

The Determination of Safe Concentration of Non-Carcinogenic Toluene in Surabaya Printing

Penentuan Konsentrasi Aman Toluena Non Karsinogenik di Percetakan Surabaya

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ABSTRACT

Introduction: Safe concentrations of non-carcinogenic toluene can cause adverse effects on health. Based on the results of a research, toxic effects on toluene exposure can cause cancerous (leukimia) and non-cancerous (aplastic anemia). The Research objective to determine the safe concentration of non-carcinogenic toluene in Surabaya printing. **Methods:** The research design used was observational analytic, cross sectional research design with a quantitative approach. The research location was a printing press in Surabaya. The variables in this study were the concentration of toluene levels (ppm) and RQ in workers. Total population was 37 workers, while the study sample was taken using accidental sampling method with a total sample of 30 respondents. The formula for determining the concentration of toluene non carcinogen intake is $(C \times R \times E \times f \times E \times D t) : (W \times b \times 30 \times 365)$. **Results:** The concentration value of toluene exposure was greater than the standard set by labor regulations No. 5 of 2018 about occupational health and safety of the work environment by 0.2 ppm. A total of 10% of workers falls under normal category, 73% above normal category and 27% below normal category. **Conclusion:** In this study, we found new findings, viz the concentration of toluene exposure in Surabaya printing area was above normal with a concentration of 0.2 ppm and this is considered not normal.

Keywords: non carcinogenic toluene, safe concentration, surabaya printing, toluene

ABSTRAK

Pendahuluan: Konsentrasi aman toluene non-karsinogenik dapat menyebabkan efek buruk pada kesehatan. Berdasarkan hasil penelitian, efek toksik terhadap paparan toluen dapat menyebabkan penyakit kanker (leukimia) dan non-kanker (anemia aplastik). Tujuan penelitian untuk mengetahui konsentrasi aman toluena non karsinogenik di percetakan Surabaya. **Metode:** Desain penelitian yang digunakan adalah analitik observasional, desain penelitian cross sectional dengan pendekatan kuantitatif. Lokasi penelitian adalah percetakan di daerah Surabaya. Variabel dalam penelitian ini adalah konsentrasi kadar toluena (ppm) dan RQ pada pekerja. Jumlah populasi sebanyak 37 pekerja, sampel penelitian diambil dengan metode accidental sampling dengan jumlah sampel 30 responden. Rumus untuk menentukan konsentrasi asupan non karsinogen toluen adalah $(C \times R \times E \times f \times E \times D t) : (W \times b \times 30 \times 365)$. **Hasil:** Nilai konsentrasi paparan toluen lebih besar dari standar yang ditetapkan oleh peraturan ketenagakerjaan No. 5 tahun 2018 tentang K3 Lingkungan Kerja sebesar 0,2 ppm. Sebanyak 10% pekerja berada di bawah kategori normal, 73% di atas kategori normal dan 27% di bawah kategori normal. **Simpulan:** Pada penelitian ini ditemukan temuan baru yaitu konsentrasi paparan toluena di percetakan Surabaya berada di atas normal dengan konsentrasi 0,2 ppm dan hal ini tergolong tidak normal.

Kata kunci: konsentrasi yang aman, percetakan surabaya, toluene, toluena non karsinogenik

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INTRODUCTION

Indonesia is a country with many small, medium and large industries. The rapid development of the industry can increase employment. However, this can also increase health risks. Occupational health risks can be caused by work accidents, exposure to hazardous chemicals, risky behavior for workers, or working environment conditions that are not in accordance with the requirements. One of the industries with the risk of hazardous chemicals exposure- especially benzene- is the printing industry (Irmasari, 2018).

There is no data regarding the use of toluene in industry in Indonesia. Toluene is a solvent that is most often used in the industrial sector, including solvents for paints, glues, pharmaceutical products, thinners, inks, additives for cosmetic products, plastics industry, and synthetic fibers. Meanwhile, for the domestic use, it is found in disinfectants and adhesives (Wispiyono and Handoyo, 2016). The printing and tanning process often uses toluene (Parekh et al., 2011).

