Measurement of Benzene Levels in Decrease Hemoglobin Levels among Printing Industry Workers

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Abstract: The printing industry used chemicals that are harmful to the environment and humans, one of which is a volatile organic compound is benzene, was used as an ink solvent. The effect on the health of workers is damage to the blood formation system (bone marrow), which can pose a risk of a decrease in the number of elements of the blood cell which include a decrease in hemoglobin levels. The population is 50 workers from 6 printing industry, samples were taken by *consecutive sampling techniques.* The results showed that workers who were exposed to benzene and had decreased hemoglobin levels by 17 people. *Chi square* test showed a correlation between long of exposure and benzene levels with anemia. The results of multiple logistic regression test showed that the levels of benzene most afected on anemia, benzene levels had a chance 44,5% to affected with anemia. Advice for workers should use Personal Protective Equipment (PPE) such as masks chemical cartridge types, optimizing the air vents and turn on the exhaust fan. For owners of printing should be able to provide appropriate PPE. For the Department of Labor can make policy and monitor existing regulations.

1 INTRODUCTION

The printing industry used chemicals that are harmful to the environment and society, one of which is the volatile organic compounds released from the printing process, especially in cleaning materials, inks and other solutions to wet the printing plate. Benzene was used as an ink solvent. Chronic exposure to benzene can cause bone marrow damage and decrease in hemoglobin levels.

Benzene is a carcinogenic substance (cause of cancer) to workers or humans exposed. Epidemiological studies prove the relationship between exposure to benzene derived from solvents containing benzene with the incidence of acute myelogenous leukemia (AML). Damage to the systemimmune also occur on exposure to benzene through inhalation. This is shown by the decrease in the number of antibodies and decreasing the number of leukocytes in workers who are exposed (ATSDR, 2007).

The most systemic effect produced on chronic and moderate benzene exposure is the failure of red blood cell formation. The initial biomarker for low levels of benzene exposure is a reduction in the number of blood cells. The usual clinical finding in benzene hematoxicity is cytopenia, which is a decrease in the elements contained in blood cells that cause anemia, leukopenia, or thrombocytopenia in humans and animal experiments. Benzene can cause damage in a very dangerous body called aplastic anemia, which is where the body fails to form red blood cells due to damage to the bone marrow that produces blood cells. This aplastic anemia is an early indication of acute non-limphocytic leukemia (acute non-lymphocyte leukemia).

Benzene absorption pathway through breathing, skin or eye mucosa. Chronic effects of benzene exposure are damage to the blood formation system (bone marrow) which can pose a risk of reducing the number of elements of the blood cell including a decrease in hemoglobin levels (Mahawati et al, 2006).

The most significant health effects of benzene exposure in the short and long term are hematoxicity, immunotoxicity, neurotoxicity, and

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carcinogenicity. In addition, there are three types of effects on bone marrow due to benzene exposure, namely bone marrow depression that leads to aplastic anemia, changes in cromosomes, and carcinogenicity (IPCS EHC 150, 1993).

Benzene exposure can occur in the printing industry, shoe making, rubber processing, and raincoat manufacturing in its chemical processes. The main exposure is through inhalation, although dermal exposure (contact with skin) is also possible. Health effects are divided into several exposures, depending on the duration or length of exposure. Acute exposure (≤ 14 days), intermediate exposure (15-364 days), and chronic exposure (365 days or more) (Rendi, N.S, 2012).

Repeated chronic benzene exposure even in low concentrations can cause various blood disorders, namely anemia, aplastic anemia, thrombocytopenia, pancytopenia, and acute leukemia (Hays et al, 2012).

