Relationship between Toluene Concentration, Malondialdehyde (MDA) Level and Health Complaints in Workers of Surabaya Printing Industry

Pradita Sekar Ayu[1], Abdul Rohim Tualeka[2], Shintia Yunita Arini[3], Syamsiar S Russeng[4], Pudji Rahmawati[5], Ahsan Ahsan[6], Indri H Susilowati[7]

[1]Research Scholar, Department of Occupational Health and Safety, Public Health Faculty, Airlangga University, Surabaya, Indonesia, [2]Professor, Department of Occupational Health and Safety, Public Health Faculty, Airlangga University, Surabaya, Indonesia, [3]Research Scholar, Department of Occupational Health and Safety, Public Health Faculty, Airlangga University, Surabaya, Indonesia, [4]Professor, Department of Occupational Health and Safety, Public Health Faculty, Hassanudin University, Makassar, Indonesia, [5]Professor, Department of Development of Islamic Society, State Islamic University Sunan Ampel, Surabaya, Indonesia, [6]Professor, Public Health Faculty, Brawijaya University, Malang, Indonesia, [7]Professor, Public Health Faculty, Indonesia University, Depok, Indonesia

Abstract

Introduction: Toluene is one of the chemical compounds used in the production process in the printing industry. Exposure toluene that exceeds the threshold value continuously can result in increased levels of malondialdehyde and the possibility of experiencing various health complaints. The purpose of this study was to determine the relationship between toluene concentrations, malondialdehyde levels and health complaints in workers at X Surabaya printing.

Methods: This research is observational with quantitative approach and cross sectional design. The study was conducted on workers in X Surabaya printing. The number of respondents in this study were 19 people. The variables studied were toluene concentration, malondialdehyde levels, and health complaints. Data were analyzed using Pearson correlation test.

Result: The average concentration of toluene was 1.2311 ppm and the average concentration of malondialdehyde was 8,323 MU. Pearson correlation test results showed the relationship of toluene concentration with malondialdehyde obtained p value = 0.508 (p> 0.05). While the results of health complaints that were most experienced were coughing (74%), headaches (63%) and shortness of breath (26%).

Conclusion: There is no significant relationship between toluene concentration and malondialdehyde level. While the most commonly experienced health complaints are coughing, headaches, and shortness of breath.

Key Word**:** *Malondialdehyde levels, health complaints, toluene concentration*

Corresponding author:
Abdul Rohim Tualeka,
Department of Occupational Health and Safety, Public Health Faculty, Airlangga University, 60115, Surabaya, East Java, Indonesia; abdul-r-t@fkm.unair.ac.id; +6281333519732

Introduction

Informal industrial sector is frequently found in developing countries such as Indonesia. One industry that is developing both on a small and large scale is the printing industry. Each industrial sector has certain risks and potential hazards. In the production process in the printing industry is inseparable from the use of

chemicals. One of the chemicals used is volatile organic compounds or Volatile Organic Compounds (VOCs) which are usually used as solvents. Organic solvents are widely used in printing activities such as tin, copper, and other metals[1]. Materials that are often used in general are toluene. Toluene is widely used in printing activities. Toluene is used in 75% of work activities in printing. The use of toluene dominates the printing ink components around 60-75%[2].

Toluene is a chemical compound that belongs to the aromatic hydrocarbon group. In the printing industry thinner is used as a solvent, printing ink and glue that causes the risk of exposure to toluene vapor due to its volatile nature. Thinner has a strong and pungent odor so that it can irritate the eyes and breathing[3]. These toxic chemicals can spread during the production process and affect the health of exposed workers. ACGIH (2019) recommends the toluene threshold (TLV) value at work is 20 parts per million (ppm) with a dose of toxic gas based on 8 hours / day 40 hours / week of work time[4]. Toluene can enter the body through three pathways namely inhalation, ingestion and skin contact. The volatile nature of toluene causes the easy entry of these substances through the respiratory tract. Toluene that is absorbed is distributed throughout the body, especially in tissues that contain lots of fat such as adipose tissue, brain bone marrow, kidneys and liver. Toluene is detoxified in the liver before it is excreted out of the body through urine in the form of hipuric acid[5].

