The Correlation Between Green Open Space with Carcinogen Toxicity Score of Benzene in Shoes Home Industry Surabaya

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ABSTRACT

Benzene is a carcinogenic substance that can be found as chemical compounds in shoes-making industries that use glue as a raw material. The objectives of this research were to identify the presence of Green Open Space (GOS), GOS requirement, benzene concentration in work environment, carcinogen toxicity score of benzene, and to analyze the correlation of GOS with carcinogen toxicity score of benzene. This research was an observational research, cross-sectional analysis with the sample of 10 people determined by purposive sampling technique. The data analysis was using cross tabulation and statistic prevalence risk (PR) method to find out the correlation of the presence of GOS with carcinogen toxicity score of benzene.

The results showed that most respondents (70%) did not have green open space. Analysis of Green Open Space requirement calculation for 10 respondents in 10 work locations got the value of private GOS requirement of 104.8 m^2. There was a 10% sampling point with a benzene concentration (2.91 mg/m^3) that exceeds the threshold value (1.6 mg/m^3). The carcinogen toxicity score of benzene differed in each workplace where the highest was in the 9^{th} location with the value of 0.160. There was a correlation between the presence of Green Open Space and carcinogen toxicity score of benzene (PR>1) in which workplaces without a GOS at risk of 1.555 times had a higher carcinogenic toxicity score compared to sites with Green Open Space. Suggestion as an alternative of GOS presence at the workplace was by planting ornamental plants in hanging pots such as Spider plant, Boston fern, Peace lily, Dutch betel, and Golden pothos that was effective in reducing benzene contaminants. In addition, it was suggested to consume foods with CYP2E1 enzymes contained in beef liver and salmon to decrease benzene levels in the body.

Keywords: *Benzene, Carcinogen Toxicity Score, Green Open Space, GOS Requirement*

INTRODUCTION

Benzene is a carcinogenic substance and one of the most widely used chemical compounds in the industry as a solvent, raw material or intermediate material in the manufacture of chemical compounds. Benzene exposure sources may come from vapors of benzene-containing products such as glue that used in shoes-manufacturing[1].

A research conducted in China showed that 65% of shoes-making facilities had benzene concentrations that were still above OEL (40 mg/m^3)[2]. Benzene is a carcinogenic compound to humans through inhalational exposure associated with an increased incidence of myeloblastic leukemia and lymphoid leukemia among workers[3]. Leukemia incidence was found in Turkish shoemakers at 13/100.000 which was larger than the general population level of 6/100.000[4].

While in Indonesia, the growing of shoes industry can not be separated from the use of glue in the production process where organic solvents have been found in the glue form of benzene (1-2%) to glue the shoe soles. The research on informal shoemaker in Ciomas showed that the average of benzene vapor level (1.40 ppm) exceeding TLV (0.5 ppm) with the effect of irritated respiratory disturbance that derived from the use of glue[5]. Other research conducted at Tambak Oso Wilangun Surabaya showed that there was a correlation

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between working hours and urine tt-MA levels due to benzene exposure, the average of benzene exposure was 0.5111 derived from the used of glue[6].

Based on some research mentioned above, it is understandable that exposure to benzene can cause various health risks. In the activities, the shoemaker in shoes home industry Surabaya is very vulnerable to benzene exposure from the organic solvent in glue which a major source of exposure that can affect environmental quality and health problems. To determine the extent of the carcinogenic effects caused by benzene exposure, it is necessary to identify hazards at an early stage including the determination of carcinogen toxicity scores of benzene[7]. Pollution caused by benzene exposure could be minimized by implementing the Green Open Space (GOS) at work environment. Cultivation of certain tree species was considered appropriate to grow and effective for reducing air pollution[8]. Based on Indonesian Law Number 26 Year 2007 on Spatial Planning, there must be at least 10% of private GOS provided from the total area[9].

This research aims to identify the presence of Green Open Space, GOS requirement, benzene concentration in the worksite, carcinogen toxicity score of benzene and to analyze the correlation between GOS with carcinogen toxicity score of benzene.