Exposure to benzene with high levels through inhalation (breathing) can cause death, while exposure to low doses causes dizziness, rapid heartbeat, headache, tremor, confusion and out of focus. If ingested or consumed ingredients with high benzene content can cause coughing, hoarseness, and burning sensation in the mouth, pharynx and esophagus, stomach irritation, excessive drowsiness, and ultimately death. Neurological effects have been reported in humans exposed to high levels of benzene. Fatal exposure through inhalation causes vascular congestion in the brain. Chronic inhalation exposure can cause distal neuropathy, insomnia, and memory loss. Oral exposure has the same effect as exposure through inhalation. Animal studies suggest that exposure to benzene through inhalation results in reduced electrical activity in the brain, loss of reflexes, and tremors.

Exposure to benzene through the skin does not cause nerve damage. Acute exposure through oral and inhalation with high benzene levels can cause death, which is associated with central nervous system (CNS) depression. Chronic low-level exposure is related to effects on the peripheral nervous system. Chronic exposure to benzene causes greater toxicity than acute exposure, because this exposure can occur at levels below the odor threshold. More exposure to the work environment through breathing (inhalation), in addition to through ingestion (swallowed) and through the skin. Symptoms and signs of chronic poisoning can appear quickly, but the latent period of benzene is as long as 29 years, from the last exposure until the toxicity in the body disappears (Hamilton, 2003).

High concentrations of benzene exposure have a narcotic effect on the central nervous system (CNS). Acute effects include mild dizziness, headaches, excitement, unstable gait, euphoria, confusion, nausea, vertigo, and drowsiness. If exposure continues, it can cause seizures until death. Inhalation is the most common route of exposure, but skin exposure can cause edema, burning, and blisters (Harbison et al, 2015).

Repeated and prolonged chronic exposure to benzene at work, even in low concentrations, can cause a variety of blood disorders that vary from anemia, thrombocytopenia, aplastic anemia, pancytopenia, and acute leukemia (Hays et al, 2012).

Anemia is a condition when the body lacks red blood cells or the concentration of hemoglobin in the blood is insufficient so that there is a disruption in transporting oxygen throughout the body. Anemia indicator for age > 15 years is when blood Hb (hemoglobin) concentration is < 12 mg / dL in women and < 13 mg / dL in men (Tarwoto and Wartonah, 2008). Anemia can be detected through symptoms that appear like pale, easily tired, palpitations, tachycardia (faster heart beat) and shortness of breath (Arisman, 2004). Other complaints are dizzy, lethargic, dizzy and easily drowsy. Prolonged anemia will cause decreased work productivity and organ damage.

In Indonesia there are many health cases due to exposure to benzene in the air. The health effects of benzene exposure on bodyworkers who use benzene as a paint solvent, found that 42,9 percent of respondents experienced excessive benzene exposure and there were cases of anemia by 68,9 percent (Mahawati, 2006).

Results of research on workers Mixing Plastic Packaging Industry Operators at PT. X shows that there is a relationship between the duration of benzene exposure with blood hemoglobin levels in workers. Prevalence Ratio Analysis shows that the duration of benzene exposure (RP = 2,2) is a risk factor for a decrease in blood hemoglobin level (Sukmavita, 2006).

Research conducted in the Petroleum Processing Industry found that there was a significant relationship between benzene levels and the blood profile of Hemoglobin. Exposure to benzene is a major source of disruption to the profile of blood in the form of interference against concentration hemoglobin (Ramon, 2007).

Based on initial surveys that have been carried out in several printing companies in the city of Medan, it was found that the number of workers in the production section numbered 15 people with an

average of 9 hours work hours, overtime workers when there is a piece that must be completed within a certain time. The condition of the workplace is closed and there is an air conditioner that is always turned on, a very pungent odor is emanating from the production room to the outside of the room, in the room there is no ventilation for air exchange so workers keep inhaling the aroma, workers out of the room only during recess. Some workers wear Personal Protective Equipment (PPE) in the form of medical masks, workers complain the smell is still smelled even though wearing PPE because it is not in accordance with the potential hazards at work.

Measurement of benzene in the working environment uses a Gas Chromatography measurement tool with a Flame Ionization Detector and refers to the 1501 method (NIOSH, 1994). Measurement of hemoglobin levels using a Portable Hemoglobin Meter.

