Waluya The International Science Of Health Journal
Vol.4 No.2

ISSN: 2829-2278

WALUYA THE INTERNATIONAL SCIENCE OF HEALTH JOURNAL

Magnitude of Toluene Exposure Risk in Digital Printing in Kendari City

Asrif Atmin, Erwin Azizi Jayadipraja, Aziz Harun

Mandala Waluya University, Indonesia
Correspondence: asrifatmin@gmail.com

ARTICLE INFO

Article history
Received : May 31th, 2025
Revised : June 23th, 2025
Accepted : June 29th, 2025

Keywords
Toluene Exposure,
Printing Industry Workers.

ABSTRACT

Introduction: Initial survey of the number of Printing companies in Kendari City as many as 20 companies, the production produced includes printing billboards, banners, invitation printing industry, stickers, business cards, screen printing industry for cloth, clothes and other basic materials. Shows that workers in the printing company will be at great risk of exposure to chemicals in the production process while working in printing. So the author conducted a study entitled Analysis of Toluene Exposure Risk in Digital Printing Industry Workers in Kendari City.

Method: The study used a quantitative approach with a descriptive survey method, the sample consisted of 100 employees, with detailed evaluations of 35 respondents in 7 locations. Air measurements were conducted on December 20, 2022 to determine the concentration of toluene, which ranged from 0.051 to 0.118 ppm.

Result: The majority of respondents had a high school education (82.86%), were over 30 years old (57.14%), and were male (91.43%). Although the toluene concentration was far below the threshold of 50 ppm, the highest Intake (I) value was recorded at 0.481 mg/kg/day. Of the 35 HQ values analyzed, 15 exceeded 1, indicating a high health risk. In addition, 32 RQ values indicated a high carcinogenic risk.

Conclusion: The need for good risk management even though toluene concentrations are within safe limits and the variation in health risks among workers indicates the importance of continuous monitoring and better risk management.

Introduction

Law of the Republic of Indonesia Number 36 of 2009 concerning Health in Article 164 states that occupational health efforts are aimed at protecting workers to live healthily and be free from health problems and negative effects caused by work. Article 165 paragraph 1 also states that workplace managers are required to carry out all forms of health efforts through prevention, improvement, treatment and recovery for workers. In addition, paragraph 2 states that workers are

required to create and maintain a healthy workplace and comply with applicable regulations in the workplace.[1]

Based on data from the International Labor Organization (ILO) in 2020, 1 (one) worker in the world dies every 15 seconds due to work accidents and 160 workers experience work-related diseases.[2] The results of the ILO survey stated that Indonesia is ranked second lowest in the world in the implementation of K3, which is ranked 152 out of 153 countries. It was explained that out of 15,043 large-scale companies, only around 317 companies (2.1%) implemented SMK3 and the occupational safety standards in Indonesia are also the worst when compared to other countries in the Southeast Asia region. This can be associated with the still high number of accidents and illnesses due to work in Indonesia.[3]

Industrial development in Indonesia is currently progressing rapidly in line with the demands for various types of products.[4] To meet these needs, many industries have been established, both large-scale and home industries. With the growth of these industries, it is undeniable that chemicals will be used, both as mixtures and as raw materials.[5]

Printing is a technology or art that produces copies of an image very quickly, such as words or pictures (images) on paper, cloth, and other surfaces. Every day, billions of printed materials are produced, including books, calendars, bulletins, magazines, newspapers, posters, wedding invitations, stamps, paper, walls, and cloth. This is because printing can quickly communicate thoughts and information to millions of people. Printing is considered one of the most important and influential inventions in the history of human civilization.[6]

The rapid growth of the printing industry in Indonesia has increased the use of machines and chemicals in this industry.[7] Thus the potential danger and risk of poisoning, accidents, and occupational diseases and the effects and adverse effects caused by machines, materials or chemicals are relatively very large. Some of the chemicals often used in Printing are benzene, toluene and isopropanol.[8]

