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Relationship between Toluene Concentration and RQ Toluene with Neurotoxic

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ABSTRACT

Toluene is very dangerous for human health. Workers who use toluene as a solvent can be exposed to the risk of health problems such as dizziness, vertigo, eye irritation, skin irritation, respiratory problems, liver, kidney, and central nervous system disorders. This study aims to determine the relationship between concentration and characteristics of non-carcinogenic risk of toluene with neurotoxic effects in five industries in the Surabaya area. This is an observational study with a cross-sectional design conducted on five industries in Surabaya that uses toluene as a solvent in the production process, namely in industries in Osowilangun, Ketintang, Jemursari, Kalijudan, and AUP. The population in this study was a total of 90 workers exposed to toluene in the five industries. The research sample of 77 people was taken using the accidental sampling method. The variables studied in this study were toluene concentration, toluene RQ and neurotoxic effects. A total of 50 workers (65%) have unsafe RQ. A total of 48 (62.3%) workers had neurotoxic effects. There was no relationship between toluene concentration and RQ toluene with neurotoxic effects (p value> 0.05). The majority of workers (52%) are in locations with toluene concentrations below the threshold limit value; The majority of workers (65%) have 50 unsafe RQs, and A total of 48 workers (62.3%) had neurotoxic effects; Respondents exposed to toluene concentrations above the threshold are at risk of having a neurotoxic effect of 1.38 times greater than respondents exposed to toluene below the threshold, respondents with RQ values in the unsafe category are at risk of having a neurotoxic effect of 1.4 times greater than respondents with RQ values in the safe category. RQ of toluene is the primary determining neurotoxic.

Keywords: Toluene, Risk Quotient, neurotoxic, safety of work

INTRODUCTION

Toluene is a clear, colorless liquid and smells like benzene. This is a flammable and volatile liquid (ATSDR, 2000). Toluene vapor is heavier than air and can spread long distances. Toluene can begin to smell in the air at a concentration of 8 ppm and be felt in water at a concentration of 0.04 to 1 ppm. This substance is hazardous to human health. From many previous studies of toluene, toluene has been proven to cause death and cause extensive health effects in the human body, including in the form of death and disruption of systemic effects (respiratory organs, heart, eyes, liver, kidneys, musculoskeletal, hemato-immunological systems, endocrine, skin, neurology, reproduction, and weight loss) (ATSDR, 2000) (ATSDR, 2015) ('Toluene Material Safety Data Sheet Number', 2009) (Moeljosoedarmo, 2008).

Currently, the amount of toluene used globally reaches 0.5 x 107 to 1 x 107 tons. Industrial use of toluene in Europe is 2.38 million tons (2007), one million tons in North America (2009), and 23 million tons in Asia (2006) ('Toluena uses and market,', 2008). Toluena production in 1994 in the USA was estimated at more than three million tons. It is estimated that workers are exposed to 4-5 million people yearly ('Toluena uses and market,', 2008). There is no data regarding the use of toluene in the industry in Indonesia. In the industrial field, toluene is widely used as a base material and solvent. Materials that use toluene include paint solvents, thinners, inks, glues, pharmaceutical products, additives for cosmetic products, the pesticide industry, crude petroleum, the plastic industry, and synthetic fibers. In the household, toluene is mainly found in disinfectants and glues ('Toluena uses and market,' 2008). Toluene is used in printing and tanning processes (Mckeown, 2013).

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 produce ingestion and skin contact is the entry point. Low toluene exposure dose to the nerve can cause nerve disorders. Nerve disorders due to toluene exposure consist of two types: neurotoxic and neuropathy (Pratamasari, 2015). 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 and physical and biological agents, better known as neurotoxic or neurotoxic substances. This disorder results in changes in memory, attention, mood, disorientation, deviations of thought, and somatic, sensory, and cognitive functions as neurotoxic effects due to neurotoxics.

