Safe Concentration of Benzene Exposure to Worker's in Gas Station at the Area of Diponegoro University, Semarang

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Abstract

Benzene is one of the aromatic hydrocarbon compounds that are widely used in the industrial sector. Benzene exposure in the work environment has been set a threshold value. Benzene exposure in humans can provide health effects especially disrupting the central nervous system, hematopoietic system, and immune system. Acute effects can include laryngeal irritation, dizziness, pallor, shortness of breath, headache, fatigue, drowsiness, and fainting. While the chronic effects can be cancer.

This research is a study with an environmental health risk analysis approach with the aim to assess and make predictions that will occur due to exposure to benzene in public fuel station (SPBU) officers around the area of Diponegoro University, Semarang. The Environmental Health Risk Analysis (ARKL) approach consists of several steps, namely hazard identification, response dose analysis, exposure analysis, and risk characteristics.

The results of the measurement of benzene concentrations in gas stations around the Diponegoro University in Semarang at point 1 were 0.38 ppm and at point 2 was 0.51 ppm. So that the concentration is still below the Threshold Value (NAB) according to the Minister of Manpower Regulation Number 5 of 2018. Based on manual calculations for safe limits benzene concentration is obtained 0.08538 mg / m3 or 0.02672 ppm. This means that the highest concentration of benzene in the work environment is 0.51 ppm, with an average body weight of 55.67 kg, height of 159 cm with a working time of 8 hours, and safe concentration so as not to cause a non-carcinogenic risk is 0.08538 mg / m3 or 0.02672 ppm.

Keyword: *Benzene, Safe Concentration, Gas Station*

Introduction

Besides being used in industry, benzene is found to be widely available in our daily lives. Benzene is produced by distillation of coal or crude oil. This material is used as one of the raw materials in the production of many aromatic compounds such as styrene, phenol, cyclohexane, and nitrobenzen, also in drugs, pesticides, and detergents. Sometimes benzene is also used as an extraction solvent. This material can also be found in solvents for wax, resin, rubber, plastics, film, and glue paint. In recent years the use of solvents has been restricted or banned in many countries due to its toxicity. Benzene is present in gasoline (petroleum), toluene and xylene in impure form.[1]

Around 1990 benzene was used as an indicator of exposure to gasoline fuel, especially for workers at gas stations. The volume of benzene in gasoline fuels ranges from 2 - 6% in the Nordic country. The allowed working time is 8 hours a day, the gas station staff in the Nordic are exposed to benzene around 0.5-1 mg / m3. Exposure to gasoline vapor at gas stations, especially when refueling gasoline into the car tank. Filling 30 liters containing 5% volume of benzene into the car, there is around 700 mg of benzene inhaled. The total concentration of hydrocarbons in the air during the

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process of refueling gasoline is 10 to 100 times benzene. Gas station staff can also be exposed to vehicle gas emissions, including polycyclic aromatic hydrocarbons, aldehydes, and 1,3-butadiene.[2]

According to WHO, one of the sources of benzene in ambient air comes from benzene evaporation in fueling stations. Benzene concentrations in ambient air are estimated to be inhaled and exposed to fuel station workers of 0.12 ppm. Benzene exposure in humans can provide health effects especially disrupting the central nervous system, hematopoietic system, and immune system. Acute effects can include laryngeal irritation, dizziness, pallor, shortness of breath, headache, fatigue, drowsiness, and fainting. While the chronic effects can be cancer.[3]

According to the Agency for Toxic Substances and Disease Register (ATSDR), hazardous and toxic chemicals contained in 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 impact on health.[3]

Population growth in the city of Semarang has increased in accordance with data from the Central Statistics Agency (BPS) in 2013 of 1,672,999 people. This was also due to population growth in each sub-district in Semarang City, especially Tembalang and Banyumanik Districts. Where the two sub-districts are several universities, one of which is Diponegoro University. This made the attraction of migrants from various regions to come to the two sub-districts. As in the 2013 Central Bureau of Statistics (BPS) data, the population in Tembalang and Banyumanik Subdistricts was 147,564 people and 130,494 inhabitants.[4]

Every day the gas station around the area of Diponegoro University fills 24,000 liters of fuel. The fuel in the Gas Station causes a strong odor that can be inhaled and entered into the human body, one of them is a gas station officer who maintains fuel installations. The smell of these fuels contains benzene organic compounds. 5 Other studies show that the results of benzene exposure in the air to the refueling station staff are 0.23 ppm or 0.73 mg / m3.[6]

