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Evaluating the semi-quantitative risk of occupational exposure to chemicals in one of the petrochemical industries

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A R T I C L E   I N F O

A B S T R A C T

Among the work-related risk factors in different industries exposure to chemicals can be mentioned that can have irreparable danger to staff. Therefore, to reduce the risk of exposure to chemicals in the workplace, risk assessment takes place. Thus, the aim of the present study is to study the semi-quantitative risk of chemicals. This study was conducted using semi-quantitative risk assessment method provided by the Singapore Ministry of Labor Health and Safety Unit in Olefin unit of one of the petrochemical industries located in Special Zone Asalooyeh in 2015. Seven chemical substances are identified in this unit that only one of them (14.2 percent) has a high risk level. The results showed that in this unit Sodium hydroxide (caustic) with quantitative risk level of 4.3 has the highest risk factor. For this reason, control measures should be used to reduce the risk of exposure to sodium hydroxide.

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1. Introduction

Ever-increasing growth of industry has exposed millions of people to multiple types of chemicals in the world (Timbrell, 2002). Among the harmful chemical factors of the workplace gases, vapors, and solid and liquid particulate matters can be noted, each of which has its own effects, and these effects depend on the type of material, the path flow of chemicals, the duration of the exposure of the person and its concentration in the environment (Esmaeilzadeh et al., 2015). At least 6,500 chemicals are produced and a large number is added to them each year (Timbrell, 2002). Working with chemicals in various industries can have irreparable risks for staff, so to reduce the risk of exposure to chemicals in the workplace, risk assessment takes place (Karami et al., 2014). Using chemical health risk assessment, one can have a comprehensive assessment of the exposure of employees tofactors causing health hazard,and after determining the level of risk one can predict control measures, more training of staff, monitoring and health care to protect employees against exposure to hazardous chemicals (OS&HD, 2005). In a study conducted by Golbabai et al. as health risk assessment of exposure to chemical pollutants in a petrochemical industry in 2011, benzene with a factor of 4.5-5 had the highest risk (Golbabai et al., 2012). Jahangiri et al. conducted a study titled health risk assessment of occupational exposure to harmful chemical agents in a petrochemical industry and concluded that Epichlorohydrin has the highest amount of risk (Jahangiri and Motovagheh, 2011). Moreover, a study by Jalali et al. entitled as occupational risk assessment of exposure to chemicals in order to provide control measures in a polyurethane foam industry in 2012, and it was found that Toluene Diisocyanate has the highest risk factor (3.67) between 7 chemicals accounted detected (Jahangiri et al., 2012).

In the petrochemical industry, by performing several processes of petroleum products and raw materials of several industriesthey are produced and the employees are exposed to diverse contaminants and are at risk (Esmaeilzadeh et al., 2015). More than 95% of organic chemicals and their derivatives such as chemicals, plastics, and fertilizers are produced in the petrochemical industry, so risk assessment in this industry has a great importance (Karami et al., 2014). Thus, the aim of this study is to assess the risks of occupational exposure to chemicals in one petrochemical industry designed to provide control measures.

2. Materials and methods

This study is a descriptive-analytic study of cross-sectional type done in a petrochemical complex located in Asalooyeh in 2015. All chemicals in Olefin unit were assessed using semi-quantitative risk assessment method provided by the Singapore Ministry of Labor Health and Safety Unit. Semi-quantitative risk assessment of chemicals will be carried out through the following steps (Jalali, 2013; Malakouti, 2014):

2.1. Determine the hazard ratio (HR)

At this stage, after identifying chemicals (with careful study of the work process, using the guidance of technical officials and professional health experts, visiting the site and the manufacturing process), a list of chemicals is produced. Then the risk factor is determined in one of two ways of harmful effects of toxic agents or acute chemical toxicity. For this purpose, a list of LD50 (the dose at which 50% of the rats die from ingestion) chemical materials is prepared, and on the basis of these data and information, including the classification of carcinogenic and other harmful effects of chemicals, such as their impact on body organs, HR is determined for that substance based on the ranking table between 1 to 5.

2.2. Determining the exposure ratio (ER)

After determining HR, exposure ratio will be calculated according to the results measured exposure index (chemical monitoring) from the actual level of exposure and in the absence of exposure index (EI), and in this petrochemical units due to lack of monitoring chemical exposure index, EI method will be used to determine ER. ER through is calculated through exposure EI indices and based on the physical properties of contaminants such as vapor pressure in relation to the olfactory threshold limit value (OT / PEL) and the control measures, the use of chemicals involved and the number of hours worked per week using the following equation:

$$ER=[(EI)_1 \times (EI)_2 \times \ldots\ldots \times (EI)_n]^{1/n}$$

EI: Physical features of the contaminants

Exposure indices are in an ordinal scale of 1 to 5 classified in the order of severity of exposure, so that 1 is the very low exposure, 3 is the average exposure, and 5 shows the very high exposure.

