

Relationship between the Safe Benzene Concentration with Blood Profile of Printing X Surabaya Workers

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Abstract

Introduction : Benzene is a volatile compound and widely uses as a solvent. In its work process, printing industry used materials containing benzene. One of the target organs of benzene exposure is bone marrow. Therefore, the effect of benzene exposure is damage to the blood formation system.

Methods : This research was an observational study with a quantitative approach and cross-sectional design. Subjects used 11 workers population of printing X Surabaya. All variables were analyzed by using rank spearman correlation.

Result: The test results showed that most of the levels of benzene exposure exceeded the determined Limit Value. A total of 6 (64%) workers worked ≥ 10 years. The test results revealed significant benzene exposure with changes in HCT and MCHC values. The average safe concentration of benzene is 0.01868. The results of safe C testing with blood profile showed that significant for safe C Benzene with red blood cells RBC and HCT ($p < 0,05$).

Conclusion : The results of the calculation of safe C benzene and blood profile of workers showed a significant relationship between safe C and RBC and HCT. There was no significant relationship in WBC, HGB, MCV, MCH, MCHC.

Keyword : Safe concentrations of benzene, blood profile, white blood cells, red blood cells, hemoglobin, HCT, MCV, MCH, MCHC

Introduction

Industries are developing in Indonesia, especially non-formal area. Each industrial sector has certain potential hazards and risks. A potential hazard is

something that has the potential for an incident to result in a loss. Risk is the combination and consequences of a dangerous event and the likelihood of it occurring. Potential hazards can include chemical, biological, physical, ergonomic and psychological factors¹. One of the informal industries that can have potential chemical hazards and risks is the printing sector. Printing is an industrial process of transferring text or images on paper or other objects and producing them in bulk using ink and through a printing machine. One of the ingredients used is volatile organic compounds

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or Volatile Organic Compounds (VOCs) usually used as solvents. The material that is often used in general is benzene. The printing industry has the potential to cause benzene exposure to workers, especially in production units that make direct contact with benzene during the work process. Benzene exposure to the industrial sector can be easily assessed if the amount of materials used and work environment are well defined. The general sector or general population is more difficult to measure because it is influenced by the lifestyle of each individual and varies greatly and the weather conditions around and the environment of residence differ so that it can affect exposure².

Benzene is a toxic air pollutant. The Environmental Protection Agency (EPA) and the International Agency for Research on Cancer (IARC) have classified benzene in the Group A category, which is a chemical that is proven to be carcinogenic to humans³. Benzene - also known as benzol - is a colorless liquid with a sweet odor. Benzene easily evaporates in air very quickly and is slightly soluble in water⁴. The benzene threshold value (TLV) at work is 0.5 ppm for 8 hours per day or 40 hours per week⁵. According to Permenaker Number 05 of 2018 concerning Occupational Safety and Health at Work Environment, the threshold value for benzene is 0.5 ppm. One of the target organs of benzene exposure is bone marrow. The effect of chronic benzene exposure is damage to the blood formation system, in the form of latent and irreversible bone marrow damage⁶. In the book *Encyclopaedia of Occupational Health and Safety*⁷, benzene exposure has been linked to aplastic anemia, which is often a fatal disorder. The occurrence of death is usually caused by infection due to a reduction in the number of white blood cells, leukopenia, thus disrupting the body's defense system, or by bleeding due to a reduction in the number of platelets the body needs for normal clotting.

According to research conducted by Nikmah³,

there is a significant relationship between benzene exposure and Mean Corpuscular Volume (MCV) of workers in the printing industry X City of Semarang. There was no significant relationship between benzene exposure with hemoglobin, erythrocytes, leukocytes, platelets, hematocrit, Mean Corpuscular Hemoglobin (MCH), and Mean Corpuscular Hemoglobin Concentration (MCHC) in workers in the Semarang X printing industry. According to research conducted by Tinelli Haen⁸, the chi-square test conducted on the concentration of benzene exposure with blood profile and showed that there was a significant relationship between the concentration of benzene and the amount of hemoglobin, erythrocytes and eosinophils.

Methods

The study was conducted in the Production Room, in printing industry X Surabaya. The study was conducted in October 2019 and already has a certificate of ethics test. This research was an observational study with a cross-sectional design through a quantitative approach. The subjects of the research were the workers in the production unit consist of 11 workers. The object sample is benzene that was inhaled by workers in the production department of the printing industry X Surabaya. Risk assessment is used to calculate the estimated level of health risk and determine the control in the form of a safe exposure concentration (C). The steps taken in risk assessment include hazard identification, exposure analysis, dose response analysis and risk characteristics.

