Conference Paper

Safe Concentration Benzene in Environmental Shoes Home Work Industry Surabaya

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Abstract

Often found in industries, although the concentration of exposure to chemicals in industry was smaller than the chemical threshold value according to the Minister of Manpower and Transmigration of the Republic of Indonesia No. 13 year of 2011 but has had an effect on the workers [1]. The purpose of this study was to determine the safe concentration of benzene in the shoe industry home work environment. The research method used was descriptive qualitative research by describing benzene concentration in work environment, respiration rate of worker, body weight, duration of work per day, frequency of exposure in one year and characteristic of benzene risk to worker. The method used to measure benzene vapor level in the working environment was Flame Ionization Detector chromatography, worker's weight was measured by needle scales, the respiration rate of the worker was calculated using the formula of weight conversion to the respiration rate; length of work per day, working frequency per year, duration of work and the use of insurance for workers was done by interview. The sample size was 20 people. The data analysis used was descriptive by determining the level of risk of benzene exposure on the worker as well as the safe concentration of benzene in the work environment. The results showed that RQ (Risk Quotient) 60 percent of workers > 1, meaning that 60 percent of workers were not safe to work due to exposure to benzene. Meanwhile, the safe concentration of benzene, 0.3 mg/m^3, was very small compared to the benzene threshold value in the working environment according to the Minister of Manpower and Transmigration of the Republic of Indonesia No. 13 of Year 2011 amounted to 0.5 ppm or 1.59 mg/m^3. From the results of the study, it can be concluded that most shoe home industry workers were not safe against exposure to benzene. The safe concentration of benzene in the shoe industry home was 0.3 mg/m^3 smaller than 2000 times compared to the benzene threshold value according to the Minister of Manpower and Transmigration of the Republic of Indonesia No. 13 of Year 2011.

Keywords: benzene, risk quotient, safe concentration, work environment

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1. Introduction

In the world, many industries use benzene as a solvent. Industries that use benzene include in shoe industry, paint, pesticide, medicine, rubber, plastic, glue and others. The use of benzene as a solvent in the United States has been half the source of exposure comes from cigarette smoke. The average amount of intake of benzene has been absorbed by smokers (32 cigarettes per day) was about 1.8 mg per day. This amount has been 10 times greater than the average daily intake of benzene from non-smokers.

Glue used by industry, including shoe industry in Indonesia also contains benzene. The presence of benzene in the glue used in the shoe industry affects benzene exposure in the home of the shoe industry. The safe limits of benzene exposure in the work environment need to be known so that benzene exposure does not have an effect on the worker. The limit of exposure to benzene according to ACGIH has been 0.5 ppm [2], according to OSHAS 1 ppm [3], according to NIOSH 1 ppm [4], according to regulation No. 13 of 2011 is 0.5 ppm.

Based on some research results the average benzene concentration in the work environment is still below the threshold but has had an impact on worker health. EPA (Environmental Protection Agency) estimates that exposure to benzene in the air of 0.004 ppm in the long term risk of causing the leukemia cases/10,000 population (2013) [5]. Based on the research results Haen MT and Oginawati K (2012), in the industrial area of the shoe with a flat benzene in the responder's breathing zone 0.2383 has an impact on changes in hemoglobin, erythrocytes and eosinophil [6].

With benzene concentrations in some industries falling below the Permenakertrans, ACGIH, NIOSH or OSHAS threshold (NAB) thresholds but have had an effect for workers to indicate that a benzene NAB formula should be revised in the working environment. The determination of the safe limits of benzene concentrations in the work environment should involve knowledge of the respiration rate of the worker (R), reference of concentration (RfC) benzene, the length of work/day (tE), the frequency of work each year (fE), the duration of work (years) weight (Wb) and the average year of cancer (70 years 365 days) and non-cancer (30 years x 365 days).

This research is aimed to find out the benzene intake in the body, the level of risk of benzene exposure as well as the safe concentration of benzene in the shoe industry home work environment. The results of this research is expected that workers in the home industry of shoes can be safe in work.

2. Methods

This research category was descriptive qualitative research with study design cross sectional. The population of this study was all shoe home industry workers in Romokalisari Surabaya, East Java Province of the Republic of Indonesia which amounted to 20 people. The number of research samples was 20 people.

