Neurotoxicity Risk Among Workers Exposed to Toluene in Plastic Sacks Industry

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Abstract. Toluene is highly flammable chemical liquid. The most common hazards associated with toluene is inhalation. Toluene can produce fumes which can cause nausea, headaches, unconsciousness and even death. The main target of toluene is the Central Nervous System (CNS). The nervous system exposed to low doses of toluene can cause neurotoxic. This study was using a cross sectional design with 32 printing workers of total sampling. The location of this study took place in one of plastic sacks industry in Sidoarjo, East Java. The measurement of toluene concentration in the air was carried out with a vacuum pump combined with a tube containing activated carbon (active charcoal). Toluene concentration measurements were carried out at four locations and early detection of neurotoxicity risk was carried out using the German version of the Q18 questionnaire. Based on American Conference of Govermental Industrial Hygienists (ACGIH, 2011) The Threshold Limit Value of toluene is 20 ppm. The result showed the average concentration of toluene in the printing department is 14.92 ppm, which means it is in safe concentration. Nevertheless, the toluene concentration of location 2 is above the limit of 31.54 ppm. Based on the distribution of questionnaire results, 75% of subjects have a positive symptoms of neurotoxicity risk due to exposure to toluene in the work environment. The most health complaints were difficulty to focus (46.9%), feeling irritable/emotional (43.8%), difficulty to understand the news content or books (40.6%) and the heart beats abnormally without any pressure (40.6%). The workers are require to wear personal protective equipments regularly and the managements are require to do risk assessment to reduce all the health risk in the workplace.

Keywords: neurotoxicity · toluene · risk · workers · exposure

1 Introduction

The industrial production process of plastic sacks is inseparable from the dangers and risks of occupational safety and health. One of the hazard is the chemical use of toluene as a paint solvent in the plastic sacks printing process.

Toluene is a volatile, colorless, aromatic hydrocarbon, commonly used as a paint solvent, a mixture of gasoline, nail polish, and as a solvent in the printing business. The workers exposed to toluene as a solvent will have health problems, such as dizziness, vertigo, eye irritation, skin irritation, respiratory problems, liver, kidney and central

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nervous system disorders. Toluene is irritating to the skin, eyes, and respiratory tract. It can cause systemic toxicity by ingestion or inhalation and is slowly absorbed through the skin. The most common route of exposure is via inhalation and the main target of toluene is the Central Nervous System (CNS).

The nervous system exposed to low doses of toluene can cause neurotoxic. Neurotoxicity is defined as an adverse or functionally impaired change in the nerves, both the central nervous system and the nervous system caused by chemical exposures. This disorder occurs in memory, attention, mood, disorientation, thought distortion, and somatic, sensory, and cognitive functional changes as a neurotoxic effect.

2 Methods

2.1 Study Subjects

This study was using a cross sectional design with 32 printing workers of total sampling. The inclusion criteria were willing to take part of this study, not being ill in the last 2 weeks and 1 year minimum of working period.

2.2 Study Location, Instruments and Measurement

The location of this study took place in one of plastic sacks industry in Sidoarjo, East Java. The measurement of toluene concentration in the air was carried out with a vacuum pump combined with a tube containing activated carbon (active charcoal) by expert officers from the laboratory of the Technical Implementation Unit for Occupational Safety and Health Surabaya. Toluene concentration measurements were carried out at four locations, where the locations represented the four printing machines.

Early detection of neurotoxicity risk was carried out using the German version of the Q18 questionnaire. The questionnaires were collected through interviews on the subjects of the study and physical examination by the doctor to see the neurological complaints in the subjects of the study (Table 1).

3 Results

3.1 Toluene Concentration

Based on American Conference of Govermental Industrial Hygienists (ACGIH, 2011 The Threshold Limit Value of toluene is 20 ppm. The result showed the average concentration of toluene in the printing department is 14.92 ppm, which means it is in safe concentration. Nevertheless, the toluene concentration of location 2 is above the limit of 31.54 ppm [1].

The difference of toluene concentrations at each location can be caused by an enclosed production of printing area, lack of ventilation for air exchange and heat temperatures. A study by Farshad (2013) showed the same line that the toluene concentrations which above threshold value limit caused by ventilation systems [2].