BTX is a Volatile Organic Compound (VOC), a compound containing carbon which evaporates at a certain pressure and temperature or has high vapor pressure at room temperature. The most commonly known VOC is the solvents group. Other types of VOCs such as monomers and deodorizers are widely used (Tunsaringkarn et al., 2012; Joshi and Adhikari, 2019). Toluene is a volatile organic compound (VOC) which is highly volatile at room temperature and is the most used solvent. Data from the National Institute of Occupational Safety and Health reported that there were 4.8 million workers exposed to Toluene (Phanprasit et al., 2019). BTX is a toxic chemical, both carcinogenic or triggering cancer (Gammon and Santella, 2008; Reid et al., 2012; White et al., 2014), increases oxidative stress (Bae et al., 2010) and non-carcinogenic such as affecting the hematopoietic system, central nervous system and reproductive system (Smith, 2010; Sulistyanto et al., 2020; Tualeka et al., 2020).

Volatile Organic Compound (VOC) emissions can cause the spread of pollutants or dangerous pollution because it has been linked to several health impacts and environmental development conditions (Singh A.K., Tomer Neetu, 2012; Tualeka, Tri and Jalaluddin, 2019). Several studies have shown that VOCs, even at low concentrations, can produce adverse health effects including nausea, eye and throat irritation, induction of asthma attacks,

dizziness, fatigue, and mental health problems (Tunsaringkarn et al., 2012). VOCs have many types, but emphasis is placed on mono-aromatic volatile organic compounds, namely benzene, toluene, ethylbenzene, and xylene (BTEX). This type of VOC is often considered a carcinogenic compound (Heibati et al., 2018; Masekameni et al., 2018). Benzene and ethyl benzene exposure is usually associated with an increased incidence of hematopoietic cancer and a risk of leukemia (Khalade et al., 2010). Whereas toluene and xylene are not carcinogenic, but can cause adverse effects on reproductive organs. It usually occurs when the exposure is chronic at low to high concentrations (Wispiyono and Handoyo, 2016; Tualeka, Rahmawati, et al., 2019).

Benzene, Toluene and xylene (BTX) are several types of air pollutants which are Polycyclic Aromatic Hydrocarbons (PAH). PAH is formed due to incomplete combustion of organic matter, spreads in the environment and is mixed. The main sources of PAH exposure to humans are working environment, passive and active smoking (White et al., 2014) as well as food, water and air pollution (Bae et al., 2010; Almadiana and Tualeka, 2020; Oktavia et al., 2020; Sulistyanto et al., 2020).

Toxic properties of BTX in high levels of exposure cause neurotoxic symptoms. Continuous exposure to high levels of BTX can cause damage to the human bone marrow, damage to DNA in mammalian cells and damage to the immune system. Light concentrations exposure causes irregular heartbeat, dizziness, headache, nausea and even fainting. If exposure is prolonged, the initial manifestations of toxicity are anemia, leukocytopenia and thrombocytopenia (Singh A.K., Tomer Neetu, 2012; Singh et al., 2016).

Benzene and toluene exposure can also reduce levels of Leukocyte Telomere Length (LTL) (Haen and Oginawati, 2009; Sakizadeh, 2019). The main effect that can arise from xylen vapor exposure is depression in the central nervous system with symptoms such as headaches, dizziness, nausea and vomiting. All of these symptoms can occur at 100 ppm exposure (U.S Environmental Protection Agency, 2005).

The money and time needed to reduce BTX emissions from outside sources is higher than required for the reduction of active and passive smoking. However, reducing BTX emissions from external sources is certainly more beneficial to the public and more effective in terms of reducing

atmospheric pollution globally (Wispriyono and Handoyo, 2016). The improvement of air quality to minimize health effects in the workplace include increasing the ambient and local ventilation, replacing the solvent-based products with water-based products, and establishing routines to maintain container closure after use (Cruz, Rivera-García and Woodward, 2014; Thetkathuek et al., 2015).