The research variables were benzene concentration in shoe industry home, respiration rate of worker at work, length of work/day, working frequency every year, duration of work. The data obtained in the implementation of research obtained through primary data and secondary data. Primary data include benzene concentration in work environment, respiration rate of respondent in work, length of work/day, working frequency every year, duration of work and worker's weight. Measurement of benzene concentration in work environment was done by using NIOSH 1501 measurement method with active carbon absorber pipe (charcoal) by using Gas Chromatography (GC) technique by officer from UPTK3 Surabaya. Worker respiration rate measurement with weight conversion formula to respiration rate with the following formula:

$$R = (2.3 \ln W - 6.8)/24 \ldots\ldots\ldots\ldots (m3/h)$$

Weight measurement with weight scales. Calculation of length of work/day, frequency of work each year, duration of work with interview techniques on respondents. The secondary data, among others, are benzene reference of concentration (RfC). Steps taken in risk assessment were: hazard identification, exposure analysis, response dose analysis and risk characteristics.

3. Results

Knowledge of benzene exposure in the working environment of shoe industry workers was very important. This was to determine the level of risk of exposure to benzene workers.

In Table 1, it was found that at 6 point measurement, 75 percent of benzene concentration was still below the threshold value of 0.5 ppm or 1.6 mg/m^3.

Worker characteristics include length of work/day (tE), annual working frequency (fE), duration of work (Dt) are listed in Table 2.

Table 2 illustrates the distribution of exposure time frequencies, exposure frequencies, and duration of exposure. In the results of this research the exposure time (tE) is categorized into two, that is, $\leq$ 8 hours/day and $>$ 8 hours/day. From the result of the

Table 1: Benzene concentration in the working area (home) of shoes in Romokalisari Surabaya, 2016.

Concentration of Benzene	N	Percentage (%)
≤ 1.6 mg/m^3	6	75
> 1.6 mg/m^3	2	25
Total	8	100
Mean		1.3475
Median		0.6350
Std. Deviation		2.54762
Min–Max		0.04–7.44

Table 2: Distribution of working days/days (tE), annual working frequency (fE), duration of work (Dt) of craftsmen at home industry Romokalisari Surabaya, 2016.

Ket.	(tE)	Total		(fE)			(Dt)	Total	
		N	%		n	%		n	%
	≤ 8 hours	1	5	≤ 265 days	–	–	≤ 25 year	10	50
	> 8 hours	19	95	> 265 day	20	100	> 25 year	10	50
Total		20	100		20	100		20	100

Source: Primary Data, 2016.

research, 1 worker (5%) had exposure time ≤ 8 hours/day and 19 workers (95%) had exposure time > 8 hours/day. The study also obtained an average time of exposure 10.55 hours/day. This indicates that each work location has different exposure times for each other. The exposure frequency band (fE) is categorized into two, that is, ≤ 265 days and > 265 days. Based on the result of the research, all workers have exposure frequency > 265 days. The average worker in a year works for 346.75 days. Exposure duration (Dt) is categorized into two, that is, ≤ 25 years and > 25 years. From the results of the study showed that the results are balanced between the two, each of 10 workers (50%). Average duration of exposure 24.93 years.

Based on the results of the interviews were known workers are workers who shoe industry workers have long occupied the work and have long worked before. Therefore, care should be taken of the length of the work as this may suggest that they were always in an enabling environment for benzene.

From the result of the research, one of respondent with number 1 had weight of 51.4 kg (Wb), every day work 9 hours/day (tE), number of working days for 313 days (fE) and has worked for 34 years (Dt). With inhalation rate (R) of 0.6 m^3/hr and tavg for carcinogenic substances was 10950 days. With the result of benzene air measurement

having benzene concentration (C) 0.04 mg/m^3, so the amount of non-carcinogenic intake was:

$$= \frac{0.04\ \text{mg/m}^3 \times 0.6\ \text{m}^3/\text{hours} \times 9\ \text{hours/days} \times 313\ \text{days} \times 34\ \text{year}}{51.4\ \text{Kg} \times 10950\ \text{days} \cdot \text{years}}$$