Toluene metabolism can also produce toluene epoxide which is very reactive and is a free radical. If there is an imbalance in the amount of oxidants and antioxidants in the body, conditions of oxidative stress can occur. One of the biomarkers of oxidative stress is the activity of lipid peroxidation that can be measured from the levels of malondialdehyde (MDA) in organs. Malondialdehyde is a compound that is used as one of the instructions for oxidative stress because it can describe the activity of free radicals in cells[6]. Lipid peroxidation is a continuous reaction of free radical oxidation to lipids. Oxidation of free radicals to lipids produces malondialdehyde compounds. An increase in malondialdehyde levels indicates an increase in free radicals or oxidants in the blood. If there is an increase in free radicals continuously, then lipid peroxidation will produce more free radicals that damage tissue. High MDA levels indicate the oxidation process in the cell membrane, conversely a decrease in MDA levels is generally followed by an increase in high antioxidant status[7].

Continuous exposure toluene can have adverse effects on health. Workers who use toluene as a solvent can be affected by health problems such as dizziness, vertigo, eye irritation, skin irritation, breathing, liver, kidney, and central nervous system disorders[5]. Exposure toluene can have acute and chronic effects on the human body system. Workers who are exposed to this substance can experience neuropsychological symptoms, such as mild headaches, fatigue, and cognitive impairment. The effects of solvents on psychological conditions and emotional disorders include depression, headaches, fatigue, anxiety, feelings of motion sickness, and insomnia. Other disorders may include difficulty concentrating or remembering, fatigue and drowsiness. Low toluene exposure to the nerves can cause neurological disorders[8]. There are many factors in the use of solvents related to neurological disorders including personal factors such as age and gender, inappropriate behavior such as smoking and alcohol consumption, not using personal protective equipment such as masks and gloves, improper working conditions, working hours long, and also exposure pathways to the body such as the respiratory tract and skin[9]. A serious health problem with toluene is its effect on the central nervous system which can occur temporarily, such as headaches, dizziness or unconsciousness[10].

Workers who are exposed to toluene are more likely to experience complaints of short or forgetful memory, often feel irritated for no particular reason, often feel depressed for no particular reason, have abnormal heart beats, often sweat for no particular reason, often headaches, weakness in the arms or legs and trembling in the hands[11]. Based on preliminary studies, the room where the respondent works has a poor ventilation system. This causes toluene vapor does not circulate properly in the room and can be inhaled by workers. Most workers rarely use Personal Protective Equipment (PPE) such as masks because they feel uncomfortable and sometimes forget to wear while doing their work.

Methods

This research is observational with quantitative approach and cross sectional design. The study was conducted on workers in X Surabaya printing. The number of respondents in this study were 19 people. The variables studied were toluene concentration, malondialdehyde levels, and health complaints. Data

were analyzed using Pearson correlation test.

Data on the characteristics of respondents were obtained through a questionnaire. The concentration of toluene in the air was measured at three points using the NIOSH 1501 method with the Gas Chromatography Technique[12]. The measurement was carried out by the Work Safety and Health Technical Implementation Unit (UPTK3) Surabaya. Measurement of malondialdehyde (MDA) levels was carried out by taking respondent's blood samples and then analyzed at the Nutrition Laboratory of Airlangga University. Health complaints experienced by respondents were obtained through a questionnaire. Testing and data analysis using Pearson correlation test.

Result

Characteristics of Respondents

Table 1. Characteristics of Respondents

Characteristics of Respondents	Frequency	Percentage
Gender		
Male	15	79%
Female	4	21%
Age		
16-25	2	11%
26-35	4	21%
36-45	8	42%
46-55	3	15%
56-65	2	11%
Years of Service		
< 10 years	10	53%
≥ 10 years	9	47%

Based on table 1, most workers were male (79%), aged 36-45 years (42%), had ten years of service <10 years (53%).