The main target of toluene is the Central Nervous System (CNS). Symptoms that may arise include fatigue, easy drowsiness, headaches, and nausea (ATSDR, 2000). Symptoms of CNS poisoning appear immediately after inhalation of high concentrations of toluene and 30-60 minutes after exposure. CNS's mild effects include headaches, dizziness, confusion, nausea, improper judgment, and staggering, blurred vision. More severe effects include loss of consciousness, coma, and death. Coma can be in a long time, although most victims quickly regain consciousness after they are removed from exposure. Haen and Oginawati (2011), in their study of sole shoe workers in Cibaduyut, Bandung, where the most compound was toluene, many respondents had health complaints that were identical to the symptoms of toluene exposure, including dizziness, nausea, weakness, and shortness of breath. ILO research (2004) explains that five health problems are often experienced by workers in the Ciomas and Tasikmalaya shoe industry, one of which is often dizzy, amounting to 37.31%. Research conducted by Orbaek and Nise (1989) in EPA (2005) shows that workers exposed to

11-42 ppm toluene have neurological disorders such as feelings of fatigue, difficulty focusing, and headaches.

Surabaya is a city with rapid development of the industrial sector. In the production process, various industries use toluene as a solvent. Considering that toluene is a hazardous material that has the potential to adversely affect its workers, such as neurotoxic effects in the form of headaches, this study aims to determine the relationship between the concentration and characteristics of non-carcinogenic risk of toluene and neurotoxic effects in five industries in the Surabaya area. No research on the concentration and characteristics of non-carcinogenic risks and their effects on the liver has ever been done in five industries in the Surabaya area, most of which use toluene as an organic solvent.

METHODS

This research was conducted in five industries in Surabaya that use toluene as a solvent in the production process. These five places are in Romokalisari, Ketintang, Jemursari, Kalijudan, and AUP. This is an observational cross-sectional design. The research subjects were 90 workers exposed to toluene in the research sites, with 77 respondents taken as samples using the accidental sampling method. Research variables include toluene concentration, RQ toluene and neurotoxic effects.

Data collection was carried out by interview using a questionnaire in which all respondents agreed to become research subjects, as evidenced by the signing of informed consent. The measurement of toluene concentration in the air was measured using a vacuum pump device combined with a tube containing active charcoal by expert staff from the Laboratory of the Technical Implementation Unit for Occupational Safety and Health (UPTK3) Surabaya. Measurement of air toluent concentrations in the work environment is measured using the NIOSH 1501 measurement method with activated carbon absorption, namely the Gas Chromatography (GC) technique. Assessment of non-carcinogenic characteristics (Risk Qoutient (RQ)) is a comparison between intake and intake (Ink) with reference (RfD or RfC) (Tualeka, 2014).

RESULT

Distribution of Characteristics of Respondents were exposed to toluene in industries in Surabaya

Respondent characteristics include age, sex, level of education, and work area. Below is the distribution table of respondent's characteristics who in Surabaya shoe industry.

Table 1. Frequency Distribution of Characteristics of Workers Exposed to Toluene in Five Surabaya Industries

Characteristics of Respondents	Frequency	Percentage
Age		
16-25	15	19,5%
26-35	13	16,8%
36-45	24	31,2%
46-55	16	20,8%
56-65	9	11,7%
Sex		
Male	61	79,2%
Female	16	20,8%
Level of Education		

Primary	14	18,2%
Junior High	19	24,7%
Senior High	43	55,8%
Univesrsity	1	1,3%
Working Area		
Romokalisari	24	31,2%
Ketintang	12	15,6%
Jemursari	10	13%
Kalijudan	20	26%
AUP	11	14,3%

Source: primary data

Based on table 1, a total of 24 (31.2%) industrial workers aged 36-45 years, 61 (79.2%) workers were male and the highest level of education (43 or 55.8%) were high school / Vocational School. Most workers (24 or 31.1%) work in the Romokalisari area.