MATERIAL AND METHOD

This research was an observational research, cross-sectional analytical which was done in shoes home industry Romokalisari Surabaya with the sample of 10 people determined by purposive sampling technique. The variables in this study include the presence of Green Open Space, the requirement of GOS, benzene concentration, and carcinogen toxicity score of benzene. The data was analyzed by cross-tabulation and prevalence risk (PR) statistic method to find out the correlation of the presence of Green Open Space with carcinogen toxicity score of benzene. Data collection included primary data and secondary data. Primary data were obtained through questionnaires and interviews on the presence of Green Open Space. In addition, observation and measurement of benzene concentrations in the work environment were observed. While the secondary data obtained from the results of previous research. The method of measuring benzene concentration in the working environment was using NIOSH 1501 method with Gas Chromatography (GC) technique[6,10].

FINDINGS

Green Open Space: Green Open Space (GOS) is a type of open space that filled with plants which are ecologically useful in decreasing pollution levels. Based on observations at the workplace, most respondents (70%) did not have GOS.

The results of research on the requirement of GOS showed that 90% of respondents did not know the need for plants at workplaces. Based on the social aspect, 70% of respondents agreed that the plant serves a purpose to control the risk of pollution at workplaces. Based on the economic aspect, 60% of respondents stated that the cost incurred for plants in the workplace was affordable.

Based on human oxygen demand and oxygen demand at the workplace (as a benzene contaminating unit), the GOS requirement analysis can be calculated using the following formula[11] :

1. **Human Oxygen Demand**

   $X = P \times 4420.8$ liter/day/person $\times$ 1.2 kg/m3

Descriptions:

X: the amount of oxygen demand (ton/day)

P: population

4420.8: average of oxygen suction capacity in humans per day

1.2: average of constant air, 1 m air yields 1.2 kg/m_3

The oxygen requirement for 10 respondents in this study was 53049,6 ton/day.

2. The need for oxygen in the workplace as a benzene contaminating unit can be calculated using the following formula:

   $Z = 0.014 \times$ number of benzene pollutant units

   The need for oxygen of respondents in the workplace as a benzene contaminating unit was 0,14 ton/day.

3. Green Open Space requirement can be calculated using the following formula:

$$L = \frac{(X+Z)}{(54)(0.9375)}$$

Descriptions:

L : the required green open space area (m_2)

X : human oxygen demand (ton/day)

Z : workplace oxygen requirements (ton/day)

54 : a constant that suggests that every 1 m_2 of plants per day can produce 54 grams of dry matter

0.9375 : a constant value indicating that 1 gram of dry matter can produce 0.9375 oxygen.

Green Open Space requirement based on oxygen requirement of 10 respondents and oxygen demand of 10 working sites of benzene contaminating units was 1048 m_2.

The ownership status of Green Open Space was divided into public green open spaces and private green open spaces. Private GOS is a green open space that privately planted on private land[11]. The requirement for GOS based on Indonesian Law Number 26 in 2007 about Spatial Planning, private GOS is provided at least 10% of the total area. After analyzed the calculation of GOS requirement for 10 respondents in 10 work locations, the value of private GOS requirement was 104.8 m_2 that covered 10% of the sample area. Meanwhile, in the reality, most respondents did not have Green Open Space that caused the distance between the workplaces with one another was too close, so there was no land that could be planted to be utilized as Green Open Space.

BenzeneConcentration: Theenvironmentalmeasurement was performed to determine the concentration of benzene exposure in the work environment. In this case, the measurement was done at 10 sampling sites. The results of the benzene concentration measurement can be seen in Table 1 below:

Table 1: Distribution of Benzene Concentration at Shoes Home Industry Surabaya

Benzene Concentration (TLV = 1.6 mg/m_3)	N	%
≤ 1.6 mg/m_3	9	90
> 1.6 mg/m_3	1	10
Total	10	100

The results of the study showed that the concentration of benzene in the work environment showed different results for each location of measurement. This was due to the variation and number of products produced in the workplace. The more shoe was produced, the more of benzene concentration was in the workplace. This was influenced by the increased use of glue as an adhesive. In this case, there was approximately 10% of sites had been measured benzene concentration above the threshold (0.5 ppm or equivalent to 1.6 mg/m_3) specified in Indonesian Regulation of the Minister of Manpower and Transmigration No. PER.13/MEN/X/2011 about the Threshold Value of Physical Factors and Chemical Factors in the Workplace[12]. Although most concentrations were still below the TLV, there would be damage of chronic effects to the blood clotting system that could caused bone marrow damage in a long time [13].