The questionnaire was distributed to workers of the production unit and aimed to obtain personal data and other information needed by researchers. Benzene dust is measured by using Gas Chromatography technique by measuring NIOSH 1501 which has a mg / m^3 unit of measurement carried out by UPT K3 Surabaya. Blood samples are taken by the doctor. Workers' blood vein profile measurements were taken as much as 3 cc and accommodated in EDTA

tubes. The blood sample is then used to calculate the blood profile ie White Blood Cells (WBC), Red Blood Cells (RBC), Hemoglobin (HGB), Hematocrit (HCT), Average Size of Red Blood Cells (MCV), Amount of Hemoglobin in Each Blood Cell Red (MCH) and Hemoglobin Concentration in Each Red Blood Cell (MCHC). Blood examination and testing activities are carried out by the Airlangga University FKM Nutrition Laboratory. Blood sampling is done while the worker is at work, while data analysis used Spearman rank correlation test.

Calculation of safe concentration is known by using the calculation formula⁹:

$$C_{safe} = \frac{RfC \times Wb \times tavg}{R \times tE \times fE \times Dt}$$

Where:

RfC: reference dose or concentration (mg / m³) and due to exposure through inhalation.

Wb : weight (kg)

Tavg: average time period, 30 years x 365 days / year (non carcinogenic) or 70 years x 365 days / year (carcinogenic)

R : intake rate (m³ / hour)

tE : exposure time per day (hour / day)

fE : annual exposure frequency (day / year)

Dt : duration of exposure, real time or 30 years projection

Result & Discussion

Table 1. Table of Worker Characteristics of printing X Surabaya 2019

Respondents Characteristics	Frequency	Percentage
Age		
25-30	1	9%
31-35	6	55%
36-40	3	27%
41-45	0	0%
46-50	1	9%
Gender		
Male	11	100%
Female	0	0%
Years of Service		
< 10 years	5	46%
≥ 10 years	6	56%

Source: primary data

Table 1 showed that most workers were 31-35 (55%) years old, all were male (100%) and had <10 years (46%) and ≥ 10 years (56%).

Table 2. Safe concentrations of benzene and RQ of printing X workers in Surabaya 2019

No. Res	Wb (kg)	Tavg	RfC (mg/kg/day)	C (ppm)	C (mg/m ³)	R (m ³ /hour)	fE (day/year)	Dt (year)	RQ Index	C safe (hour/day)
1.	76	10950	0,000313	0,9282	2,959253	0,668870279	260	15	237,3557	0,012468
2.	60	10950	0,000313	0,1586	0,505643	0,616667757	260	20	63,14976	0,008007
3.	55	10950	0,000313	0,9282	2,959253	0,597452745	260	10	195,3084	0,015152
4.	53	10950	0,000313	0,0414	0,13199	0,589272798	260	15	13,37429	0,009869
5.	60	10950	0,000313	0,1586	0,505643	0,616667757	260	12	37,88985	0,013345
6.	68	10950	0,000313	0,9282	2,959253	0,644307952	260	5	85,17942	0,034741
7.	68	10950	0,000313	0,1586	0,505643	0,644307952	260	4	11,64357	0,043427
8.	67	10950	0,000313	0,0414	0,13199	0,641036287	260	9	6,905405	0,019114
9.	50	10950	0,000313	0,0414	0,13199	0,57640508	260	6	5,546869	0,023795
10.	66	10950	0,000313	0,1586	0,505643	5,594988607	260	2	58,59755	0,008629
11.	83	10950	0,000313	0,1586	0,505643	0,621665401	260	13	29,91325	0,016904

Table 2 contains calculations to find the safe C value of benzene and RQ per worker.

Calculation of safe concentration (safe C) of benzene is calculated using the following formula

$$C\ safe = \frac{RfC \times Wb \times tavg}{R \times tE \times fE \times Dt}$$

Where:

RfC: reference dose or concentration (mg / m³) and due to exposure through inhalation.