Toluene Concentration

Table 2. Distribution of Toluene Concentrations in five Industries in Surabaya

Working areas	Measurement Points	Toluene Concentrations (Threshold= 20 ppm)	
		< NAB	≥ NAB
Ketintang	Point 1	2,15 ppm	
	Point 2	0,42 ppm	
	Point 3	0,30 ppm	
Jemursari	Point 4	2,99 ppm	
	Point 5		40,27 ppm
	Point 6	1,91ppm	
AUP	Point 7	0,99 ppm	
	Point 8	0,04 ppm	
	Point 9	0,003 ppm	
Kalijudan	Point 10	0,43 ppm	
	Point 11		33,89 ppm
	Point 12		38,38 ppm
Osowilangun	Point 13		289,3 ppm
	Point 14		30,5 ppm
	Point 15		62,7 ppm
	Point 16		58,5 ppm
	Point 17	15 ppm	
	Point 18		137,5 ppm
	Point 19	9,3 ppm	

Source: Primary data

Table 2 shows that the highest concentration of toluene in the air was at Point 13 with a value of 289.3 ppm and the lowest at Point 9 with a value of 0.003 ppm with an average of 32.9

ppm. There are 8 measurement points with the results of toluene levels above the threshold issued by ACGIH (2011) (20 ppm) and there are 11 measurement points with the results of toluene levels below the threshold. The average results of air toluene levels are below the threshold set by ACGIH (2011).

Table 3. Distribution of Toluene Concentrations in Toluene Exposed Workers in Five Industries in Surabaya

Toluene Concentration	Total	
	N	%
>20 ppm	37	48
≤20 ppm	40	52
Total	77	100

There were 37 (48%) respondents who were in toluene concentrations above the value issued by the American Conference of Governmental Industrial Hygienists (ACGIH) (2007) of 20 ppm and 40 (%) respondents were in concentrations <20 ppm.

Non-Carcinogenic Risk

Table 4. Distribution of Toluene Risk Characteristics among Toluene Exposed Workers in five Industries in Surabaya

Risk Characteristics	Total	
	N	**%**
Unsafe (≥1)	50	65
Safe (<1)	27	35
Total	77	100

Health risk characteristic is stated as Risk Quotient (RQ, Risk Level) which is calculated by dividing the intake or intake (Ink) by reference (RfC). The calculation results of Risk Quotients (RQ) can show the level of health risks of workers due to exposure toluene in the work environment. If the RQ value is more than or equal to 1 (RQ> 1) then the worker has a health risk due to toluene exposure. On the other hand if the RQ value is less than 1 (RQ <1) then the worker is still safe from health risks due to exposure toluene (Kolluru, 1996). Based on the RQ calculation in table 4, the majority of workers (50 workers or 65%) have an RQ value> 1 which means they have a health risk impact due to toluene exposure.

Table 5. Distribution of Neurotoxic Effects in Five Industries in Surabaya

Variable	Category	Total	Percentage
Effect neurotoxic	Neurotoxic	48	62,3%
	Non- Neurotoxic	29	37,7%
Total		77	100%

Table 5 shows that as many as 48 (62.3%) respondents had neurotoxic effects while 29 (58.4%) respondents did not have neurotoxic effects.

Relationship between Toluene Concentration and neurotoxic effects

Table 6. Relationship of Toluene Concentration and neurotoxic effects

Toluene Concentration	Neurotoxic effects				Total		p-value	Ratio Prevelence
	Neurotoxic		Non-neurotoxic k					
	N	%	N	%	N	%		
> 20 ppm	27	73%	10	27%	37	100%	0,064	1,38
≤ 20 ppm	21	52,5%	19	47,5%	40	100%		
Total	48	62,3%	29	37,7%	77	100%		

Based on table 6, the majority (73%) of workers exposed to toluene with concentrations above the threshold (> 20 ppm) have neurotoxic effects, and the majority (52.5%) workers who are exposed to toluene concentrations with exposure below the threshold (≤20 ppm) have an effect neurotoxic. The results of the statistical analysis test with the chi-square test show a p-value of 0.064 (p> 0.05) which means there is no relationship between toluene concentration and neurotoxic effects. The PR value obtained is 1.38, meaning that respondents exposed to toluene concentrations above the threshold are at risk of having a neurotoxic effect 1.38 times greater than those exposed to toluene below the threshold.