Toluene Concentration

Table 2. Distribution of toluene concentrations in X Surabaya printing

Measurement Point	Toluene Concentration (ppm)
Point 1	0,3050
Point 2	2,1516
Point 3	0,4271

Based on table 2, the measurement results show the concentration of toluene at point one in the bending part is the lowest (0.3050 ppm). The second point on the printing press is the highest (2.1516 ppm). The third point in the sorting and finishing (0.4271 ppm). The average measurement of toluene concentration in the air was 1.2311 ppm. The measurement results of toluene concentration in Surabaya X printing air show that the concentration of toluene in the workplace air has not exceeded the TLV set in Indonesian Ministry of Manpower and Transmigration Regulation no. 05 in 2018 (20 ppm).

Malondialdehyde levels

Table 3. Distribution of malondialdehyde levels in X Surabaya printing workers

Respondent number	MDA (MU) Level
1	5.279
2	9.680
3	7.340
4	7.710
5	5.397
6	10.735
7	4.351
8	12.168
9	11.120
10	5.232
11	5.139
12	5.589
13	7.426
14	8.915
15	12.863
16	14.402
17	10.214
18	7.926
19	6.657

Based on table 3 of the 19 respondents who had taken blood samples the highest levels of malondialdehyde were 14.402 MU and the lowest was 4.351 MU. The average yield of malondialdehyde workers in X Surabaya printing was 8,323 MU.

Relationship of Toluene Concentration and Malondialdehyde Level

Table 4. Statistical Test Results between Toluene Concentration and Malondialdehyde Level

Dependent Variable	Independent Variable	P value	Correlation coefficient
Toluene concentration in the air	Malondialdehyde levels	0,508	-0,162

Based on Pearson correlation test results there is no significant relationship between toluene concentration and malondialdehyde levels with a value of p = 0.508 (p> 0.05).

Health Complaints

Table 5. Distribution of health complaints of printing workers X Surabaya

Health Complaints	Yes		No	
	n	%	n	%
Headache	12	63%	7	37%
Tottering	1	5%	18	95%
Breathing problem	5	26%	14	74%
Cough	14	74%	5	26%
Decreased appetite	1	5%	18	95%
Sore eyes	2	10%	17	90%
High tempered	1	5%	18	95%
Nausea	2	10%	17	90%
Itchy Skin	1	5%	18	95%

Based on table 5, most respondents experienced health complaints due to exposure toluene at work, including coughing (74%), headaches (63%), and shortness of breath (26%).

Discussion

Of the three measurement points is the bending, printing, sorting and finishing the highest was 2.1516 ppm and the lowest was 0.3050 ppm with the average of 1.2311 ppm. From these results value of toluene concentration in printing air X did not exceed the toluene Threshold Value (TLV) determined by Indonesian Ministry of Manpower and Transmigration Regulation Number 05 of 2018 (20 ppm)[13]. Although the concentration of toluene is below the normal limit, continuous inhalation this can affect the amount of toluene that enters the body[14]. Workers exposed to toluene in the long term can potentially have a negative impact on the health of X Surabaya printing workers.

In this study no significant relationship was found between the concentration of toluene in the air and MDA levels in Surabaya X printing workers. However, the longer workers are exposed to toluene compounds, the more and accumulates in the body resulting in an increase in free radicals and lipid peroxidation. Lipid peroxidation subsequently results in MDA. Subandrate & Syafudin (2016) found that the average level of MDA in gas station employees was higher than the

average level of MDA control[15]. This is because the oxidant compounds in the gas station environment are metabolized into free radicals which oxidize lipids and form MDA. This is in line with Giyanti's research (2018) which states that MDA levels in the group exposed to shoe craftsmen are significantly higher than MDA levels in the group not exposed to toluene[16]. According to Moro et. al (2012), the levels of malondialdehyde were significantly higher in painters compared to controls with MDA levels relatively nearly as high as those of controls ($p < 0.001$)[17]. Research by Dewi & Ayuniastuti (2019) also shows that there are significant differences between the MDA levels of gas station attendants who are higher compared to the control group[18].