Safe concentrations of non-carcinogenic toluene can cause adverse effects on health. Based on the results of a research project, toxic effects on toluene exposure can cause cancerous (leukimia) and non-cancerous (aplastic anemia) forms (Al-Ghamdi et al. 2003; Fahrudhi 2017). The research explained that all shoe factory workers have non-carcinogenic and carcinogenic health risks. Toluene that enters through respiratory tract enters through the blood into the lungs, then it will quickly affect the workers' health in long term (Lee et al. 2005; Williams et al. 2015). The exposure of toluene that enters the nerve can cause nerve disorders. The nerve disorders are divided into two types those are neurotoxic and neuropathy (Fadhila, Soebijanto and Dr. dr. Ismail Setyopranoto, 2015).

Based on the research conducted by Irmasari, (2018) a study in Surabaya Rungkut printing industry found that high concentrations of toluene in the air could cause an increase in workers' urine hippuric acid levels (Irmasari, 2018). Gammon and Satella in their study mentioned that increased hippuric acid can have adverse effects on health, one of which is acute health ailments, eye irritation, and skin cancer (Gammon et al. 2008). Based on the research in toluene toxicology book, exposure to toluene causes nasal mucus flow or lung function at 100 ppm, but not at 10 or 40 ppm, causing eye and nose irritation, headaches, dizziness and drunk. In this study, a test of visual perception, psychomotor function, alertness and cortical function decreased due to high toluene exposure (U.S.Environmental Protection Agency 2005; Parekh et al. 2011).

Toluene is a non-carcinogenic toxin so the risk characteristics are expressed as a Risk Quotient (RQ) which can be calculated by dividing the intake value by reference (RfC). RQ is used as a benchmark for safe exposure that can be accepted by the human body. If the exposure received by workers exceeds the TLV for a long time, it can cause a disease (Zuhro, Tualeka and Harsetianingrum, 2018).

Based on research carried out by Wispriyono and Handoyo, it was found that toluene level is always below normal with tE \leq 8 hours/day, R

of 0.56 m³/hour and 18 years (Wispriyono and Handoyo 2016). Based on research performed by Fahrudi, it showed that the value of toluene exposure by RQ $>$ 1, tE of 10.55 hours/day and R of 0.635 m³/hour, 34 years, above normal (Fahrudhi 2017). Febriantika (2017) in his research in printing industry in Semarang City found that exposure to toluene was RQ $>$ 1, tE 8 hours/day and R of 1.4810 m³/hour which means above normal or above the threshold. The results of research conducted by Zuhro, Tualeka and Harsetianingrum, (2018) showed that the value of toluene exposure was always above normal with RQ $>$ 1, tE 10 hours/day and R of 1.267 m³/hour.

Based on various research results above, there has been no research report on the determination of safe concentration of non-carcinogenic toluene in Surabaya printing. Therefore, a research on the value of non-carcinogenic toluene concentration in Surabaya printing exposed to toluene needs to be carried out. The research objective is to determine the safe concentration of non-carcinogenic toluene in Surabaya printing. In the present research, the value of safe concentration of non-carcinogenic toluene in Surabaya printing was determined. The results of this study can provide input to the industry so that workers can avoid various diseases due to high toluene exposure.

METHODS

This is an observational analytic, cross-sectional research design with a quantitative approach to calculate and describe the data collected. Calculations in this study were carried out using a number of processing application (Microsoft Excel 2010). The study was carried out in printing press exposed to toluena in Surabaya due to the use of toluene as a solvent in its production process. This research was conducted from April 5 to November 31, 2019. The population in this study were 37 workers exposed to toluene. The research sample was taken using the accidental sampling method with a sample of 30 respondents.

The variables in this study included effective doses of intake needed by each individual by calculating body weight, length of work (years), average working period in every day (hours), and working time in a week (days), Risk Quotient (RQ) and measurement of toluene concentration. Weight measurement was carried out by using a manual weighing method with a body scale. Measurements

of working period, average daily work, and weekly working time were obtained through in-depth interviews with the respondents. The measurement of benzene in the work environment used an air sampling pump.