$$= 0.004084\ \text{mg/kg} \cdot \text{days}$$

So, the intake (intake) of benzene per day for the first worker was 0.004084 mg/kg · day. That was, workers with a weight of 51.4 kg who work in shoe industry home with a concentration of 0.04 mg/m^3 exposure work every 9 hours with working frequency of 313 days/year for 34 years has daily non-carcinogen benzene intake of 0,004084 mg per kg. Meanwhile, for the calculation of carcinogenic intake using the formula and the value of the same variable but by using tavg for carcinogenic substances was 25550 days. Here's the calculation of carcinogenic Intake (intake) per day first worker:

$$= \frac{0.04\ \text{mg/m}^3 \times 0.6\ \text{m}^3/\text{hours} \times 9\ \text{hours/days} \times 313\ \text{days} \times 34\ \text{year}}{51.4\ \text{Kg} \times 25550\ \text{days}}$$

$$= 0.0018\text{mg/kg} \cdot \text{days}$$

So, the intake (benzene) of carcinogens per day for the first worker was 0.0018 mg/kg.day. Risk characteristic for non-carcinogen effect can be known by dividing the value of non-carcinogen Intake with RfD or RfC value with the following formula:

$$RQ = \frac{I_{nk}}{Rf\,D \text{ atau } Rf\,C}$$

After the value of RQ was used the assumption If the value of RQ ≤ 1 indicates the absence of the possibility of risk of non-carcinogenic health effects but need to be maintained so that the numerical value of RQ does not exceed 1. While RQ > 1 indicates the possibility of risk of non-carcinogenic health effects and the need for control efforts [7].

Based on Table 3, it can be seen further that the calculation of RQ when it is RQ ≤ 1 as many as 8 people (40%) and RQ > 1 as many as 13 people (60%), for 5 years exposure RQ ≤ 1 of 7 people (35%) and RQ > 1 as many as 13 people (65%). For exposures 10 years and 15 years showed the same results that is RQ ≤ 1 as many as 6 people (30%) and RQ > 1 as many as 14 people (70%). For 20 years and 25 years exposure showed the same result that is RQ ≤ 1 as many as 5 people (25%) and RQ > 1 as many as 15 people (75%). While for the exposure of 30 years of RQ ≤ 1 as many as 4 people (20%) and RQ > 1 as many as 16 people (80%). The longer the benzene exposure to the worker the riskier the non-carcinogenic health effects are evident at the 10th and 20th to 25th year exposure hits and the 30-year exposure shows an increase in the number of workers at risk of non-carcinogenic health effects.

Table 3: Percentage of current RQ, 5th, 10th, 15th, 20th, 25th, and 30th shoe crafts workers in Tambak Oso Wilangun Surabaya Village, 2016.

Exposure	(RQ)	Total		Total
		N	(%)	
RQ currently	RQ ≤ 1	8	40	20
	RQ > 1	12	60	
RQ 5 year	RQ ≤ 1	7	35	20
	RQ > 1	13	65	
RQ 10 year	RQ ≤ 1	6	30	20
	RQ > 1	14	70	
RQ 15 year	RQ ≤ 1	6	30	20
	RQ > 1	14	70	
RQ 20 year	RQ ≤ 1	5	25	20
	RQ > 1	15	75	
RQ 25 year	RQ ≤ 1	5	25	20
	RQ > 1	15	75	
RQ 30 year	RQ ≤ 1	4	20	20
	RQ > 1	16	80	

In non-carcinogenic risk management used is the RQ value. In lowering the risk concentration value, RQ = 1 is the value of intake = RfC. In this calculation the data used were the average of benzene concentration (C) of 1.35 mg/m3, inhalation rate (R) of 0.635 m3/h, the working time (tE) of salaam 10.55 hours/day, the exposure frequency (fE) for 346.75 days/year, exposure duration (Dt) for 30 years, worker's weight (Wb) is 65 Kg, and non-cancer tank is 30 years x 365 days/year. In this research, risk management is to calculate safe intake (I), reduce benzene concentration (C), reduce contact time with exposure source (tE), reduce exposure frequency (fE) and reduce exposure duration (Dt). The calculation to obtain a safe value performed on respondent 1 as follows:

$$RQ = 1$$

$$I_{nk} = RfC$$

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

$$I_{nk} = RfC$$

$$\frac{C \times R \times te \times Fe \times Dt}{Wb \times Tavg} = RfC$$

Thus, to find the safe value (Dt safe) benzene in the shoe industry home working environment can be derived from the aforementioned formula to be as follows:

$$C\ aman = \frac{Rf C \times W b \times tavg}{R \times tE \times f E \times Dt}$$