2 RESEARCH METHODS

The locations of the printing industry in the city of Medan which are the sampling places in this study were in the District of Medan Baru, Medan Area and Medan Selayang.

Here are the locations of the printing industry in the city of Medan which is where sampling in this study are:

Table 1: Location of The Printing Industry.

Printing industry	Research sites
Printing Industry 1	Medan Barat District
Printing Industry 2	Medan Sunggal District
Printing Industry 3	Medan Barat District
Printing Industry 4	Medan Sunggal District
Printing Industry 5	Medan Barat District
Printing Industry 6	Medan Area District

The sample in this study amounted to 50 workers were taken from 6 the printing industry. Samples were taken by consecutive sampling technique by means of researchers going to each printing industry in the study location until the number of samples is met. Every worker who meets the inclusion criteria will be included as a research subject.

The inclusion criteria in this study are as follows: workers who have worked for at least 1 year, are willing to be the subject of research by signing the consent form. Exclusion criteria are workers who suffer from diabetes mellitus, kidney failure and malignancy, workers who have the habit of taking vitamin supplements routinely every day, and female workers who are menstruating and pregnant.

The univariate analysis conducted was useful to see the frequency distribution in categorical data such as age, sex, long of exposure, length of service, levels of benzene in the workplace air, health complaints, smoking habits, use of PPE and anemia.

Bivariate analysis was carried out to determine the relationship between the independent variable and the dependent variable. Bivariate analysis used is the chi square test used for categorical data with categorical data, if it meets the requirements used Pearson chi square and if it does not meet the requirements used Fisher's Exact.

Multivariate analysis aims to analyze the relationship of several independent variables with one dependent variable. Multivariate analysis is used is a multiple logistic regression test, one of the mathematical models approaches to analyze the effects of several independent variables on categorical dependent variables, to find out which independent variables are more closely related to the dependent variable.

Primary data were obtained from interviews using a structured questionnaire to obtain demographic data of research subjects including other ages, sex, and years of service. Data on worker habits regarding use of personal protective equipment during work, smoking habits, length of exposure to benzene chemicals in the work space and health complaints data will also be obtained from interviews with questionnaires.

Measurement of benzene in the air refers to the method in 1501 (NIOSH, 1994). Examination of ambient air samples for the measurement of benzene was carried out at the Laboratory Center of Occupational Health and Safety. Sampling was done with a sampler in the air (air sampler instrument) pengabsorb material in the form of activated carbon (coconut shell carchoal). The steps of air sampling method is as follows:

1. Air sampling by using a simple vacuum pump connected by a glass tube containing activated carbon (coconut shell charcoal), which is placed at the points specified by the velocity (flowrate) 0,2 liter / min for 30 minutes in accordance with the provisions of NIOSH method 1501

2. The activated carbon that already contains benzene taken to the laboratory for analysis
3. The tube contains activated carbon and activated carbon solved dissolved in CS2 solution that will extract the benzene contained in activated carbon are then injected into the Gas Chromatography
4. Gas Chromatography was used equipped with a flame detector ionitation
5. The solution will be driven by gas injection (carrier gas) through a capillary tube (column oven)
6. Benzene will reach the detector at the time and on the detector will be seen outside of the peak of benzene were then compared with a standard to obtain the concentration of benzene.

Measurement of hemoglobin concentration in the blood using the Portable Hemoglobin Meter. Tools and materials used namely Hemoglobin Meter Portable Easy Touch, Strip Hemoglobin Easy Touch, Pen Lancet, Lancet Needles, Alcohol swabs and wipes. The inspection measures hemoglobin levels in workers is as follows:
1. Health workers turned Hb Meter Portable tools Easy Touch
2. Officers enter into the tool Portable Strip Hb Hemoglobin Meter Easy Touch
3. The clerk swiped / cleaning tip ring finger or middle finger with alcohol swab workers
4. The officer poked his fingertips worker with pen sterile lancet, lancet needle is replaced with a new lancet needle and every worker uses a different needle and sterile lancet
5. The clerk pressed a fingertip has been punctured, the first blood smear is coming out with a tissue
6. Take the next blood, and then insert it into the Strip hemoglobin that has been put into the Hb Portable Meter Easy Touch
7. Wait ± 10-15 seconds, then the officer noted the number that appears on the monitor.

