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Analysis of benzene exposure considering workers characteristic in the oil and gas industry

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Abstract. Operations and processes in the oil and gas industry have hazardous chemicals. Hence the possibility of having a work accident is high. Chemicals that exist are produced by activities related to the oil and gas industry processes, one of which is benzene. Because it has a severe impact on occupational health and safety, benzene exposure must be measured. Measurements were run through risk analysis to assess Hazard Index (HI) and make predictions of benzene exposure by focusing on the characteristics of workers, which can worsen the effect of the exposure. This study elaborated on several workers' characteristics from a literature study's human factors point of view. These characteristics were smoking, age, type of task, personal protective equipment use, exposure duration, regulations, hand washing habits, length of exposure, and nutritional status. Literature study results showed that regulatory characteristics, handwashing habits, and length of exposure were worsening the benzene exposure to workers. The other factors were in between agreed and disagreed in worsening the benzene exposure. These results perform as a base study in the further benzene analysis of oil and gas end distributor.

1. Introduction

Operations and processes in the oil and gas industry have hazardous chemicals; hence the possibility of having a work accident is high. Chemical work accidents in the course of carrying out work can threaten every worker to face occupational health and safety risks caused by his work. Case studies of workers in oil refineries investigating health hazards are critical to identifying health hazards for worker safety [1].

The oil and gas industry is the primary source of volatile aromatic hydrocarbons in the environment [2]. Benzene is the primary aromatic hydrocarbon compound whose presence is produced one of them by activities related to the oil and gas industry process. Benzene is a hazardous chemical classified as a class 1 carcinogen and mutagen that can be infected by humans and animals through dermal, oral, and inhalation exposure [3]. Benzene exposure to workplace workers mainly occurs through inhalation compared to dermal and oral [4]. The average benzene exposure in humans through inhalation has been reported to be around 50 to 80% [5]. Acute exposure to benzene concentrations can also affect fatigue, dizziness, headache, drowsiness, confusion, tremors, and loss of consciousness [7] [8]. Chronic exposure can cause more serious adverse health effects, such as myeloid leukemia, myeloma,



reduced production of red and white blood cells from the bone marrow, decreased immune system, central nervous system damage, slow reflexes, liver and kidney failure, and cancer [8].

This explanation reveals the problems faced in the oil and gas industry regarding benzene exposure. This study, therefore, aims as literature review to understand benzene exposure to humans considering the characteristics of workers who can exacerbate benzene exposure to workers to determine risks endanger health and safety at work.

2. Literature Review

2.1. Industrial Hygiene

The Occupational Safety and Healthy (OSHA) defines Industrial Hygiene as a science aimed at anticipating, recognizing, evaluating, and controlling environmental factors from the workplace conditions that may cause illness, health problems, and well-being, or significant inconvenience and inefficiency among the worker. Industrial hygienists as occupational safety and health professionals controlling the work environment against occupational health hazards that arise as a result of or during work. Industrial hygiene monitoring and analysis to detect the extent of worker exposure and then base any hazard controls on actual exposure data [6].

The science ergonomics studies and evaluates focuses on the design of a working system where humans work a full range of tasks, including lifting, holding, pushing, walking, and reaching. All work systems consist of human components, machine components, and the environment that interact with each other. The relationship between humans and the environment is handled by industrial hygienists [9].

2.2. Benzene

Benzene (C_6H_6) is a cyclic organic chemical compound usually found in an environment that is flammable, colorless with a distinctive aromatic fragrance that is volatile into the air. This compound is a natural part of crude oil, gasoline, and cigarette smoke as a source of exposure [10].

Benzene exposure to humans is unavoidable because it requires measurement of benzene that occurs in the industrial oil and gas environment. The procedure for analyzing air samples refers to NIOSH 1501 (Hydrocarbons, Aromatic). Sampling and analysis can be done through the collection of benzene vapor in worker breathing zone by put down a personal sampling pump (Figure 1) that has been installed charcoal tube (Figure 2) near the respiratory tract of the worker. Subsequently, chemical analyzes were performed using gas chromatography in Figure 3 [10].