The inclusion criteria in this study were all workers exposed to toluene, aged ≥ 16 years, willing to participate (signing informed consent) and able to communicate. Workers with acute physical or mental illness, those taking medication for medical conditions, and those with infections and/or acute illnesses that might suppress their immune systems as well as pregnant women were excluded from the study. The research sample was taken using accidental sampling method which resulted in 81 respondents who met the inclusion and exclusion criteria.

Questionnaires were distributed and direct interviews were conducted to obtain information on general characteristics of the subjects including age, gender, body weight, job characteristics including daily working hours, duration of work, and years of working.

The air was taken from near the breathing zone during working hours. Sampling was taken using an absorber tube (charcoal tube), a low flow pump (0.05-0.1 liter/minute), and a personal sampling pump. The absorber tube was placed between the chest and nose (breathing zone) of the worker. After sampling, the contents of the tube were removed and dissolved in a solution of carbon disulfide (CS₂) and analyzed through Gas Chromatography, Flame Ionized Detector (GC/FID) based on the NIOSH method number 1501.

The formula for calculating toluene intake in workers is:

$$\text{Intake} - \text{nc} = \frac{C \times R \times tE \times fE \times Dt}{Wb \times 30 \times 365}$$

Where:

Intake-nc : Intake of non-carcinogen

- C : Agent Concentration (mg/m³)
 R : Toluene reaction rate (m³/hour)
 tE : Working time / day (hours)
 fE : Working time / week (days)
 Dt : Working time (years)
 Wb: Worker's Weight (kg)
 30 : Non-carcinogenic Toxins
 3655 : The number of days in a year

Risk quotient (RQ) was calculated using the following formula:

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

Where:

I = Non-carcinogenic Intake from the calculation of exposure (mg/kg/day)

RfC = Reference Concentration (mg/kg/day)

After RQ value was calculated, effective dose per day for workers was calculated using an RQ value > 1 using the formula below:

$$\text{Effective dose of food intake} = \left\{ \left(\text{Intake}_{nc} \times \frac{Mr \text{ Enzyme}}{Mr \text{ Toxin}} \right) - (C \text{ enzyme} \times 70) \right\} \times \frac{100}{A}$$

(Tualeka et al. 2019).

Data processing was carried out after data collection and interviews with respondents were conducted. The next process included editing, coding, data entry and tabulation. Univariate analysis yielded frequency and percentage distribution.

RESULTS

This research was conducted with a sample of 30 workers with the largest body weight characteristics was 87 and the smallest was 45. This study did not specifically explain the gender of the worker. Work is carried out on an average of 8 hours per day and 4-7 days a week. The longest period of worker worked is 24 years.

The RQ calculation results in table 1 show that if RQ value > 1 , agent concentration is at risk of causing adverse health effects. If RQ < 1 then agent concentration is not at risk of causing adverse health effects, yet can cause adverse health effects. The highest exposure to toluene levels was 2.15 ppm and 8.09 mg/m³.

The RFC used in this study was 0.05 according to the calculation of RQ formula. The highest intake value for non-carcinogenic toluene was 0.45, while the lowest was 0. Based on the calculations in table 2, from 30 respondents whose RQ values were calculated, there were 11 respondents with RQ value greater than 1 (RQ > 1).

The calculation of detox to toluene-exposed workers was carried out on these 30 respondents. A total of 36% of workers had a high risk of being affected on their health. Around 64% of workers