The raw materials used in production contain chemicals, one of which is benzene. Sources of benzene in printing can come from ink cartridges, cylinders on uncovered printers, paper webs, paper outlets, ink spills, and ink filling funnels. In addition to benzene vapors coming out of printing machines, workers can also be exposed to benzene from activities they do such as pouring solvents to clean cylinders or ink containers.[9]

Materials that have the potential to cause skin irritation in the printing industry include alcohol, alkali, developer, ink, fat, wax, caustic soda, chlorine, washing solution, hand cleanser, thinner, etc. While materials that can cause allergic contact include potassium dichromate, formaldehyde, paint, hydroquinone glue, and adhesive glue.[10]

In addition to benzene, toluene is also widely used in the printing industry. Toluene dominates the components of printing ink around 60-75%. Some printing processes produce high doses of toluene exposure. High doses of toluene exposure occur during the cleaning process.[11]

The concentration of isopropanol in the air is 237.53 ppm. The correlation of isopropanol exposure in the air with oxalate crystal sedimentation in urine shows a very strong correlation of around 0.5, this shows that the higher the exposure to isopropanol, the higher the oxalate crystal sedimentation. The effects of isopropanol exposure can cause neurological effects and chronic kidney toxicity.[12]

Kendari City is the center of activity in Southeast Sulawesi Province which has extraordinary appeal so that industrial development has progressed very rapidly. One of the industries that has progressed rapidly in Kendari City is the Graphic Industry, namely the Printing Industry. The magnitude of the estimated impact that occurs for workers in printing due to exposure to benzene, toluene and isopropanol so that it is necessary to make efforts to prevent and control the concentration of exposure to benzene,

toluene and isopropanol on the health of workers in printing in Kendari City, So the author conducted a study entitled Analysis of Toluene Exposure Risk in Digital Printing Industry Workers in Kendari City.

Method

The study used a quantitative approach with a descriptive survey method, conducted from November 2022 to February 2023 in 20 printing industries. The sample consisted of 100 employees, with detailed evaluations of 35 respondents in 7 locations. Air measurements were conducted on December 20, 2022 to determine the concentration of toluene, which ranged from 0.051 to 0.118 ppm. The analysis includes the calculation of Intake (I), Hazard Quotient (HQ), and Risk Quotient (RQ) values, as well as the application of Root Cause Analysis (RCA) and Failure Modes and Effects Analysis (FMEA).

Result

Table 1 based on the data in table, the results of laboratory tests show that the concentration of toluene in seven digital printing industries in Kendari City ranges from 0.051 to 0.118 ppm, with a conversion value of 0.192 to 0.444 mg/m³. All of these results are well below the threshold set at 50 ppm (188 mg/m³), indicating that toluene exposure at these locations is still within safe limits. This indicates that the health risks associated with toluene exposure for workers in the digital printing industry in Kendari City are relatively low. However, it is still important to monitor and control exposure to ensure that working conditions remain safe and there is no increase in long-term health risks for workers.

Table 2 based on the distribution table of exposure frequency, working period, and average period of exposure time of workers in the digital printing industry in Kendari City, it can be seen that the majority of workers are exposed to toluene for 9 hours per day with an exposure frequency of 194-250 days per year. The working period varies from 5 to 8 years, with the weight of workers ranging from 53 to 74 kg. The average exposure period is between 970 and 1750 days, indicating the long duration of exposure during the working period. The inhalation rate used in the calculation is 0.83 m³/hour, reflecting the average working conditions with a moderate load. These data indicate that although the frequency and duration of exposure are high, the measured toluene concentration is below the safe threshold, indicating that toluene exposure in workers is still within the acceptable tolerance limit according to applicable standards.