Figure 1. Personal sampling pump



Figure 2. Charcoal tube



Figure 3. Gas chromatography

The Indonesian government's steps to minimize benzene exposure make regulations regarding limits on the value of chemicals that can expose workers while in the workplace. Based on the Minister of Manpower and Transmigration Regulation No. PER.13/MEN/X/2018 of 2011 concerning the Threshold Limit Value (TLV) of physical and chemical factors in the workplace, the recommended benzene TLV to prevent health impacts is 0.5 ppm. Measurements can be made with a risk analysis used to assess the Hazard Index (HI) [11].

2.3. Worker Characteristics

This study is based on several characteristics that are likely to affect benzene exposure. It is known from previous studies that smoking, age, type of task, PPE use, exposure duration, regulations, hand washing habits, length of exposure, and nutritional status are characteristics that can exacerbate benzene exposure in Table 1.

Table 1. Literature review result.

Location Characteristics	+	TBBM	SPBU	Oil Refinery
	-			
Smoking	+	[12]	[13] [14] [15] [16] [17] [18]	[17] [19] [20] [21] [22]
	-		[23] [24] [25] [26]	[27] [28]
Age	+	[12] [29]	[15] [18] [30]	[21] [22]
	-		[17] [23] [24] [25]	[20]
type of task	+	[12] [31] [32] [33]		[34]
	-	[35] [36]	[36]	[36]
PPE use	+		[37]	[22] [23]
	-		[26]	
Duration exposure	+		[15] [37]	[21] [39] [40]
	-		[15] [24] [25] [26]	[27] [28]
regulations	+	[42]		
hand washing habits	+		[37]	
length of exposure	+		[42] [43] [44]	[39] [40]
nutritional status	+			[21]
	-			[27]

(+) Effect; (-) No Effect

2.3.1. Smoking habits

Research agrees that the more significant number of cigarettes smoked affects the levels of benzene that enters the body. The information on petroleum distribution location when considered smokers, a positive relationship was found between personal air exposure levels of ethylbenzene levels in urine samples [12]. The information on service station BTX levels for exposure to smoking subjects is higher than nonsmokers [18] [13]. Smokers are found to be significantly higher than nonsmokers [15]. In smokers, the SPMA value and the value of benzene are significantly higher than nonsmokers [14] [16]. The information on oil refinery personal exposure that smoking has an impact on air exposure, exposure is higher in smokers than nonsmokers ($P < 0.001$) [17] [19]. Smokers and nonsmokers show statistically significant differences and confirm that smoking is a major confounding factor when assessing benzene exposure to work [20]. Smoking habits of oil refinery workers are mostly light smokers [21]. As many as 41 people or 83.7% of 49 respondents had smoking habits [22].

Research does not agree that the increasing number of cigarettes smoked affects the levels of benzene that enters the body. There were no significant differences in smoking characteristics in the oil service station [23] [24] [25] [26]. There were no significant differences between smokers and nonsmokers in the oil refinery between employees exposed to and not exposed to benzene [27]. Whereas the other study, there was no significant difference in ttMA levels in respondents with smoking habits ($p = 0.559$) [28].

2.3.2. Age

Research that agrees that the older the workforce is, the higher the risk of benzene poisoning. The information on petroleum distribution age grouping shows that health effects increase from the age of workers is 40 years. Research shows that age has a strong relationship with the hematological index on the health of oil workers [12] [29]. The information on the service station, the average age is 40.5 years [15]. The exposure group's average age was 38 years, ranging from 20 to 57 years [18]. The age of oil refinery workers is most in the age range of 49-52 years [21]. Whereas the other study, the average age of respondents in this study is the tankers is 36 years [22]. Data were obtained from a questionnaire about age in the group studied $p < 0.05$ [30].

Research that disagrees that the older the workforce is, the higher the risk of benzene poisoning. The information on the service station, there was no significant dependence of Benzene in the air on age characteristics [17] [23] [24] [25]. The information on oil refinery research shows no significant difference between subjects exposed to work and the age of the worker [20].

2.3.3. Types of Tasks

Research that agrees that the filling task, the higher the risk of benzene exposure. The information on petroleum distribution this type of task was found to be the most important characteristic associated with exposure [32]. Research that agrees to the older the workforce is, the higher the risk of benzene tanker loading is the highest risk occupation at this facility [12] [33]. The highest lighted occupations (8 hours) TWA is maintenance workers who can be directly affected by benzene [31]. Based on the information on oil refinery, the most predictive independent variable of benzene exposure is work assignment [34].

Research that does not agree that the type of filling task the higher the risk of benzene exposure. The information on petroleum distribution 8-hour TWA type of task for low benzene within the working limit of gasoline component exposure [35] [36].