Table 1. The Characterization of Non-Carcinogen Risks in Surabaya Printing Workers 2019

| Toluene (ppm) | Toluene (mg/m ³) | Weight (kg) | Average working time per day (hours) | Working time per week (days) | Duration of working (years) | Breathing rate (m ³ /hour) | Intake | RfC | RQ |
|---------------|------------------------------|-------------|--------------------------------------|------------------------------|-----------------------------|---------------------------------------|--------|------|------|
| 1 | 3.8 | 76 | 8 | 7 | 15 | 0.67 | 0.09 | 0.05 | 1.81 |
| 0.04 | 0.16 | 60 | 8 | 4 | 20 | 0.62 | 0.01 | 0.05 | 0.12 |
| 1 | 3.8 | 55 | 8 | 6 | 10 | 0.6 | 0.08 | 0.05 | 1.49 |
| 0 | 0.01 | 53 | 8 | 7 | 15 | 0.59 | 0 | 0.05 | 0.01 |
| 0.04 | 0.16 | 60 | 8 | 6 | 12 | 0.62 | 0 | 0.05 | 0.07 |
| 1 | 3.8 | 68 | 8 | 6 | 5 | 0.64 | 0.03 | 0.05 | 0.65 |
| 0.04 | 0.16 | 68 | 8 | 6 | 4 | 0.64 | 0 | 0.05 | 0.02 |
| 0 | 0.1 | 67 | 8 | 6 | 9 | 0.64 | 0 | 0.05 | 0 |
| 0 | 0.1 | 50 | 8 | 7 | 6 | 0.58 | 0 | 0.05 | 0 |
| 0.04 | 0.16 | 66 | 9 | 7 | 2 | 5.59 | 0.01 | 0.05 | 0.11 |
| 0.04 | 0.16 | 83 | 8 | 7 | 13 | 0.62 | 0 | 0.05 | 0.06 |
| 2.15 | 8.01 | 87 | 8 | 7 | 7 | 0.7 | 0.1 | 0.05 | 2.02 |
| 0.43 | 1.6 | 50 | 8 | 7 | 10 | 0.58 | 0.04 | 0.05 | 0.82 |
| 2.15 | 8.09 | 60 | 8 | 6 | 24 | 0.62 | 0.45 | 0.05 | 8.87 |
| 2.15 | 8.09 | 52 | 8 | 7 | 6 | 0.59 | 0.12 | 0.05 | 2.43 |
| 0.43 | 1.6 | 49 | 8 | 7 | 9 | 0.57 | 0.04 | 0.05 | 0.75 |
| 2.15 | 8.09 | 65 | 8 | 6 | 8 | 0.63 | 0.14 | 0.05 | 2.81 |
| 0.31 | 1.15 | 65 | 8 | 6 | 1 | 0.63 | 0 | 0.05 | 0.05 |
| 0.31 | 1.15 | 60 | 8 | 7 | 15 | 0.62 | 0.04 | 0.05 | 0.79 |
| 2.15 | 8.09 | 55 | 8 | 6 | 14 | 0.6 | 0.28 | 0.05 | 5.47 |
| 2.15 | 8.09 | 55 | 8 | 5 | 20 | 0.6 | 0.4 | 0.05 | 7.81 |
| 0.43 | 1.6 | 51 | 8 | 7 | 6 | 0.58 | 0.03 | 0.05 | 0.49 |
| 0.43 | 1.6 | 50 | 8 | 7 | 10 | 0.58 | 0.04 | 0.05 | 0.82 |
| 2.15 | 8.09 | 60 | 8 | 7 | 13 | 0.62 | 0.25 | 0.05 | 4.8 |
| 2.15 | 8.09 | 70 | 8 | 7 | 15 | 0.65 | 0.26 | 0.05 | 5.01 |
| 0.43 | 1.6 | 62 | 8 | 7 | 2 | 0.62 | 0.01 | 0.05 | 0.14 |
| 0.43 | 1.6 | 60 | 8 | 7 | 5 | 0.62 | 0.02 | 0.05 | 0.37 |
| 0.43 | 1.6 | 45 | 8 | 6 | 10 | 0.55 | 0.05 | 0.05 | 0.88 |
| 0.43 | 1.6 | 60 | 8 | 5 | 4 | 0.62 | 0.02 | 0.05 | 0.29 |
| 2.15 | 8.09 | 65 | 8 | 7 | 4 | 0.63 | 0.07 | 0.05 | 1.4 |

fell under normal $RQ < 1$, which means that the agent was not at risk, yet their health is at risk if the exposure increases.