In addition, the level of toluene concentration is also influenced by room temperature. The secondary data showed that the printing area of plastic sacks is 30 °C. According

Table 1. Toluene Exposure On Printing Workers

Location	Toluene Concentration	Subjects	Percentage (%)
Location 1	8,93 ppm	8	25,0
Location 2	31,54 ppm	11	34,4
Location 3	9,67 ppm	6	18,8
Location 4	9,53 ppm	7	21,9

Table 2. The Frequency Distribution Of Neurotoxicity Risk

Variable	Symptoms	Subjects	Percentage (%)
Neurotoxicity Risk	Positive	24	75,0
	Negative	8	25,0

to ILO ICSC: 0078 (2002) the toluene contamination of the air can be reached rather quickly on evaporation of toluene at 20 °C. This Study aimed to observe the neurotoxicity risk among workers exposed to toluene in plastic sacks industry [3] (Table 2).

3.2 Neurotoxicity Risk

The result showed 75% of subjects have a positive symptoms of neurotoxicity risk due to exposure to toluene in the work environment. Respondents were categorized as having a positive symptoms of neurotoxicity risk if they had 5 or more out of 18 health complaints on the Q18 questionnaire. The neurotoxicity risks were subjective health complaints of printing workers.

Based on the distribution of questionnaire results, 75% of respondents had more than 5 health complaints such as difficulty in focus to something, often feeling irritable/emotional without apparent cause, feeling excessive fatigue, headache and other symptoms. A study by Orbaek and Nise (1989) in US EPA showed the same result that workers exposed to toluene (11–42 ppm) within 28 years work periode had neurologic symptoms such as fatigue, difficulty to focus and headache [4, 5].

4 Discussion

4.1 Toluene Concentration

Based on American Conference of Govermental Industrial Hygienists (ACGIH, 2011) The Threshold Limit Value of toluene is 20 ppm [1].

A study by Agustina (2016) showed that the toluene concentration in the car painting workplace were about 0.0019 ppm to 18.5726 ppm. Another study by Badjagbo, et al.

(2010) showed that the toluene concentration was about 0.2927 and below the threshold limit value [6, 7].

Dissimilar with a study by ekaputri (2012) showed that the average toluene concentration in an informal workshop was 71.29 ppm. Another study by Jafari, et al. (2009) showed that the toluene concentration in a painting company was 105.82 ppm. In this case, the toluene concentration were above the threshold limit value [8, 9].

The measurement of toluene concentration showed that 3 out of 4 location (Location 1, 3 and 4) were below the threshold limit value and Location 2 was above the threshold limit value because there was a pile of toluene material to use near the location.

The amount of toluene exposure depends on the location of the workplace (ventilation), and physical factors, such as wind direction, temperature, humidity, and air pressure. Observation result showed that the printing workplace was in closed area and has 16 blowers and lack of air exchange. The temperature was about 30 °C, and high enough to accelerate the toluene evaporation in the air.

The toluene exposure can cause symptoms of acute and chronic poisoning. Early symptoms of acute poisoning have been observed in experimental exposure conducted on volunteers with exposure levels of approximately 750 mg/m3 for 8 h or 1,125 mg/m3 for 20 min can cause respiratory tract irritation and eye irritation (IPCS, 1986). Chronic poisoning occurs with an exposure rate of about 200–400 mg/m3 continuously for 8 h daily, 40 h a week [10].

Toluene concentrations above the threshold limit value can cause neuropsychological symptoms, a study by Darwati (2004) explained that workers exposed to toluene have a 7.12 times high chance of neuropsychological symptoms compared to workers who are not exposed to toluene [11].

4.2 Neurotoxicity Risk

The Q18 questionnaire result showed that 75% of respondents had positive neurotoxicity symptoms. The most health complaints were difficulty to focus (46.9%), feeling irritable/emotional (43.8%), difficulty to understand the news content or books (40.6%) and the heart beats abnormally without any pressure (40.6%).

The results of the physical examination of the nervous system include (examination of mental status, cranial nerve, motor nerve, sensory nerve and reflex nerve) showed that almost all respondents did not experience nervous system disorders but there was 1 respondent who had a verbal response. This is inversely proportional to the results of the Q18 questionnaire interview about the subjective health complaints about nervous disorders.