Benzene exposure in the work environment has been set a threshold value. In Indonesia the AMbang Limit (NAV) of benzene is 0.5 ppm. Use the Regulation of the Minister of Manpower and Transmigration number PER / 13 / MEN / X / 2011 concerning the Physical and Chemical Factor Threshold Values in the workplace and according to NIOSH, the threshold value of benzene is 0.1 ppm.[7]

Fuel oil is a mixture of more than 500 volatile hydrocarbon compounds and benzene is a hydrocarbon compound which is a major concern in studies that explain health problems due to bensi exposure 8. The population of workers who work in industries that produce or use benzene can be exposed to the highest exposure levels .9 ATSDR (2007) states that the main exposure route occurs through inhalation, although dermal exposure and oral exposure may also occur.[3]

Material and Method

This research is a research with an environmental health risk analysis approach with the aim of assessing and making predictions that will occur due to benzene exposure in gas station officers around the Diponegoro University Semarang area. The Environmental Health Risk Analysis (ARKL) approach consists of several steps, namely hazard identification, response dose analysis, exposure analysis, and risk characteristics.

The population of this study were all officers at four gas stations around the area of Diponegoro University. The number of officers at the four gas station around the Diponegoro University area is 78 people and the study sample was calculated using the Slovin formula.

The sampling technique used purposive sampling based on certain considerations made by researchers with the inclusion criteria was officers who had direct contact with benzene sources, male and / or female, worked on the morning and afternoon shifts and worked ≥ 1 year. Measurement of benzene concentrations in ambient air that is inhaled directly by gas station officers using a personal dust sampler and coconut shell charcoal. Secondary data consists of workplace administrative data, such as number of workers, length of service, type of fuel, work shift schedule. Study of intake calculations, non carcinogenic, carcinogenic, dose response values, and technical methods of Environmental Health Risk Analysis (ARKL).

Findings

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

The characteristics of the workers in this study included the body weight and working time of 27 workers

in the Ciputat area gas station area. Based on Table 1, 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 worker weight and height of workers, the body surface area and the rate of respiration of workers can be calculated using the following formula.

1. **The surface area of the worker's body**

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

Information :

BSA: Body surface area / body surface area (m2)

W: Weight / weight (kg)

h: Height / Height (cm)

2. **Worker breathing rate:**

= 5,3 ln – 6,9 / 24

Description:

BR: Breathing rate (m3 / hour)

W: Weight / Weight (kg)

Table 1. Distribution of Characteristics of Characteristics of Workers, Employee Respiratory Rate and Length of Time Working at Gas Station Around Diponegoro University Semarang Area

Worker	W (kg)	H (cm)	BSA (m2)	BR (m3/hour)	t (hour/day)
1	40	159	1,32916	0,52713	8
2	43	159	1,3781	0,5431	8
3	44	159	1,39403	0,54818	8
4	52	159	1,51548	0,58507	8
5	46	159	1,42537	0,55799	8
6	47	159	1,44078	0,56274	8
7	49	159	1,47111	0,57194	8
8	44	159	1,39403	0,54818	8
9	47	159	1,44078	0,56274	8
10	49	159	1,47111	0,57194	8
11	50	159	1,48605	0,57641	8
12	45	159	1,40979	0,55314	8
13	54	159	1,54434	0,5934	8
14	58	159	1,60052	0,60918	8
15	59	159	1,61426	0,61296	8
16	60	159	1,62788	0,61667	8
17	65	159	1,69435	0,63434	8
18	62	159	1,65479	0,62391	8
19	70	159	1,75831	0,65071	8

Cont... **Table 1. Distribution of Characteristics of Characteristics of Workers, Employee Respiratory Rate and Length of Time Working at Gas Station Around Diponegoro University Semarang Area**

20	72	159	1,78326	0,65693	8
21	68	159	1,73301	0,64431	8
22	75	159	1,82003	0,66595	8
23	64	159	1,68127	0,63092	8
24	66	159	1,70734	0,63772	8
25	55	159	1,55858	0,59745	8
26	57	159	1,58666	0,60534	8
27	58	159	1,60052	0,60918	8
28	60	159	1,62788	0,61667	8
average	55,67	159	1,56	0,59	8

The results of the analysis of the calculation of body surface area and worker respiratory rate according to table 1 show that the average body surface area of workers is 1.56 m2 and the average respiration rate of workers is 0.59 m3 / hour.