In table 2, the calculation of the safe concentration of toluene shows that the average exposure to toluene was 0.887 ppm with a maximum value of 2.15 ppm and the lowest value of 0 ppm. The average of $RQ > 1$ with a result of $1.67 > 1$, the highest or maximum exposure value of 8.87 with $RQ > 1$. The lowest value is high approaching 1 with a value of 0.88 toluene exposure.

The concentration value of toluene exposure was higher than the standard set by labor regulations

No. 5 of 2018 about occupational health and safety of the work environment by 0.2 ppm (Ministry of Manpower, 2018).

DISCUSSION

Toluene levels with $RQ = 6.97$ in printing industry in Medan was compared to the normal limit of $RQ > 1$ (Marganda et al. 2018). Inhalation and skin exposure to toluene among printing workers in plastic bag factories supports the finding. This suggests that the majority of workers of $RQ = 9.72$

Table 2. The Calculation of Safe Toluene Concentration (ppm) Surabaya Printing 2019

| No | Toluene (ppm) | RQ |
|-----------|---------------|----------|
| 1 | 1.00 | 1.809342 |
| 2 | 0.04 | 0.121743 |
| 3 | 1.00 | 1.488819 |
| 4 | 0.00 | 0.008231 |
| 5 | 0.04 | 0.073046 |
| 6 | 1.00 | 0.649315 |
| 7 | 0.04 | 0.022447 |
| 8 | 0.00 | 0.00425 |
| 9 | 0.00 | 0.003414 |
| 10 | 0.04 | 0.112967 |
| 11 | 0.04 | 0.057668 |
| 12 | 2.15 | 2.020519 |
| 13 | 0.43 | 0.822443 |
| 14 | 2.15 | 8.865256 |
| 15 | 2.15 | 2.426236 |
| 16 | 0.43 | 0.749459 |
| 17 | 2.15 | 2.80596 |
| 18 | 0.31 | 0.04972 |
| 19 | 0.31 | 0.785434 |
| 20 | 2.15 | 5.46574 |
| 21 | 2.15 | 7.8082 |
| 22 | 0.43 | 0.487461 |
| 23 | 0.43 | 0.822443 |
| 24 | 2.15 | 4.802014 |
| 25 | 2.15 | 5.011415 |
| 26 | 0.43 | 0.143584 |
| 27 | 0.43 | 0.366622 |
| 28 | 0.43 | 0.876938 |
| 29 | 0.43 | 0.293297 |
| 30 | 2.15 | 1.40298 |
| Average | 0.887 | 1.678667 |
| Maximum | 2.15 | 8.87 |
| Minimum | 0 | 0.88 |
| Above TLV | 74% | 36% |
| Below TLV | 26% | 64% |
| TLV | 0.2 ppm | |

above the threshold limit can cause respiratory problems and skin cancer (Valcke et al. 2012; Phanprasit et al. 2019).

Another research found that around 86.2% of workers experience acute respiratory problems due to exposure to toluene at work (Nakhooda et al. 2019). The research showed that the average exposure to non-carcinogenic toluene was 1.67,

which is above the threshold. If this happens continuously, it can cause a risk of disruption to the workers' health. In conclusion, printing workers with exposure to toluene are always on the edge of more dominant boundaries.

However, in contrast to the results of research conducted by (Haen and Oginawati, 2009), the results of his research indicated that not all exposure to toluene was above the threshold. In his research, it was stated that the average toluene level was 3.9399 ppm or it could be interpreted that it was below the threshold. This research was supported by Wispriyono and Handoyo, (2016) on toll workers who stated that the toluene exposure with RQ values was below the threshold. Based on research conducted by Masekamani et al., (2018), it was stated that toluene levels have the lowest exposure among benzene, xylene, ethylbenzene, p-xylene and o-xylene. Based on these results, it shows that the RQ value is not always above the threshold value.