From the results of interviews with the questionnaire, health complaints experienced by Surabaya X printing workers were quite varied. The results of research on health complaints due to toluene exposure showed that the most common health complaints experienced by workers include coughing, headaches and shortness of breath. Based on research conducted in Magelang, complaints felt due to toluene exposure such as shortness of breath, dizziness, weakness and nausea[19]. Other research conducted in the Ciomas shoe industry, Bogor, there were complaints or health problems that were felt more than 50% were colds, fatigue, headaches, and tingling. The complaint is thought to be due to acute exposure to toluene[20].

Haen & Oginawati's research (2012) conducted in the shoe industry shows that many respondents have health complaints that are identical to the symptoms of BTX exposure, including dizziness, nausea, weakness and shortness of breath[21]. A study in Thailand described psychosomatic symptoms including headaches, shortness of breath, lethargy, fatigue, nausea, vomiting, and loss of appetite in workers exposed toluene[9]. Not using PPE when working can increase exposure to toluene that enters the body through inhalation and results in an increased risk of health complaints experienced by workers. This is most likely caused by risky behavior of workers, where most workers do not wear masks when working.

Conclusion

The results of this study indicate that there was no significant relationship between the concentration of toluene in the air and malondialdehyde levels in X Surabaya printing workers. The concentration of toluene in the air in Surabaya X printing is safe because it is under the TLV recommended by Indonesian Ministry of Manpower and Transmigration Regulation No. 5 of 2018. The higher the toluene concentration, the higher the concentration of malondialdehyde in workers. Health complaints due to toluene exposure are most numerous and often experienced by workers including coughing, headaches, and shortness of breath.

Acknowledgement: The authors would like thank to all parties involved in this research. Especially, workers in Surabaya X Printing which has allowed the data collection.

Conflict of Interest: Nil

Source of Funding: The source of this research cost from self

Ethical Clearance: The study was approved by ethical clereance certificate Number: 605/HRECC. FODM/IX/2019 from the institutional Health Research Etchical Clereance Commision, Airlangga University

Reference

1. Marganda S, Ashar T, Nurmaini N. The Effect of Toluene Exposure on Central Nervous Disorder among Printing Workers. *Indones J Med*. 2018;3(3):125-133. doi:10.26911/theijmed.2018.03.03.01
2. Pratamasari F, Setyopranoto I, Soebijanto S. Pajanan Toluen Udara dan Kejadian Neuropati Saraf Tepi di Percetakan Offset. *Ber Kedokt Masy*. 2016:359-366. doi:10.22146/bkm.8254
3. Irmasari F. Kadar Toluen di Udara Lingkungan Kerja Berkorelasi terhadap Kadar Asam Hipurat Urine pada Pekerja Percetakan di Rungkut Surabaya. *J Kesehat Lingkung*. 2018;10(2018):328-335. https://e-journal.unair.ac.id/JKL/article/view/7239/5782.
4. ACGIH. *TLVs and BEIs: Treshlol Limit Values for Chemical Substance and Physical Agents & Biological Exposure Indices*. Cincinnati: American Conference of Government Industrial Hygienist; 2019.
5. Agency for Toxic Substance and Disease Registry. *Toxicological Profile for Toluene*. Atlanta: U.S. Department of Health and Human Services; 2017.
6. Ismanto H. HUBUNGAN KADAR TIMBAL (Pb) DENGAN KADAR MALONDIALDEHID

(MDA) DALAM DARAH PADA IBU HAMIL DI WILAYAH PANTAI KABUPATEN BREBES. *J Kesehat Masy*. 2019;7(2):54-63. doi:10.14710/mkmi.18.2.28-34