Figure 1: Measuring Levels of Benzene in the Air Working Environment

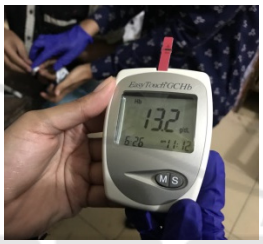

Figure 2: Measurement of hemoglobin concentration on Workers

3 RESULTS AND DISCUSSION

The results of research in 6 printing industries found 2 printing industries which have benzene levels that pass through the threshold value of 1.5602 mg/m³ and 0.9366 mg/m³, and the printing industry which has the lowest benzene content in the printing industry 6 is 0.0662 mg/m³. Based on the measurement results obtained above it can be seen that there is a very big difference between the measurement results under the threshold value and the measurement results above the threshold value, this is certainly due to differences in the levels of benzene in each printing industry that is influenced by several factors including: types of raw materials used, work methods and work methods in the printing industry, the amount of production produced, and the condition of the space in the printing industry.

Table 2: Location and Description of the Work Environment.

Printing Name	Benzene levels in the air (mg/m³)	Ventilation Systems, Printing Machine and Room Size
Printing 1 (DD)	1,5602	Offset printing, the machine used was 4, and there is no ventilation. Size 9x4 meter room.
Printing 2 (DPI)	0,9366	*Digital printing*, the machine used was 2, with air conditioner, and there is an exhaust fan but it is not used. Size 7x5 meter room.
Printing 3 (SKL)	0,4523	*Digital printing*, the machine used was 1, no ventilation, doors and windows are always open. Size 7x8 meter room.
Printing 4 (TDP)	0,1575	*Digital printing*, the machine used was 1, with air conditioner, and no exhaust fan. Size 6x6 meter room.
Printing 5 (AK)	0,0718	Offset printing, the machine used was 5, the main door is always open as the air exchange. Size 14x5 meter room.
Printing 6 (RGR)	0,0662	*Digital printing*, the machine used was 1, the main door is always open as air exchange, and there is a fan. Size 5x4 meter room.

Based on observations in several printing industry production rooms using Air Conditioner (AC) and no exhaust fans , while 4 other printing industries did not pass through the threshold value because some printing already use exhaust fans, ventilation sufficient with the opening of the main door of printing and windows in production room, and other things are caused when air measurements took place the printing industry was not doing the production process.

The number of respondents in the printing industry in this study amounted to 50 people. Characteristics of respondents consisted of: age, gender, long of exposure, years of service, health complaints, smoking habits and the use of personal protective equipment (PPE).

Respondents aged ≥ 29 years were 25 people (50%) and aged < 29 years were 25 people (50%). The majority of male gender is 38 people (76%). The majority of long exposure > 8 hours is 35 people (70%). The majority of work period ≥ 2 years is 36 people (72%). The majority of worker's smoking habits are those who do not smoke as many as 33 people (66%). The majority of PPE uses are those that do not use as many as 43 people (86%).

Table 3: Distribution Characteristics of Printing Industry Workers.

Characteristics of Workers	n = 50	%
Age		
≥ 29 years	25	50
<29 years	25	50
Gender		
Male	38	76
Female	12	24
Long of Exposure		
> 8 hours	35	70
≤ 8 hours	15	30
Work Period		
≥ 2 years	36	72
<2 years	14	28
Health Complaints		
Yes	19	38
No	31	62
Smoking Habit		
Yes	17	34
No	33	66
Use of PPE		
No	43	86
Yes	7	14

The most benzene levels were ≤ 0.5 mg/m³ as many as 32 people (64%) and > 0.5 mg/m³ as many as 18 people (36%). The majority of workers who were not anemia were 33 people (66%) and those who anemia were 17 people (34%).