B. **Benzene Concentration**

The results of the measurement of benzene concentration at both points in the Ciputat region gas station environment showed the same results, which was equal to 0.58 mg / m3 (0.18 ppm).

Table 2. Distribution of Benzene Concentration in Gas Station Around the Area of Diponegoro University, Semarang

Measurement Location	**Benzene Concentrartion (ppm)**
Location 1	0,38
Location 2	0,51
Average	0,44

Based on the results of measurements made, the concentration of benzene in the work environment at the gas stations around the Diponegoro University Semarang area is 0.44 ppm. This benzene concentration is below the threshold value (NAB) 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 benzene concentration was above the Minimum Risk Level (MRL), the level of exposure to inhalation benzene determined by ATSDR, namely for acute exposure (≤14 days) = 0.009 ppm, moderate exposure (15-364 days) = 0.006 ppm, and chronic exposure (≥365 days) = 0.003 ppm.

C. **Calculation of Human Km**

The results of the Human Km calculation are shown in table 3. Based on table 3, the average Human Km at the Gas Station Around the Area of Diponegoro University Semarang is 35.37.

Table 3. Results of Human Km Calculation for Workers at Gas Station Around the Area of Diponegoro University Semarang

Worker	Human KM
1	30,0942
2	31,2023
3	31,5631
4	34,3127
5	32,2724
6	32,6213
7	33,3082
8	31,5631
9	32,6213
10	33,3082
11	33,6463
12	31,9197
13	34,9663
14	36,2382
15	36,5493
16	36,8577
17	38,3627
18	37,467
19	39,8109
20	40,3756
21	39,238
22	41,2082
23	38,0665
24	38,6567
25	35,2886
26	35,9244
27	36,2382
28	36,8577
Average	35,3764

D. **Noael**

One of the objectives of 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)

Swaen et al. (2010) 's research states that NOAEL benzene is 3.0 mg / m3 or equivalent to 0.022 mg / kg which is permitted from the calculation of formulations as follows.[10]

$$NOAEL\ benzene = \frac{3\ x\ 0{,}00013\ x\ 8}{0{,}1405}$$
$$= 0{,}022\ \text{mg/kg}$$

E. *Safe Human Dose*

$$SHD = NOAEL \frac{W\ human}{Human\ km}$$

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

F. **Limits on Safe Benzene Concentration**

Determining the safe limits of benzene concentration in gas stations around the area of Diponegoro University in Semarang uses the following formula (Soemirat, 2003).[11]

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

To convert units of mg / m3 to ppm the following formula is used.

$$C\ safe = \frac{\#\ mg/m^3}{(MW)}\ x\ 24{,}5\ ppm$$

Information :

C safe : concentration of toxin in the air that is safe for workers (mg / m3)
SHD : Safe Human Dose (mg/kg)
W : Weight (kg)
δ : % of substances absorbed by the lungs
BR : Human respiratory rate (m3 / hour)
t : Working time (hours)
MW : Molecular Weight

Based on the above formula, the results of calculating the safe concentration of benzene at the Around Regional Gas Station in Diponegoro University Semarang were obtained from the SHD value, average worker weight, percentage of substance absorption, average respiration rate of workers and average length of work time:

$$C\ safe = \frac{(0{,}00362)(55{,}67)}{(50\%)(0{,}59)(8)}$$
$$= 0{,}08538\ mg/m^3$$

$$C\ safe = \frac{0{,}08538\ x\ 24{,}45}{78{,}11}$$
$$= 0{,}02672\ ppm$$

The results of calculating safe limits in the air for upper workers can be used to predict toxins in the air in a safe work environment for workers if there is no determination of the Threshold value (William, 1985 in Tualeka, 2013)[12], and to compare with the NAV that has Defined by various institutions both by the Ministry of Manpower and Transmigration, the National Standardization Agency, ACGIH, NIOSH and OSHA.

Conclusion

The results of the measurement of benzene concentrations in gas stations around the area of Diponegoro University in Semarang at point 1 were 0.38 ppm and at point 2 was 0.51 ppm. So that the concentration is still below the Threshold Value (NAB) according to the Minister of Manpower Regulation Number 5 of 2018. Based on manual calculations for safe limits benzene concentration is obtained 0.08538 mg / m3 or 0.02672 ppm.

This means that the highest concentration of benzene in the work environment is 0.51 ppm, with an average body weight of 55.67 kg, height of 159 cm with a working time of 8 hours, and safe concentration so as not to cause non-carcinogenic risk is 0.08538 mg / m3 or 0.02672 ppm.

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