For the full calculation results only displayed calculations of workers who are at risk of non-carcinogenic can be seen in the following table:

Table 4: Results of calculation of safe value of benzene exposure to non-carcinogenic health effects on benzene craftsmen in Tambak Oso Wilangun Surabaya Village, 2016.

Workers Number	c early (mg/m^3)	c. safe (mg/m^3)
9	0.15	0.9
10	0.15	1.2
11	1.12	0.3
12	1.12	2.1
13	1.12	0.4
14	1.2	0.4
15	1.27	0.9
16	1.27	0.6
17	1.27	0.6
18	2.91	0.9
19	7.44	1.1
20	7.44	2.3

Source: Primary Data, 2016.

Based on the safe calculation in Table 4, researchers take the safe risk of non-cancer risk by choosing the safe value of the smallest calculation result data because it is safer and healthier that can be applied by the craftsman in Tambak Oso Wilangun Surabaya Village that is safe at 0.3 mg/m^3.

4. Discussion

Based on the result of benzene concentration measurement conducted at 8 sampling point at work location of shoe craftsman in Tambak Oso Wilangun Surabaya Village, it is found that the highest concentration of benzene in the working environment was 2,333 ppm or equal to 7.44 mg/m^3 and the lowest is 0, 0129 ppm or equivalent to 0.04 mg/m^3. Based on the observed concentration of benzene measured at each different point in the industry, the concentration of benzene is measured high, it is because

some of them are due to the production of shoes produced a lot, so the glue used also follows the amount of shoe production produced.

Benzene exposure time in the work environment illustrates the number of hours worked per day in the work environment. From the research result, it was found that the lowest time of worker is for 6 hours per day and the highest work for 17 hours per day. From the results of this study above the threshold value of normal working hours. This is in line with KEP.102/MEN/VI/2004 which states that the standard working hours are 7 hours of work a day or 6 days a week or 8 hours of work a day or 5 days a week [8]. Based on the results of research related to working hours obtained the results of the highest time 17 hours a day. This is due to high orders and fast production deadlines so that workers strive to meet the target order.

Related to the frequency of exposure, it is shown the time spent by workers to work in the shoe-making industry within the span of 1 year. From the results of the study indicated that the workers spend the lowest time or working day 260 days/year and the highest 365 days/year. Based on the EPA reference the annual working frequency in the industry is 250–300 working days/year.

The duration of exposure in this study explains how long the worker worked in the shoe home industry location. The duration of exposure is one of the variables used for the assessment of Intake (intake) of benzene exposure in the body. Long time work in home industry in varies between 3 to 43 years.

The results of the perceived level of individual non-cancer risk at present, 5 years to 20 years found that more than 60 percent of workers had calculated RQ > 1. While for 25 years to 30 years old more than 75 percent to 80 percent of workers were at risk non-cancer health effects. The results explain that individually most workers are at risk of non-carcinogen health effects and are in unsafe conditions against benzene exposure.

The concentration of benzene exposure to shoemaker workers in Tambak Oso Wilangun Surabaya Village is influenced by the air condition at the worker's location and the lack of material in the form of shoe glue used for the shoe production process. From the calculation of non-carcinogenic health risk control to safe benzene exposure on shoe-crafting workers in Tambak Oso Wilangun Surabaya 2016, the safe benzene conservation in the working environment or safe C was 0.3 mg/m^3. This number is smaller than the benzene threshold value according to Permenakertrans No. 13 of 2011 [4] amounted to 0.5 ppm or 1.59 mg/m^3. This means that the benzene threshold value in the working environment of the Romokalisari shoe industry in Surabaya is not

safe for the workers because its benzene concentration is 5.3 times greater than the benzene safe concentration in the home industry.

