009 ppm, moderate exposure (15-364 days) = 0.006 ppm, and chronic exposure (≥365 days)= 0.003 ppm.

D. *Animal Km and Human Km*

The first step to determine the safe dosage of toxin for workers is by calculating *Animal Km* and *Human Km.*

1. *Animal Km*

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

Description:

Animal Km: Km factor in animals

W: Experimental animal weight (white mouse)

BSA: Body Surface Area of experimental animals (White mice)

The results of the calculation of *Animal Km are* shown in table 4. The average *Animal Km* in animal experiments is white rats which are 5.81.

Table 4. Results of Calculation of Animal Km in Try Animals (White Mice)

Try Animals (White Mice)	Animal Km
1	5,81420952
2	5,81420952
3	5,82102947
4	5,82102947
5	5,80052067
6	5,81420952
Average	5, 81

2. *Human Human Km*

$$K\ m = \frac{W\ human}{BSA\ human}$$

Description:

Human Km: Km factor in human/worker

W: worker weight

BSA: Body Surface Area worker

The results of the calculation are *Human Km* shown in table 5. Based on table 5, the Human average Km for Ciputat region gas station workers is 36.70.

Table 5. Calculation Results Human Km in petrol stations Workers Ciputat Region

Workers	Human KM
1	31,92
2	42,56
3	31,56
4	36,86
5	39,81
6	40,09
7	36,86
8	33,65
9	39,81
10	33,31
11	39,81
12	33,65
13	38,07
14	36,86
15	38,95
16	32,97
17	34,97
18	33,65
19	37,77
20	39,81
21	35,29
22	40,93
23	38,36
24	35,92
25	35,29
26	32,62
27	39,52
average	36.70

E. NOAEL

one objective of the research activities in the field of toxicology is to be able to evaluate the safety of a substance. To determine the safe limit of the concentration of a chemical begins with the toxicity test determining the highest dose without causing effects on experimental animals or *No Observed Adverse Effect Level (NOAEL).*

The results of the research by Swaen et al. (2010) state that benzene NOAEL is 3.0 mg / m^3 or equivalent to 0.022 mg/kg which is allowed from the calculation of formulas as follows.

$$NOAEL\ benzene = \frac{3\ x\ 0{,}00013\ x\ 8}{0{,}1405}$$

$$= 0.022\ \text{mg / kg}$$

F.

F. Safe Human Dose

$$SHD = NOAEL \frac{W\ human}{BSA\ human}$$

Based on this formula, the calculation of SHD obtained from the NOAEL value, the average animal Km, and the average human Km is:

$$SHD = 0.022 \frac{data 59.89}{36.7} = 0.003\ mg/\ kg$$

G. Limit Safe Benzene Concentration

Determination of safe limits of benzene concentration in the working environment of Ciputat region gas stations using formulas (William, 1985; Soemirat, 2003; Davis, 1991) the following.

$$C\ safe = \frac{(SHD)\ (W)}{(\delta)\ (BR)\ (t)}\ mg\ /m^3$$

To convert units of mg / m^3 to ppm the following formula is used.

$$C\ safe = \frac{\#mg\ /m^3}{(MW)}\ x\ 24.5\ ppm$$

Description:

C is safe: concentration of toxin in the air is safe for workers (mg / m^3)

SHD: Safe Human Dose (mg/kg)

W: Weight (kg)

δ: % of substances absorbed by the lung

BR: Human respiratory rate (m^3/ hour)

t: Duration of working time (hours)

MW: Molecular Weight / Molecular Weight

Based on the above formula, the results of calculating the safe concentration of benzene in the gas station in Ciputat region obtained from the value of SHD, average body weight, a percentage of substance absorption, average respiration rate of workers and the average length of work time are:

$$C\ safe = \frac{(0.003)\ (59.89)}{(50\%)\ (0,61)\ (8)}$$

$$= 0.085\ \text{mg / m}^3$$

$$Csafe = \frac{0.085\ x\ 24.45}{78.11}$$

$$= 0.026\ \text{ppm}$$

The results of calculating safe limits in the air for workers above can be used to predict the concentration of toxins in the air a safe work environment for workers if

there is no determination of the Threshold Value (William, 1985 in Tualeka, 2013), and for comparison with NAV which has been determined by various institutions both by the Ministry of Manpower and Transmigration, the National Standardization Agency, ACGIH, NIOSH and OSHA.

Conclusion

The results of measuring the concentration of benzene in the gas station in Ciputat in point 1 and point 2 were 0.58 mg/m^3 or 0.18 ppm so that the concentration was still below the Threshold Value according to Minister of Manpower Regulation Number 5 of 2018. Based on manual calculations for safe limits benzene concentration is obtained 0.085 mg / m^3 or 0.026 ppm.

TLV evaluation is a comparison of the results of the above calculation with TLV Benzene. According to Minister of Manpower and Transmigration Regulation Number 5 the Year 2018 which is 0.5 ppm. Based on manual calculations, safe limits benzene concentration in Ciputat gas station was bellow the TLV. So that the benzene threshold value is not feasible and needs to be revised.

Control recommendations are to consume the CYP2E1 enzyme contained in beef liver and salmon which serves to reduce the level of benzene in the body, use the appropriate Personal Protective Equipment (PPE) in the form of half mask respirator with an organic vapor cartridge, and plant a number of ornamental plants that can absorb and reduce benzene concentrations such as Boston and Golden Phothos[1].

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

Source of Funding: The source of this research costs from self.

Ethical Clearance: This research was approved by the Institutional Ethics Board of Airlangga Surabaya University. All subjects received complete information about the procedure and purpose of this study, each subject before the study signed an informed consent form.

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