Toluene is a non-carcinogenic toxin so the risk characteristics are expressed as a Risk Quotient (RQ) which can be calculated by dividing the intake value by reference (RfC) (Rahmadani and Tualeka, 2016). The value of toluene exposure by $RQ > 1$, tE for 10.55 hours/day and R of 0.635 m³/hour, and 34 years which is above normal (Fahrudhi 2017). Febriantika examined printing industry in Semarang City with toluene exposure of RQ value > 1 , tE 8 hours/day and R of 1, 0.4810 m³/hour, meaning that the toluene exposure was above normal or above the threshold (Febriantika 2017).

A research project from Zuhro et al. (2018) showed that the value of toluene exposure was always above normal with $RQ > 1$, tE 10 hours/day and R of 1.267 m³/hour. According to research conducted by Tunsaringkarn et. al on gas station workers in Thailand, workers with a risk of exposure to toluene $RQ > 1$ at work experienced headaches (61%), fatigue (29%) and throat irritation (11%) (Tunsaringkarn et al. 2012). Other studies showed similar results that workers with $RQ > 1$ experienced severe headache, fatigue and cough disorders (Maryiantari et al. 2016).

In this study, about 64% of workers experienced exposure to non-carcinogenic toluene below the threshold value. However, although toluene was below normal limits, it has a high risk of health problems if inhaled continuously (Prihartini 2010).

Indrawan conducted research on workers at PT. Pertamina RU IV Cilacap. The result obtained that the most contained compound is toluene and

caused many respondents to have health complaints that are identical to the symptoms of toluene exposure, including dizziness, nausea, weakness and short of breath. The value of toluene in the respondent's blood was at the average of 0.110 ppm, which means that it was above the threshold of 0.08 ppm (Indrawan 2014). In this study, table 2 shows that toluene exposure was at the average of 0.887 ppm with a maximum value of 2.15 ppm workers. These results indicate that the exposure of toluene in Surabaya printing was above the threshold.

The health effect of toluene exposure is very dangerous, in short term it can cause dermatitis (red, itchy, and dry skin), while in long-term, it can affect the nervous system, in which a number of studies on paint workers and workers in the rubberized-matting industry had long-term exposure to the potential for central nervous system damage (Heibati et al., 2018; Bioindustries, 2020). Based on the results of research conducted by Kuranchie, Angnunavuri and Attigbge, (2019) high BTX exposure conditions can reduce or eliminate a person's level of consciousness.

The use of toluene as a solvent causes health problems in workers such as dizziness, vertigo, eye irritation, skin irritation, respiratory problems, liver, kidney, and central nervous system disorders. Toluene enters the body through 3 channels, in addition to the main route of inhalation, toluene can enter the ingestion system and skin contact. Low toluene exposure dose to the nerve can cause nerve disorders. Nerve disorders due to toluene exposure consist of two types, namely neurotoxic and neuropathy (Kanwal et al., 2011; Tualeka, Wibrata, et al., 2019).

Neurotoxic is defined as adverse changes or functional disorders of the nerves, both the central nervous system and peripheral nervous system caused by exposure to chemicals, physical and biological agents better known as neurotoxic or neurotoxic substances. This disorder results in changes in memory, attention, mood, disorientation, deviations of thought, sensory, as well as somatic, and cognitive functions as neurotoxic effects due to the use of neurotoxics (Kanwal et al., 2011; Fadhila, Soebijanto and Dr. dr. Ismail Setyopranoto, 2015).

Exposure to high levels of toluene if received by workers for a long period of time can cause chronic disease. This can affect the life expectancy of a person to be lower. Thus, companies are required to carry out periodic checks so that dangerous diseases can be prevented as early as possible (Reid et al., 2012; Jonathan Posner, James A. Russell, 2014; Demir et al., 2017).

CONCLUSION

The results found that the non-carcinogenic toluene concentration was higher than the normal limit. The RQ value of workers exposed to toluene is $RQ > 1$ exceeding the threshold value. Workers who are exposed continuously to toluene concentrations can have a risk of harm to their health. The majority of workers show a neurotoxic risk due to exposure to toluene in the workplace.

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