Efforts to prevent the impact of benzene exposure require an active role from workers or business owners to minimize exposure to benzene contact with workers. One effort that can be done is to equip workers with Personal Protective Equipment (PPE). Based on the results of observation, PPE that can be used is a mask made from activated carbon and gloves. This is done because benzene exposure is not only through inhalation but also through the skin.

Shoe home industry owners should also try to lower benzene levels from the worker's body by providing the food consumed by the workers containing enzymes such as CYP2E1 enzymes derived from beef and salmon hams that can convert benzene into ttmA and glutathione derived from fruit avocado to prevent the impact of cancer on workers.

Based on the observation, behavioral aspect should also be considered in risk management. This can be done several actions, among others:

1. Storage

   Often there is a habit of putting shoes production process materials such as glue used in any place, this can lead to the possibility of exposure. For that it needs to be made a special place to store shoe production materials especially glue, saline storage closing container of glue should also be done properly.

2. Ventilation

   Ventilation is a process of providing fresh outdoor air which is exchanged with indoor air naturally. The main function of ventilation as the exchange of outside air with indoors, it is also intended to control the temperature of the air so as not to heat and stuffy so increase the intake of benzene exposure. According to the Minister of Health Regulation No. R1. 1077/MENKES/PER/2011 about indoor ventilation guideline of good ventilation house is to meet the criteria of ventilation area > 10% of floor area of workplace [9]. Some work site observations have considerable ventilation area, but some work sites lack sufficient ventilation for air circulation.

3. Smoking habit

   Based on research results in the workplace, which adds the risk of exposure to benzene in cigarette smoke. At work sites filled with benzene smells and vapors will be exacerbated by the smoking of workers at the work site. This should get

attention, especially with smoking at work sites and the incidence of cigarette smoke makes the air condition of the work environment becomes increasingly minimal oxygen and can increase the intake of benzene exposure. Smoking habits can be reduced to maintain the condition of the body to be in a state fit and minimize the severity caused by benzene exposure effects.

4. Personal Hygiene

   Based on the observation of the workings of workers used glue then personal hygiene is needed to reduce the risk of exposure to benzene in workers. As is known, personal hygiene is an effort to maintain personal hygiene is the responsibility of every individual or worker. Where, at the time before work, while working, and after doing shoe making work required every worker to wash hands and wear gloves while working. This effort is proposed because the exposure of benzene in addition to the air can also be through the skin that can be absorbed by the body. This is because benzene is non-polar so easily absorbed by the skin of workers who are mostly non-polar as well [10].

5. Personal protective equipment

   Based on observations at the time of the study, most workers take, apply, glue the glue using a finger without wearing gloves or spatula. This can leave glue dry on the finger and even the sample covering the palm of the hand. Habits of workers without gloves are at risk of increasing the intake of benzene in the body through the hands.

   In the observation of workers, also often found the workers do not wear clothes while working. The presence of unskilled workers who do not wear clothes while doing the work can increase the absorption of benzene through their body skin causes increased benzene effect on workers. Workers generally do not wear clothes in work because of the hot and stuffy environment and sweaty body. To avoid the impact of benzene absorbed through the skin more workers should wear clothing to avoid the risk of benzene exposure.

6. Sleeping soundly at 23.00–01.00

   To effectively reduce benzene toxin in the body then the workers were expected to always sleep soundly at the hours of 23.00–01.00. This was because detox toxins, including benzene, are effective at these hours. Workers while still working at these hours will inhibit the detoxification of benzene from within their bodies so that it will cause various diseases due to exposure to benzene [10].

5. Conclucions

Lowest benzene concentrations were present at work site 1 of 0.04 mg/m^3 and the highest concentration was found at work site 8 of 7.44 mg/m^3. Safe concentration of working environment of shoe industry of Romokalisari Surabaya was 0,3 mg/m^3, was very small compared to the benzene threshold value according to The Minister of Manpower and Transmigration of the Republic of Indonesia Number 13/MEN/X/2011 amounted to 1.59 mg/m^3. Thus, workers should be protected by using ventilation of 10 percent of the floor area, using PPE hands, nose and shirt, consuming benzene detox foods including CYP2E1 enzymes commonly found in beef liver and salmon, as well as glutathione from avocado, and not smoking, the presence of glue storage, shoe production and always clean the hands before eating and cleaning the place used in making shoes.

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