The observations result showed that 4 out of 32 respondents filled out the questionnaire for about 10–15 min longer than the others. There was a possibility that the respondents find difficulty to focus and understand the questionnaire. The interview results showed that all of respondents never had routine medical examination.

According to IPCS (1986) the subjective health complaints occur after exposure to 50 – 100 ppm. But the symptoms of CNS poisoning appear immediately after inhalation of high concentrations of toluene and 30–60 min after exposure. Mild effects of CNS include headache, dizziness, dizziness, confusion, nausea, improper judgment, staggered walking, blurred vision[10].

Tunsaringkarn et al. (2012) reported the results of an analysis of 49 workers (38 men and 11 women) at Thai petrol stations workers exposed to toluene had a 61% risk of headache, 29% fatigue and 11% throat irritation[12].

To determine the control of neurotoxicity risks due to toluene exposure, a neurotoxicity risk assessment can be carried out with the following steps:

1. Hazard Identification

Hazard identification is an attempt to determine whether or not a chemical is causally related to a particular health effect. (Paustenbach, 2002). Hazard identification is the first step to abalyse chemical risk analysis in the work environment. In this study, the printing process used toluene as paint solvent[13].

In the printing process, toluene is used as a solvent mixture in paints which is one of the non-carcinogenic toxins. The toluene was not stored in the spesific storage area but stacking next to printing sites. Therefore, by that condition of 30 °C temperatures and pile of toluene, it was easier for the workers exposed to toluene.

2. Exposure Assessment

The exposure path analysis or exposure assessment conducted by performing intake calculations. Toluene is a non-carcinogenic toxin so that perform a non-carcinogenic intake calculation.

Toluene intake through air is directly proportional to the toluene concentration in the work environment, respondent's respiration rate, daily exposure time, annual exposure frequency, duration of exposure and is inversely proportional to the respondent's body weight and the average time period of exposure.

3. Risk Characterization

Risk characterization is the last of the risk assessment process, to find out the risk characteristics, it must first be known whether the toxin is a carcinogen or non-carcinogen. Toluene is a non-carcinogenous toxin so that the risk characteristic is expressed as Risk Qoutient (RQ) which can be calculated by dividing the intake value by reference (RfC).

In this study, 19 respondents were in the safe health risk category and 13 respondents were in the unsafe health risk category. Many factors influenced the RQ value, which had the most contribution such as work period and the toluene concentration in the air.

4. Reducing the Level of Neurotoxicity Risk

To reduce the level of neurotoxicity risk is by reducing the toluene concentration value in the air. Thus, the less toluene fumes inhaled by workers the less neurotoxic risk level due to toluene exposure.

There are several things that need to be improved to reduce neurotoxicity risks among workers exposed to toluene based on observation result:

- Ventilation

Ventilation is one of the most important safety precautions to reduce toluene exposure because toluene is a volatile compound in the air. Based on observation observation

results, there were only 2 air vents in the production room, so it is necessary to add more ventilation, especially in the location around the printing sites.

- Toluene Storage

Toluene is highly flammable chemical liquid. The most common hazards associated with toluene is inhalation. Toluene can produce fumes which can cause nausea, headaches, unconsciousness and even death. Based on ebservation, toluene is stored and stacked in Location 2 , which has machines, heat temperatures that can cause damage for workers and work place. It is important to keep toluene away from heat and ignition. Toluene should be stored in a well ventilated and secure place.

- Personal Protective Equipments

In addition to the use of masks, the use of gloves on printing workers is very necessary because toluene can be absorbed through the skin. Most workers were not wearing gloves while working because they were afraid of accidents such as the gloves being stucked by machine . Choosing the right and comfortable gloves can reduce the risk of work accidents so that by using gloves will reduce exposure to toluene

- Regular Medical Checkup

Regular medical Checkeu aimed to early detect any kind of health complaints caused by chemicals or other factors and reduce health risk including neurotoxicity risk.

5 Conclusion

The toluene concentration was measured in 4 printing location, the lowest toluene concentration was 8.93 ppm and the highest was 31.54. The difference of toluene concentrations in each location cause different levels of neurotoxicity risk for workers. Most workers had a neurotoxicity risk according to the results of the Q18 questionnaire with various levels of toluene exposure. The workers are require to wear personal protective equipments regularly and the managements are require to do risk assessment to reduce all the health risk in the workplace.

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