Relationship between Toluene non-carcinogenic risk and neurotoxic effects

RQ Toluene	Neurotoxic Effects				Total		P value	Prevalence Ratio
	Neurotoxic		Non-neurotoxic					
	N	%	N	%	N	%		
Unsafe (≥1)	35	70%	15	30%	50	100%	0,059	1,4
Safe (<1)	13	48,1%	14	51,9%	27	100%		
Total	48	62,3%	29	37,7%	77	100%		

Table 4 shows that the majority of workers with unsafe RQ values (70%) had neurotoxic effects, while the majority of workers with unsafe RQ values (51.9%) did not have neurotoxic effects. The results of the statistical analysis test with the chi-square test showed a p-value of 0.059 (p> 0.05) which means there was no relationship between toluene concentration and neurotoxic effects. PR value is 1.4 which means that respondents with RQ values of unsafe categories are at risk of having a neurotoxic effect of 1.4 times greater than respondents with RQ values of safe categories.

DISCUSSION

Concentration Toluene

Based on the measurement of toluene concentration in five locations in the industry that uses Toluene as an organic solvent in Surabaya, the highest concentration is in the Romokalisari area of 289.3 ppm, and the lowest is in the AUP area of 0.0036 ppm with an average toluene measurement result 32.98 ppm. The measurement results are classified as very high when compared with the concentration of Toluene in Offset Printing workers with 72.51 ppm and a UV printing area of 68.44 ppm (Irmasari, 2018). This result is also higher compared to the measurement of toluene concentration in the painting department of the body car body X Magelang which is done at 4

points, with the highest measurement results at Point 1 of 13.7 ppm and the lowest of Point 2 of 2.3 ppm (Ridwan Dwi Setiawan Habibie, Ari Suwondo, 2016) (Ridwan, 2015) and in the Ekaputri research (2012) in a study in an informal car repair shop in Karasak which showed a mean concentration of Toluene of 71.29 ppm.

The measurements in this study reveal eight measurement points with toluene levels above the threshold issued by the American Conference of Governmental Industrial Hygienists (ACGIH 2011) of 20 ppm and 11 measurement points with toluene levels below the threshold. The average result of air toluene level was also above the threshold set by ACGIH (2011). Toluene concentrations above the set threshold can cause neuropsychological symptoms. Research by Darwati (2004) explains that workers exposed to Toluene had a 7.12 times higher chance of neuropsychological symptoms compared to those who were not exposed to Toluene.

Concentration Toluene and Neurotoxic

Based on the relationship test results, toluene concentration was not related to neurotoxic effects (p value> 0.05). However, respondents exposed to toluene concentrations above the threshold risk of having a neurotoxic effect of 1.38 times greater than those exposed to Toluene below the threshold. The body's response to toxic chemicals depends on the length and amount of exposure. Short-term exposure with low chemical concentrations may not have a noticeable effect. Conversely, long-term exposure to these chemicals can cause hazards. Research conducted by Agustina (2016) shows that groups that are exposed tend to experience more complaints, up to 2 times more than groups who are not exposed. In the exposed group, out of 18 complaints, the most frequent were short (forgetful) memories, often feeling irritated for no particular reason, often feeling depressed for no particular reason, having abnormal heartbeats, often sweating for no particular reason, often headaches (minimal one time in 1 week). Some cases of toluene exposure recorded in ATSDR (2015) include Yin et al. (1987) reported 44 men and 57 women who were exposed to TWA concentrations of 46 and 41 ppm toluene, respectively, during shoe making, printing, and audio equipment had an increased neurotoxic effect, dizziness and difficulty sleeping compared with 127 control groups.

According to IPCS (1986), research results show that as much as 40% - 60% of toluene exposure is absorbed by humans through breathing. Symptoms are caused by inhalation by the concentration of exposure. Exposure to 50 ppm causes symptoms of drowsiness and headaches. At concentrations of 50-100 ppm Toluene irritates the nose, throat, and respiratory tract. Exposure to a concentration of around 100 ppm can cause fatigue and dizziness. Exposure to more than 200 ppm can cause symptoms of motion sickness (dizziness), numbness, and nausea, and toluene exposure of more than 500 ppm can cause mental disorders and impaired coordination.