Table 1.
Distribution of Laboratory Examination Results of Toluene Concentration Using the Gas Chromatography Method

No	Digital Printing Industry Name	Sample Result (ppm)	Conversion Value (mg/m³)
1	Alif Matahari Printing Jl. Rema Fruit	0.118	0.444
2	Anugrah Printing Jl. Martandu	0.118	0.444
3	Idalia Printing Jl. Martandu	0.118	0.444
4	Gravira Printing Jl. Malik Raya	0.065	0.244
5	Kace Grafika Printing Jl. Sorumba	0.065	0.244
6	Brother Printing 66 Jl. Baruga	0.051	0.192
7	Azriel Printing Jl. Malaka	0.051	0.192

Table 2.
Frequency Distribution of Exposure (Intake (i)), Working Period and Average Period of Exposure Time

No Response	Exposure Time (tE) / hour / day	Frequency of Exposure (fE) / Day	Working Period (Years) Dt	Body Weight (Wb) (Kg)	Average Time Period (tavg)	Inhalation Rate (R) 0.83/hour
1	9	250	7	62	1750	7.47
2	9	250	6	54	1500	7.47
3	9	250	6	61	1500	7.47
4	9	250	5	72	1250	7.47
5	9	250	6	56	1500	7.47
6	9	194	6	53	1164	7.47
7	9	194	7	55	1358	7.47
8	9	194	8	71	1552	7.47
9	9	194	6	60	1164	7.47
10	9	194	6	65	1164	7.47
11	9	194	7	65	1358	7.47
12	9	194	6	73	1164	7.47
13	9	194	5	65	970	7.47
14	9	194	6	66	1164	7.47
15	9	194	7	54	1358	7.47
16	9	194	6	56	1164	7.47
17	9	194	6	66	1164	7.47
18	9	194	8	71	1552	7.47
19	9	194	7	60	1358	7.47
20	9	194	6	65	1164	7.47
21	8	194	8	64	1552	6.64
22	8	194	8	57	1552	6.64
23	8	194	6	59	1164	6.64
24	8	194	5	63	970	6.64
25	8	194	5	74	970	6.64
26	8	250	5	71	1250	6.64
27	8	250	5	54	1250	6.64
28	8	250	6	56	1500	6.64
29	8	250	7	66	1750	6.64
30	8	250	5	54	1250	6.64
31	8	194	6	60	1164	6.64
32	8	194	7	60	1358	6.64
33	8	194	6	67	1164	6.64
34	8	194	6	69	1164	6.64
35	8	194	5	66	970	6.64

Discussion

From this study, it can be seen that the amount of toluene exposure varies between respondents, influenced by factors such as exposure time, exposure frequency, work period, body weight, and inhalation rate. The data shows that respondents with higher daily exposure time and annual exposure frequency tend to have higher Intake (I) values. For example, Respondent 1 who works for 9 hours per day with a frequency of 250 days per year for 7 years has the highest Intake value of 0.481 mg/kg/day. This reflects that individuals with higher exposure time and frequency are at greater risk of health impacts due to toluene exposure.

Other respondents such as Respondent 2 and Respondent 3, although having the same duration and frequency of exposure as Respondent 1, showed lower Intake values due to their different body weights. In contrast, Respondents with lower exposure times, such as Respondent 35 who worked for 8 hours per day with a frequency of 194 days per year for 5 years, had a much lower Intake value, which was 0.041 mg/kg/day. This shows that reducing the time and frequency of exposure as well as individual factors such as body weight can significantly affect the magnitude of the health risk received.

According to the toluene exposure standard, workplace exposure to this substance must be managed to remain below the threshold set by the occupational safety and health regulatory agency. Based on regulations from the Occupational Safety and Health Administration (OSHA) and the American Conference of Governmental Industrial Hygienists (ACGIH), the maximum limit for airborne toluene exposure is 50 ppm (188 mg/m³) for an 8-hour workday.[13]

This standard is based on research showing that exposure to toluene above these levels can cause negative health effects, including central nervous system disorders, eye and respiratory tract irritation, and liver and kidney damage.[14] In the context of this study, the results showing toluene concentrations between 0.051 to 0.118 ppm (0.192 to 0.444 mg/m³) indicate that exposure in the digital printing work environment in Kendari City is still within safe limits.