2.3. Risk rate (RR)

At this stage, after the designation of the risk and exposure factors, the risk factor will be calculated based on the following relationship:

$$RR = \sqrt{HR \times ER}$$

2.4. Risk rating

After determining the risk score, to rank each of the substances, the following table will be used and controlling measures will be determined based on risk level (Table 1):

Table 1
Ranking level of risk substances.

Level of risk	Ranking
1	Very low- negligible
2	Low
3	Average
4	High
5	Very high

3. Results

In the studied unit, seven most widely used and affecting chemical were identified and examined the effects, and 14.2 percent of them have a high risk level (Figure 1).
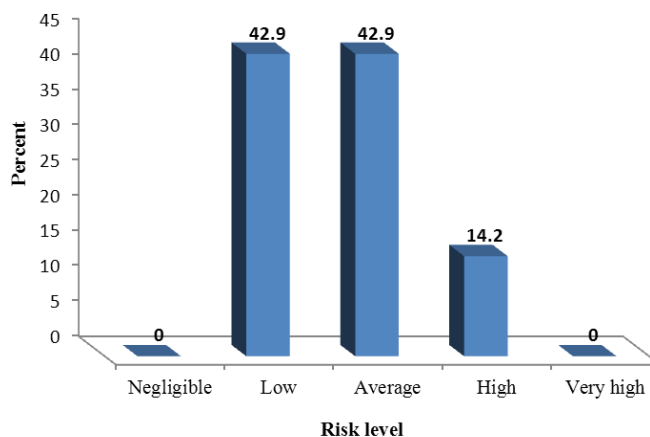

Fig. 1. Chemical percentage in each of the levels of risk in Olefin unit.

Moreover, the results showed that the largest risk factor is for Sodium hydroxide (caustic) with quantitative risk of 4.3 and qualitative risk rating high. Propylene, Benzene, and dimethyl sulfide with respectively quantitative risk levels of 3 and 3.2 and average qualitative risk level are in the next ranks (Table 2).

Table2
Determining exposures and chemical risk factors identified in the Olefin unit.

Row	Unit	Chemical	Formula	Hazard rate	Exposure rate	Risk rate	Risk level	Ranking of risk
1		Caustic soda	NaOH	3	4.57	3.7	4.3	high
2		Pyrolysis gasoline	Mixture	1	2.99	1.73	2	Low
3		Propylene	$C_3H_8O_2$	2	2.66	2.3	3.2	Medium
4	**Olefin**	Fuel oil Quiench Oil	$C_{40}H_{82}$	2	1.8	1.9	2	Low
5		Gasoline	$C_{16}H_8$	3	3.16	3.08	3	Medium
6		Coal tar	Mixture	2	3	2.5	2.4	Low
7		DMDS	$C_2H_6S_2$	3	3	3	3	Medium

4. Discussion and conclusion

Using health risk assessment of the chemicals, one canhave a comprehensive assessment of the staff exposure to the chemicals and after determining the level of risk about prediction of control measures, more training of personnel, monitoring, and health care to protect employees against exposure to hazardous chemicals, decision can be made (OS&HD, 2005). Seven chemical substances are identified in this unit where only sodium hydroxide (caustic) with quantitative risk level of 4.3 and quantitative high risk is the substance with risk factor and was known as a risk factor. The findings are inconsistent with the results of the study conducted in 2011 Golbabai et al. and obtained quantitative risk factor of sodium hydroxide (caustic) as 2.4 (Golbabai et al., 2012). RR in this study and the study of Golbabai et al is 3, so the inconsistency of risk factor is caused by sodium hydroxide exposure factor that is 2.3 in this study against the study by Golbabaiet al., which may be because of improper control measures such as open containers of material and environmental conditions prevailing at the site.

Sodium hydroxide risk material increase is due to the high coefficient of risk and exposure that is why we can reduce risk factors by actions such as reducing the amount of material used per week,and reducing exposure factor like controlling measures such as tank containing the hob be used to reduce risk. The cap of the tank while preventing the spread of vapors inside the tank contents, allows the discharge nozzle move into the tank. Among the limitations of this study, the subject can be noted that due to lack of the results of monitoring of chemicals to assess risk, exposure method is used that has lower accuracy.

Acknowledgements

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