RQ toluene and Neurotoxic

Based on the relationship test results, RQ toluene was not associated with neurotoxic effects (p value> 0.05). However, respondents exposed to toluene concentrations above the threshold risk having a neurotoxic effect of 1.38 times greater than respondents exposed to toluene below the threshold. This is in line with research conducted by Maryiantari (2016) on shoe artisans in Surabaya, where 19.6% of workers had a risk of exposure toluene RQ ≥ 1 and 20% of respondents experienced headaches, 18.2% were exhausted and 18.8% had coughing. Tunsaringkarn et al., 2012 reported the results of an analysis of 49 workers (38 men and 11 women) at a Thai gas station. As a result, toluene exposure causes a risk of headaches (61%), fatigue (29%), and throat irritation (11%).

Concentration Toluene, RQ Toluene, Neurotoxic

From the research results, the concentration of toluene and toluene RQ has no relationship with

neurotoxicity. However, the unsafe concentration of toluene causes 1.33 times neurotoxicity, while the unsafe RQ of toluene causes 1.4 times neurotoxicity. It can be concluded that toluene has a neurotoxic relationship, although the relationship is weak. From these data, when compared to the strength of the effect of toluene concentration and toluene RQ, toluene RQ has a stronger effect on neurotoxicity when compared to using toluene concentration. Toluene RQ is more validly used as a variable that has a stronger effect on neurotoxicity than toluene concentration because neurotoxicity as a health factor is not only influenced by toluene concentration as an environmental factor that causes direct disease but is also influenced by worker behavior factors, health services and genetics. **(HL. Blum,1974)(** https://www.who.int/sdhconference/resources/SDapproachestopublichealth_eng.pdf)**.)**. In the toxin risk assessment, the RQ (Risk Quotien) of workers is directly proportional to toluene concentration, toluene respiration rate, length of work every day (hours/day), frequency of work every year (days/year), and length of work (years) and inversely proportional to weight, average (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6311471/.). The higher the respiration rate of toluene, the greater the suction power of toluene into the body, thus increasing the risk of neurotoxic. Body weight affects the rate of respiration. The greater the body weight, the greater the respiration rate, so the risk of neurotoxic is greater (https://media.neliti.com/media/publications/79658-EN-safe-area-for-residential-population-to.pdf). Thus, the use of the RQ relationship with neurotoxicity is more sensitive or stronger than the use of neurotoxic toluene concentrations. Toluene's RQ has more association with neurotoxic events in workers.

Control of Toluene

The company is expected to regularly monitor temperature, wind speed and toluent levels in the air, especially in the work area where these parameters still exceed the specified threshold. This is because exposure to toluene vapor depends on the location of the workplace (open or closed), and physical factors, such as wind direction, temperature, humidity, and air pressure. Other than that. Air ventilation in the work area is needed so that the air exchange in the room can work well. It is not recommended to use an angina fan because the fan does not help the air in the room to come out, to reduce the concentration of toluene in the room beside the need for ventilation and exhaust fan, it can also use activated carbon. According to Wuntu, Bukasa and Koleangan (2008) activated carbon fiber can reduce volatile organic compounds. Workers are expected to get used to wearing personal protective equipment (PPE), especially in the form of a mask or breathing, to minimize the risk of inhalation of toluene exposure at work.

CONCLUSIONS

1. The majority of workers (52%) are in locations with toluene concentrations below the threshold value;
2. The majority of workers (65%) have 50 unsafe RQs
3. A total of 48 workers (62.3%) had neurotoxic effects;
4. Respondents exposed to toluene concentrations above the threshold are at risk of having a neurotoxic effect of 1.38 times greater than respondents exposed to toluene below the threshold, respondents with RQ values in the unsafe category are at risk of having a neurotoxic effect of 1.4 times greater than respondents with RQ values in the safe category.
5. RQ of toluene is main determining neurotoxic.

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