Overall, the variation of toluene Intake (I) values among respondents ranged from 0.038 to 0.481 mg/kg/day. These values illustrate the differences in health risks faced by digital printing workers in Kendari City. Although all values are below the limits considered hazardous, it is important to consider that health risks remain, especially for those with higher Intake values.[15]

Toluene is known to affect the central nervous system and can cause disorders such as headaches, dizziness, and at high exposures, more serious effects such as liver and kidney damage.[16] Chronic exposure can result in neuropsychological disorders.[17] According to Dr. Linda Birnbaum in a toxicologist, toluene can cause systemic poisoning with symptoms ranging from eye and respiratory tract irritation to central nervous system disorders.[18] Epidemiological studies have shown that workers exposed to toluene in the long term are at higher risk of developing cognitive and neurobehavioral disorders.[19]

Based on regulations by the Occupational Safety and Health Administration (OSHA) the workplace exposure limit for toluene is 50 ppm (188 mg/m³) for an 8-hour workday. This rule is designed to protect workers from the acute and chronic effects of toluene exposure.[20]

American Conference of Governmental Industrial Hygienists (ACGIH): ACGIH also recommends the same exposure limit of 50 ppm (188 mg/m³) as the Threshold Limit Value (TLV) for full-time exposure for 8 hours a day (Smith and Perfetti, 2018). National Institute for Occupational Safety and Health (NIOSH): NIOSH recommends a more conservative exposure limit of 100 ppm for short-term (15 minutes) exposure to protect workers from the effects of high exposure for a short period of time.

The ACGIH Threshold Limit Value (TLV) for toluene is defined as 50 ppm, which is considered a level that is not expected to cause adverse health effects in nearly all workers (American Conference of Governmental Industrial Hygiene (ACGIH), 2020). The Permissible Exposure Limit (PEL) emphasizes that toluene is at 50 ppm, which is the legal limit that employers must adhere to protect worker health (Purpura, 2013). The NIOSH Recommended Exposure Limit (REL) sets the REL for toluene at 100 ppm for short-term exposure (15 minutes) and 25 ppm for long-term exposure (10 hours per day) (Dictionary of Toxicology, 2024).

It can be concluded that the magnitude of toluene exposure in Kendari city shows variations in toluene exposure in the workplace depending on the duration, frequency, work period, body weight, and inhalation rate of individuals. Workers with longer exposure and higher frequency have higher toluene Intake (I) values, increasing health risks. Although the toluene concentration in Kendari digital printing is within safe limits, variations in Intake (I) values indicate different health risks among workers. It is important to comply with OSHA and ACGIH exposure limits to protect workers from the health effects of toluene.

The implication of this study is that the management of toluene exposure risks in the digital printing industry needs to be improved by considering individual factors such as body weight and other worker characteristics. Emphasis on the use of appropriate personal protective equipment (PPE), better work time management, and the development of routine health monitoring programs can help reduce the health risks associated with toluene exposure.

Conclusion

The need for proper risk management even though toluene concentrations are within safe limits. Variations in health risks among workers indicate the importance of continuous monitoring and better risk management. The Health Department needs to conduct routine monitoring and education programs, while the Kendari City Government should strengthen regulations on hazardous chemicals. Printing business owners are advised to improve ventilation and provide PPE, while employees need to comply with safety protocols and raise awareness of the dangers of toluene. Future research should focus on the long-term effects of toluene exposure and more effective mitigation strategies, as well as the implementation of exposure reduction measures and worker education to maintain a safe work environment.