2.3.4. Use of Personal Protective Equipment

Research that agrees that the use of PPE can reduce benzene exposure through inhalation. The information on the service station most workers still do not use personal protective equipment when doing work [22] [23] [37].

Research that does not agree that the use of PPE can reduce benzene exposure through inhalation. The information on service station based on the results of the study, no significant relationship PPE usage of gas station operators to the exposure of benzene in SPBU, Tuak Daun Merah Subdistrict, Kupang City ($p\text{-value} > 0.05$) [26].

2.3.5. Exposure Duration

Research that agrees that the number of years worked will affect the intake of benzene exposure that enters the body of the worker. The information on the service station, the average exposure duration is 16 years and 23 years [15] [37]. The information on an oil refinery, there was a significant correlation of exposure duration ($p\text{-value} < 0.05$) [38]. The working period of oil refinery workers is the most in 22-25 years [21]. The safe working period for a lifetime (30 years) is 6.1 years [40].

Research does not agree that the number of years worked affects the intake of benzene exposure that enters the body of the worker. The information on the service station, there is no significant dependence of benzene in the air on the characteristics of the length of service [17] [24] [25] [26]. The information on an oil refinery, there was no significant difference between the exposure duration of work between employees who are exposed to and not exposed to benzene [27] [28].

2.3.6. Regulations

Research that agrees that rules which are not followed are higher at risk. Regulation is a factor influencing the concentration of benzene exposure in gasoline storage and distribution facilities in developing countries [45].

2.3.7. Handwashing Habits

Research that agrees that lousy handwashing habits have a higher risk. The habit of washing hands in the Ciputat Timur gas station operator in 2017 was weak in terms of only 28 people (38.4%) [37].

2.3.8. Length of Exposure

Research that agrees that the longer working hours that occur to workers, the higher the risk. There was a significant correlation of working hours to levels of t, t-muonic acid urine (all variables, $p < 0.05$). The information on oil refinery this study concludes that the longer working hours that occur in workers, the higher levels of t, t-muonic acid urine [39]. The safe length of exposure for a lifetime of work (30 years) is 1.6 hours per day [40]. The information on service station Length of Exposure is 8 hours / day [42] [43] [44].

2.3.9. Nutrition Status

Research that agrees that the higher the weight will reduce the level of risk. The nutritional status of oil refinery workers is most in normal conditions [21]. Research that does not agree that the higher the weight will reduce the level of risk. There is no difference between abnormal nutritional status and significantly normal nutritional status between employees exposed to and not exposed to benzene [27].

3. Prospective Research

Perusahaan Pertambangan Minyak dan Gas Bumi (PERTAMINA) operates several TBBM (Terminal Bahan Bakar Minyak), one of which is the TBBM Semarang Group. According to The Agency for Toxic Substances and Disease Registry (ATSDR) [10], benzene is a hazardous chemical in oil that has a severe impact on health and safety. So the TBBM Semarang Group's environment will not be separated from the possibility of benzene exposure to workers, which can have a severe impact on work health and safety. Because it has a severe impact on occupational health and safety, benzene exposure must be measured. If more than the TLV has been determined, then corrective action is needed for health and safety. Measurements can be made for making predictions that will occur due to the presence of benzene exposure in the work environment by looking at the characteristics of workers who can exacerbate benzene exposure. When looking at literature studies for benzene exposure, some of the characteristics of workers must be considered. Some characteristics can worsen the occurrence of benzene exposure, affecting the health and safety of workers. So it is essential to conduct the assessment of benzene exposure in the TBBM Semarang Group.

4. Conclusion

Operations and processes in the oil and gas industry have hazardous chemicals, one of which is benzene that can be infected by humans. Hence, the possibility of a work accident is high for workers. After looking at the related review literature, it can be concluded that the study agreed and disagreed about the characteristics that could exacerbate benzene exposure to workers. Table 2 shows that (+) is a researcher who agrees and (-) is a researcher who disagrees. The characteristics of smoking, age, type of task, PPE use, exposure duration, and nutritional status have researchers who agree and disagree that these characteristics can exacerbate benzene exposure to workers. Regulatory characteristics, handwashing habits, and length of exposure were agreed to worsen benzene exposure to workers. So one of which PERTAMINA business units is the TBBM Semarang Group very important can be monitoring.

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