Carcinogen Toxicity Score of Benzene: The carcinogen toxicity score of benzene obtained by calculating the maximum concentration value (C_{max}) was 2.91 mg/m_3 and the value of Cancer Slope Factor (CSF) which in this study CSF taken from US-EPA value was 0.055 mg/kg.day[14] . The toxicity score formula for carcinogens can be calculated using the following formula[7] :

Toxicicity Score (TS) = Cmax × CSF

The value of carcinogen toxicity score of benzene at work location of shoemaker Romokalisari Surabaya was 0.160.

While the carcinogen toxicity score of benzene in each work location can be seen in Table 2 below :

Table 2: Carcinogen Toxicity Score of Benzene in Shoes Home Industry Surabaya

Location	C_{max} (mg/m_3)	CSF (mg/kg.day)	TS
1st Location	1.12	0.055	0.062
2nd Location	1.12	0.055	0.062
3rd Location	0.06	0.055	0.003
4th Location	0.06	0.055	0.003
5th Location	1.27	0.055	0.070
6th Location	1.27	0.055	0.070
7th Location	1.27	0.055	0.070
8th Location	1.27	0.055	0.070
9th Location	2.91	0.055	0.160
10th Location	0.04	0.055	0.002

Table 2 showed that the different carcinogen toxicity scores of benzene at each workplace were affected by the maximum benzene concentrations in every site. The highest carcinogen toxicity score of benzene at the 9th location was 0.160.

The determination of a toxicity score is one part of the hazard identification stage in the workplace. Determination of toxicity scores include determination of scores for carcinogenic and non-carcinogenic toxin levels.

The results showed that the carcinogen toxicity score of benzene was different for each location, which was influenced by the value of benzene concentrations in the work environment. The higher the benzene concentration in work environment, the higher the toxicity score. Toxicity scores indicate the toxic level of a toxin to bring health effects to the body, both non-carcinogenic and carcinogenic effects. Based on toxin exposure score, there would be some influence on the worker's health. This was in line with other studies that there was no safe lower threshold for exposure to benzene chemicals to obtain leukemia risk at all exposure levels[15].

Correlation Between The Presence of Green Open Space with Carcinogen Toxicity Score of Benzene: The basic assessment in benefiting from GOS was based on pollutant levels that related to carcinogen toxicity score of benzene in the workplace. The relationship between carcinogen toxicity scores of benzene with GOS described in cross-tabulation below:

Tabel 3: Correlation Between The Presence of Green Open Space With Carcinogen Toxicity Score of Benzene

Green Open Space (GOS)	Carcinogen Toxicity Score (TS)		Total	Prevalence Risk (95% CI)
	≤ 0.066	> 0.066		
Yes	2 (20%)	1 (10%)	3 (30%)	1.555
No	3 (30%)	4 (40%)	7 (70%)	
Total	5 (50%)	5 (50%)	10 (100%)	

Based on Table 3, respondents who did not have Green Open Space (40%) had high carcinogen toxicity scores (>0.066). From the calculation by using statistic *Prevalence Risk* (PR) method, the PR value was 1.555 (PR> 1). It could be seen that there was a correlation between the presence of GOS with carcinogen toxicity score of benzene. The locations with no GOS were at risk 1,555 times had high carcinogen toxicity score (>0.066) compared to locations with GOS. This showed that respondents who had a GOS, toxicity score of carcinogen exposed tend to be low. This showed that Green Open Space had proven to be effective as a toxin control system in benzene that exposed to shoemaker. This result was in accordance with the theory of the ecological function and direct benefits of GOS ecology that was reducing the level of pollution[11]. It was also supported by other research about how changes in the pattern of green space areas had a great influence on air pollution and microclimate patterns[16].

CONCLUSION

Most of the respondents (70%) did not have green space. The value of private GOS requirement was 104.8 m_2. Measurement of benzene concentration exceeded the threshold value (>1.6 mg/m_3). there was a correlation between the presence of GOS with carcinogen toxicity score of benzene. The locations with no GOS were at risk 1.555 times had high carcinogen toxicity score (>0.066) compared to locations with GOS.

Suggestion as an alternative of GOS presence at the workplace was by planting ornamental plants in hanging pots such as Spider plant, Boston fern, Peace lily, Dutch betel, and Golden pothos that was effective in reducing benzene contaminants. In addition, it was suggested to consume foods with CYP2E1 enzymes contained in beef liver and salmon to decrease benzene levels in the body[17].

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