Reference

1. Syafrial, H. & Ardiansyah, A. Occupational Safety and Health (K3) Procedures at PT. Satunol Mikrosistem Jakarta.*Abiwara J. Vocational Adm. Business*1, 60–70 (2020).
2. Rachman, LA, Yulianto, FA, Djojosugito, A., Andarini, MY & Djajakusumah, TS The relationship between knowledge and attitude towards the behavior of using personal protective equipment at PT Sarandi Karya Nugraha Sukabumi.*J. Integr. Health. and Science*2, 154–159 (2020).
3. Haworth, N. & Hughes, S. The International Labor Organization.*Handb. Institutional Approaches to Int. Bus.*204–218 (2012).
4. Depu, AH & Marhanto, EDP The Relationship between Promotional Media on Cigarette Packaging and the Level of Susceptibility and Seriousness that Students Feel about Quitting Smoking in State High Schools of the Same Level in the City of Kendari.*Waluya Int. Sci. Heal. J.*3, 81–87 (2024).
5. Fischer, AP & Jasny, L. Capacity to adapt to environmental change: evidence from a network of organizations concerned with increasing wildfire risk.*Ecol. Soc.*22, (2017).
6. Laser, HN Business Planning of Online Printing Information System Based on Web Application.*IF (Journal of Inform.*1, (2017).
7. Fonna, N.*Development of the Industrial Revolution 4.0 in Various Fields*. (Guepedia, 2019).

8. Irmasari, F. Toluene Levels in the Work Environment Air Correlate with Urine Hippuric Acid Levels in Printing Workers in Rungkut Surabaya.*J. Health. Environment.*10, 328–335 (2018).
9. Febriantika, D., Sulistyani, S. & Budiyono, B. Analysis of Health Risk of Benzene Exposure in Printing Industry X, Semarang City.*J. Health. Society.*5, 430–437 (2017).
10. Siregar, AF, Ashar, T. & Nurmaini, N.Benzene exposure in ambient air and urinary trans- muconic acid levels in printing industry workers in Medan City. Ber. Kedokt. Masy. 35, 107–112 (2019).
11. Wulansari, I., Rusnaenah, A. & Imdam, IA Technical Training Assistance for Making Automotive Fragrances and Thinners in Small and Medium Industries.*J. Community Serv. Sustain.*1, 19–28 (2023).
12. Sahri, M., Jannah, FR, Dewi, AN & Azmi, DA Prevalence of Health Complaints in Printing Industry Workers. J. Ilm. Wahana Pendidik. 8, 273–279 (2022).
13. Lima, AR Tolueno: correlação entre limites de exposição ocupacional e indicadores biológicos de exposição.*Rev. Bras. Med. do Trab.*20, 633–641 (2022).
14. Kuranchie, FA, Angnunavuri, PN, Attiogbe, F. & Nerquaye-Tetteh, EN Occupational exposure of benzene, toluene, ethylbenzene and xylene (BTEX) to pump attendants in Ghana: Implications for policy guidance.*Cogent Environ. Sci.*5, 1603418 (2019).
15. Heine, K. & Eckhardt, A. Limit values and guideline values in regulatory toxicology.*Reg. Toxicol.*1–28 (2020).
16. Kurniawidjaja, LM, Lestari, F., Tejamaya, M. & Ramdhan, DH Basic concepts of industrial toxicology.*FKM UI*54–118 (2021).
17. Ogbodo, JO, Arazu, AV, Iguh, TC, Onwodi, NJ & Ezike, TC Volatile organic compounds: a proinflammatory activator in autoimmune diseases.*Front. Immunol.*13, 928379 (2022).
18. Kwok, R.K.*et al.*The Distinguished Legacy of Linda S. Birnbaum, an Environmental Health Champion. Environmental Health Perspectives vol. 127 101001 at (2019).
19. Antoniou, EE & Zeegers, MP The relationship between toluene diisocyanate exposure and respiratory health problems: A meta-analysis of epidemiological studies.*Toxicol. Ind. Health*38, 595–605 (2022).
20. Paustenbach, DJ, Cowan, DM & Sahmel, J. The history and biological basis of occupational exposure limits for chemicalsagents. in Patty's industrial hygiene vol. 3 1903–2000 (Citeseer, 2000).