Wb: weight (kg)

Tavg: average time period, 30 years x 365 days / year (non carcinogenic) or 70 years x 365 days / year (carcinogenic)

R : intake rate (m³ / hour)

tE : exposure time per day (hour / day)

fE : annual exposure frequency (day / year)

Dt : duration of exposure, real time or 30 years projection

$$RQ = 1$$

$$I_{nk} = RfC$$

$$RQ = \frac{I_{nk}}{RfC}$$

$$RfC = \frac{C \times R \times tE \times fE \times Dt}{Wb \times tavg}$$

Where :

Ink : Non-cancer intakes from the calculation of exposure (mg / kg.day)

RfC: dosage or concentration (mg / m³) and due to exposure through inhalation

The calculation of the intake value is calculated by the following formula¹⁰

$$I = \frac{C \times R \times tE \times fE \times Dt}{Wb \times tavg}$$

Where :

I : intake (mg / kg / day)

C : concentration of risk agents, namely benzene (mg / m³)

R : intake rate (m³ / hour)

tE : exposure time per day (hour / day)

fE : annual exposure frequency (day / year)

Dt : duration of exposure, real time or 30 years

projection

Wb : weight (kg)

Tavg : average time period, 30 years x 365 days / year (non carcinogenic) or 70 years x 365 days / year (carcinogenic)

The results showed that one of the respondents with serial number 1 had a body weight of 76 kg (Wb), worked 8 hours/day (tE) every day, the number of working days for one year was 260 days (fE), and had worked for 15 years (Dt). With an inhalation rate (R) of 0.668 m³/hr and t avg for carcinogenic substances is 10950 days. With the measurement results of benzene air which has a concentration of benzene (C) 2.959 mg / m³, so the amount of non-carcinogenic intake is:

$$= 2,959 \text{ mg/m}^3 \times 0,668 \text{ m}^3/\text{hour} \times 8 \text{ hour/day} \times 260 \text{ day} \times 15 \text{ year}$$

$$76 \text{ Kg} \times 10950 \text{ day}$$

$$= 0,07421 \text{ mg/kg.day}$$

So the intake of benzene per day for the first worker is 0.07421 mg / kg.day

Risk characteristics for non-cancer effects can be determined by dividing the value of Non-cancer Intake by the value of RfD or RfC with the following formula:

$$RQ = \frac{I_{nk}}{RfD \text{ atau } RfC}$$

The results of the calculation of the level of non carcinogenic risk are included in the equation RQ> 1, then the concentration of risk agents can cause adverse effects to health and if RQ ≤ 1, the concentration of the agent has not been at risk of causing health effects¹¹. So, in the RQ value calculation table, all workers have health risks because RQ> 1.

Table 3: Hematology Overview of Printing X Workers in Surabaya 2019

Type of Hematology Examination	Average (\pm SD)	The lowest	The highest
WBC	6.727.300 \pm 1,35580	4,80x103	9,40x103
RBC	5.256.400 \pm 0,24246	4,80x106	5,62x106
HGB	15.563.600 \pm 0,56084	14,80	16,40
HCT	50.490.900 \pm 1,64466	47,40	53,20
MCV	96.127.300 \pm 2,20957	93,50	99,20
MCH	29.627.300 \pm 0,78879	28,80	31,10
MCHC	30.8273 \pm 0,64045	29,80	31,80

Table 3 showed that type of the hematology test were includes White Blood Cell (WBC) Level, Red Blood Cells (RBC), Hemoglobin (HGB), Hematocrit (HCT), Average Size of Red Blood Cells (MCV), Total Hemoglobin in Each Red Blood Cell (MCH) and Hemoglobin Concentration in Each Red Blood Cell (MCHC).

Table 4 Spearman rank correlation test between Safe Concentration and Result of Hematology Examination of Printing X Workers in Surabaya 2019

Independent Variable	Dependent Variable	Score r	Score p
Safe Benzene Concentration	WBC	0,409	0,212
	RBC	0,300	0,048
	HGB	0,714	0,370
	HCT	0,606	0,014
	MCV	-0,050	0,884
	MCH	0,265	0,431
	MCHC	0,247	0,464

Tabel 4 showed that the results of the Spearman rank correlation test between Safe Concentration and White Blood Cell (WBC) Level, Red Blood Cells (RBC), Hemoglobin (HGB), Hematocrit (HCT), Average Size of Red Blood Cells (MCV), Total Hemoglobin in Each Red Blood Cell (MCH) and Hemoglobin Concentration in Each Red Blood Cell (MCHC) of Printing X Workers in Surabaya 2019

Based on table 4, the rankspearman test showed a significant relationship between C safe benzene and RBC ($p = 0.048$; $p < 0.05$) and HCT ($p = 0.014$; $p < 0.05$).