7. Kahar, Soedjajadi, Sulistyorini L. Particulate Matter (PM 2 , 5) Increases MDA Levels Serum of Workers at Surabaya Bus Station. *Int J Res Advent Technol*. 2016;4(7):12-15. doi:10.13140/RG.2.2.20370.40640
8. Tualeka AR, Wibrata DA, Ilmi B, Ahsan A, Rahmawati P. Association Between Toluene Inhalation Exposure and Demography Towards Risk of Neurotoxic: A Cross-Sectional Study at Plastic Sack Industry Workers in Indonesia. *Glob J Health Sci*. 2019;11(2):20. doi:10.5539/gjhs.v11n2p20
9. Thetkathuek A, Jaidee W, Saowakhontha S, Ekburanawat W. Neuropsychological Symptoms among Workers Exposed to Toluene and Xylene in Two Paint Manufacturing Factories in Eastern Thailand. *Adv Prev Med*. 2015;2015:1-10. doi:10.1155/2015/183728
10. Phanprasit W, Songpek K, Boonyayothin V, Sujirarat D. Inhalation and dermal exposure to toluene among printing workers in a plastic bag factory. *J Heal Res*. 2019;33(1):68-79. doi:10.1108/JHR-06-2018-0031
11. Agustina U, Mukono J. Keluhan Sistem Saraf Pusat pada Pekerja yang Terpapar Toluen di Udara di Bengkel Pengecatan Mobil di Surabaya. *J Kesehat Lingkung*. 2017;9:31-39. doi:http://dx.doi.org/10.20473/jkl.v9i1.2017.31-39
12. NIOSH. 2003. *Hydrocarbons, Aromatic : Method 1501*. *NIOSH Manual of Analytical Methods Issue 3*
13. Permenaker RI No. 5. Peraturan Menteri Ketenaga Kerjaan Republik Indonesia No. 5 tahun 2018 tentang Keselamatan dan Kesehatan Kerja Lingkungan Kerja. *J Pendidikan, Teknol dan Kejuru*. 2018;4(2):200-207. doi:http://dx.doi.org/10.1016/j.fuel.2013.09.033
14. Prihartini, N. 2010. *Analisis Risiko Kesehatan Pajanan Toluen pada Pekerja Bengkel Sepatu X di Kawasan Perkampungan Industri Kecil (PIK) Pulogadung Jakarta Timur* [*Tesis*]. Fakultas Kesehatan Masyarakat Universitas Indonesia
15. Subandrate, Safyudin. Kadar MDA (Malondialdehid) Karyawan SPBU di Kota Palembang. *J Kedokt dan Kesehat*. 2016;2(3):277-281.
16. Giyanti DA. *Pengaruh Pajanan Uap Toluena Di Udara Terhadap Kadar Enzim Superoxide Dismustase (SOD) Dan Malondialdehyde (MDA) Serum Pengrajin Sepatu*.; 2018.
17. Moro AM, Brucker N, Charão M, et al. Evaluation of genotoxicity and oxidative damage in painters exposed to low levels of toluene. *Mutat Res - Genet Toxicol Environ Mutagen*. 2012;746(1):42-48. doi:10.1016/j.mrgentox.2012.02.007
18. Dewi NK, Ayuniastuti. Glutathione and malondialdehyde levels in gas station attendants of Semarang city. *J Phys Conf Ser*. 2019;1321(3):8-12. doi:10.1088/1742-6596/1321/3/032039
19. Mahendra Amien MS, Jayanti S, Suwondo A. Hubungan Paparan Toluene Dengan Gangguan Fungsi Hati Pada Pekerja Bagian Pengecatan Sebuah Industri Karoseri Di Magelang. *J Kesehat Masy*. 2015;3(1):395-404.
20. Laelasari E, Kristanti D, Rahmat B. Penggunaan Lem Sepatu Dan Gangguan Kesehatan Pekerja Industri Sepatu Di Ciomas, Bogor. *J Ekol Kesehat*. 2018;17(2):85-95. doi:10.22435/jek.17.2.150.85-95
21. Haen MT, Oginawati K. Hubungan Pajanan Senyawa Benzena, Toluena dan Xylen dengan Sistem Hematologi Pekerja di Kawasan Industri Sepatu. 2009:1-4.