Table 4: Frequency Distribution of Benzene and Anemia.

Variables	n = 50	%
Benzene Levels		
> 0,5 mg / m³	18	36
≤ 0,5 mg / m³	32	64
Anemia		
Yes	17	34
No	33	66

Table 5 shows that there was no correlation between age with anemia (p = 0,370 > α = 0,05). There was no correlation between gender with anemia (p = 0,294 > α = 0,05). There was correlation between long of exposure with anemia (p = 0,001 < α = 0,05). There was no correlation between work period with anemia (p = 0,099 > α = 0,05). There was no correlation between benzene levels with anemia (p = 0,016 < α = 0,05). There was no correlation between health complaints with anemia (p = 0,344 > α = 0,05). There was no correlation between smoking habit with anemia (p = 0,890 > α = 0.05) and there was no correlation between use of PPE with anemia (p = 0,677> α = 0,05).

Table 5: Relationship between Age, Gender, Long of Exposure, Work Period, Benzene levels, Health complaints, Smoking Habit and Use of PPE with Anemia.

Variables	Anemia				*p.value*
	Yes		No		
	n	%	n	%	
Age					
≥ 29 years	10	40,0	15	60,0	0,370
< 29 years	7	28,0	18	72,0	
Gender					
Male	11	28,9	27	71,1	0,294
Female	6	50,0	6	50,0	
Long of Exposure					
> 8 hours	17	48,6	18	51,4	0,001
≤ 8 hours	0	0	15	100	
Work Period					
≥ 2 years	15	41,7	21	58,3	0,099
< 2 years	2	14,3	12	85,7	
Benzene Levels					
> 0.5 mg / m³	10	55,6	8	44,4	0,016
≤ 0.5 mg / m³	7	21,9	25	78,1	
Health Complaints					
Yes	8	42,1	11	57,9	0,344
No	9	29,0	22	71,0	
Smoking Habit					
Yes	6	35,3	11	64,7	0,890
No	11	33,3	22	66,7	
Use of PPE					
No	14	32,6	29	67,4	0,677
Yes	3	42,9	4	57,1	

Based on the results of research from 50 respondents there were 17 people (48,6 %) who were anemia with a long of exposure above 8 hours per day. Based on the analysis results obtained p value of 0,001 (p < 0,05), which means there is a significant relationship between long of exposure with anemia. The long of exposure is related to the magnitude of the effect that will be caused because the long of exposure will affect the amount of concentration of benzene that enters the body and causes anemia, if the longer and often the worker is exposed to benzene, the greater the risk and chronic effects on health that arise. Therefore OSHA sets an exposure limit of 8 hours a day or 40 hours a week.

The results of the study are in line with the research of Sukmavita (2006) on the Plastic Packaging Industry Mixing Operator workers at PT. X which shows that there is a relationship between long of exposure with blood hemoglobin levels in workers. Prevalence Ratio Analysis shows that the duration of benzene exposure (RP = 2,2) is a risk factor for a decrease in blood hemoglobin levels that causes anemia.

Table 6: Relationship between Long of Exposure with Anemia.

Variable	*p*	RP (95% CI)
Long of Exposure		
> 8 hours	0,001	0.514 (0.373 to 0.71)
≤ 8 hours		

The results showed that of the 50 workers in the printing industry with the most anemia > 0.5 mg/m³ as many as 10 people and below or equal to 0.5 mg/m³ as many as 7 people. Chi square test results obtained p value of 0.016 (p < 0.05), which means there is a significant relationship between benzene levels with anemia. This study is in line with the results of the *National Cancer Institute* (NCI) research indicating that workers who are chronically exposed to benzene below 10 ppm are 2,6 times the tendency to experience haematological disorders (all types of neoplasms) (ATSDR, 2007).