The test results showed that most of the levels of benzene exposure in printing X industry exceeded the Threshold Value determined by Permenaker Number 05 of 2018 (0.5 ppm)¹². The highest concentration 0.9282 ppm and the lowest 0.0414 ppm. The results of the calculation of the value of Safe C and levels of exposure have exceeded the provisions. Health impacts that occur due to benzene exposure one of which is a disorder of the hematological system because the target organ of benzene is the bone marrow where blood cells are formed³. Excessive exposure to benzene causes leukemia in humans¹³. Benzene exposure generally enters through inhalation because it is an easy exposure path to pass through and with volatile benzene properties. Benzene can have a toxicity effect by using RQ calculations. RQ or risk quotient is a calculation that shows the ratio between the exposure received and the toxicity effect that will be generated. RQ values > 1 are at risk of causing cancer.

In addition to the level of benzene in the workspace, the degree of benzene exposure to labor is seen from the length of exposure work period. Work period affects the duration of exposure and the level of benzene intake received by workers while working and can risk causing health problems¹⁴. The main effect of benzene from long-term exposure is on the

blood. Benzene causes harmful effects on the bone marrow and can cause a decrease in the number of red blood cells which causes anemia¹⁵. It can also cause excessive bleeding and can affect the immune system, and increase the chance of infection¹⁶. In this study, the range of respondents working period is 2-20 years, which means that the range of work periods is quite long, so that it can be a risk factor for the effects of benzene exposure on workers health. However, on the other hand there are still workers whose tenure is less than 10 years, so that benzene exposure is not sufficient enough to be detected in the body. The Department of Health and Human Services (DHHS) has determined that benzene causes cancer in humans. Long-term exposure to high levels of benzene in the air can cause leukemia, cancer of blood-forming organ¹⁶.

Although the results of the study showed that the exposure of benzene to the respondents was still in a low level, the increase in the number of HCT ($50,490,900 \pm 1,644,666$) and a decrease in the number of MCHC ($30,8273 \pm 0,64045$) found in the respondents were accurate indicators of the existence of disorders of the blood formation system due to benzene. This means that the blood element that has shown the effect of benzene exposure is a decrease in the number of red blood cells (RBC) because HCT shows the percentage of red blood cells to total blood volume. While the MCHC Index measures the average HGB concentration in red blood cells¹⁷.

Compared with the calculation of safe C by using the rankspearman correlation test results it can be concluded that there is a significant relationship between benzene safe C levels and the number of red blood cells (RBC) of respondents with a p value (0.048). This means that the level of benzene poisoning individually experienced by respondents has shown a significant effect on impaired red blood cell formation (RBC). Spearman rank correlation test showed a

significant relationship between safe C levels benzene and hematocrit with a p value (0.014). The hematocrit value is the large volume of red blood cells (RBC) in 100 mm^3 blood and expressed in percent. It also states that there is a significant relationship between benzene exposure with an increase in hematocrit levels¹⁸.

In line with research conducted by Koh¹⁹, said that low levels of benzene exposure, even at levels less than 1 ppm, can affected the blood cell production. The most affected by benzene exposure at low levels is the production of red blood cells. This study also showed that the levels of White Blood Cells (WBC), Hemoglobin (HGB), Average Size of Red Blood Cells (MCV) and the Number of Hemoglobin in Each Red Blood Cell (MCH) in general have not shown any decrease compared to normal standards according guidelines for interpretation of clinical data from the Indonesian Ministry of Health.

Conclusion

The concentration of benzene in the workplace exceeds some TLVs that have been determined in accordance with Permenaker Number 05 of 2018 and exceeds the calculation results of benzene safe concentrations (C safe). Different concentrations of benzene in the workplace cause different levels of exposure risk for each worker. The average blood profile of workers in the printing industry X Surabaya was still under normal standards in accordance with the 2011 Ministry of Health Clinical Data Interpretation Guidelines of the Republic of Indonesia.

The results of the calculation of safe C benzene values and associated with the blood profile of workers obtained a significant relationship between safe C benzene with red blood cells (RBC) ($p = 0.048$; $p < 0.05$) and HCT ($p = 0.014$; $p < 0.05$). Whereas at WBC, HB, MCV, MCH, MCHC there was no significant relationship ($p > 0.05$).

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