Table 7: Relationship between Benzene Levels with Anemia.

Variables	*p*	RP (95% CI)
Benzene Levels		
> 0.5 mg / m³	0,016	2,54 (1.171 to 5.508)
≤ 0.5 mg / m³		

Benzene enters the body in the form of steam through inhalation and absorption mainly through the lungs, the amount of benzene vapor inhaled is around 70-80% of the total amount of benzene that enters the body. Benzene is easily absorbed through the respiratory tract with a percentage of 70-80% in the first 5 minutes, and 20-60% until the next hour (ATSDR, 2007). The main target of benzene exposure in humans is the spinal cord, which is the site of formation of blood cells. Benzene can cause the spinal cord to be disrupted so that it will result in disruption of the process of making blood cells and ultimately cause health effects due to abnormal blood cells in humans, such as anemia (CDC, 2005).

Based on the results of multivariate analysis with multiple logistic regression tests it is known that the variable levels of benzene affect anemia, with significance values (p = 0.019) and Exp (B) = 4.464. Levels of benzene chance to anemia by 44,5 % and the rest is influenced by other factors not included in this study variables.

Table 8: Effects of Benzene Levels on Aanemia.

Variable	Koef. B	Exp (B)	*p*
Benzene levels	1,496	4.464	0,019
Constant	-1.719		

The results of research from 6 printing industries found 2 printing industries that passed through the TLV or as many as 10 people (55,6 %) workers were anemia with benzene levels more than 0.5 mg/m³, and 4 other printing industries did not pass through the TLV due to already using exhaust fan, good ventilation with the opening of the main printing door and when the measurement takes place the printing industry is not doing the production process.

Some ways to reduce the level of benzene in the workplace air is by opening all the windows, doors or vents available, thereby maximizing the exchange of air that is in the workplace. In addition, if it is possible for the production process to be carried out in an open area such as on the veranda of a house or if in a closed room and using air conditioning, it should be given an exhaust fan in the workspace. Optimization of ventilation should be a priority target for changes in exposure to benzene vapors in the printing industry. The use of personal protective equipment (PPE) must also be in accordance with potential hazards in the workplace, so that benzene vapors are not directly exposed by workers in the production room.

4 CONCLUSION

1. The measurement results of benzene in the air of the working environment of the printing industry that exceeds the threshold value according to Permenaker RI No. 5 2018 which is equal to 0,5 mg/m³. From 6 printing industries, there are 2 printing industries which pass threshold value, namely printing industry 1 at 1,5602 mg/m³ and printing industry 2 at 0,9366 mg/m³.
2. A total of 50 printing industry workers were the subject of research, there were 38 people (76%) were male and 12 people (24%) were female, the majority of the duration of > 8 hours of exposure were 35 people (70%), working period ≥ 2 years totaling 36 people (72%), there were no health complaints totaling 31 people (62%), no smoking totaling 33 people (66%), and not using PPE totaling 43 people (86%).
3. Workers who have anemia are 17 people (34%) out of 50 workers who are respondents. Workers who experienced anemia were 11 men (28,9 %) and 6 women (50%).
4. Chi-square test results showed a significant relationship between duration of exposure with anemia with a p value of 0.001 (p < 0,05) and there was a significant relationship between benzene levels with anemia with a p value of 0.016 (p <0,05).
5. The results of the multiple logistic regression test showed that the levels of benzene most influence on anemia, levels of benzene chance to anemia by 44,5 %.

5 SUGGESTION

1. For Workers
   Workers can increase knowledge about health in the workplace by using PPE in the workplace to minimize exposure to benzene that enters the worker's body, such as use Chemical Cartridge type masks, optimizing air vents and turn on the exhaust fans.
2. For Owners
   Owners of printing should carry out periodic health checks, provide appropriate PPE and make rules or sanctions if workers are negligent and do not use the PPE provided, and perform a work rotation system.
3. For the Department of Labor
   The Manpower Office can make policy and monitor existing regulations.

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