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Implementation of Chemical Health Risk Assessment (CHRA) Program at Chemical Laboratories of a University

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Abstract

The use of chemicals in academic/research laboratories is obvious which need proper university's safety management. It is the prime responsibility of university top management to protect laboratory staff from chemical health risks during their work. This study elaborates a methodology for the implementation of a Chemical Health Risk Assessment (CHRA) program in a University's chemical laboratories. The objective of this CHRA program is to identify and evaluate the risks of chemical exposure among laboratory staff. The qualitative observation of CHRA program identified two categories of risk, one is a significant risk but already adequately controlled could increase in future, second is risk significant now, and not adequately controlled. Based on the conclusion of CHRA program proactive suggestions were made to reduce the risks of chemical exposure among laboratory staff. This study can be useful to implement CHRA program in chemical laboratories of a university to assess the risk of chemical exposure and required control measures for the protection of laboratory staff.

Keywords: Chemical exposure; Occupational risk assessment; Chemical Safety; Laboratory Safety; Kingdom of Saudi Arabia

1. Introduction

The use of diverse chemicals in academic laboratories is obvious, especially for research oriented working units. It is a wrong perception that academic laboratories are safe vanes of work for students and researchers (Shariff & Norazahar, 2011), as it was found that majority of them are unsafe for study and research. The use of small quantities of chemicals in academic laboratories can be a reason for this wrong perception. Chemical risk exposure in research/academia increased with the development and diversification of new techniques and materials into the field of Science as recent accidents shows; Blast in a French University (Freemantle, 2006), Blindness of a laboratory staff in University of technology, Taiwan (Wu et al., 2007), severe injuries due to Explosion of perchlorate in a University (Kemsley, 2010).Recognition of laboratory safety as compared to the safety of industrial manufacturing plants is still a challenge for health and safety of laboratory staff. Due to lack of resources, less attention has been paid to chemical risk evaluation and mitigation in the universities of developing countries.

It is important to know about the risk of chemical exposure to the laboratory staff of academic and research institutes. To evaluate chemical risk assessment, several approaches have been found in literature as; a systematic approach in the form of an online software tool named Lab-HIRA (Hazard Identification and Risk Analysis for the Chemical Research Laboratory) to conduct a risk assessment (Leggett, 2012$_{a,b,c}$), Lab-HIRA can be useful to decrease chemical accidents in the laboratories during chemical synthesis process after the implementation of risk minimization measures but this technique can be expensive for and time taking to get in-depth analysis. A comparative study designed to analyze three methods to identify chemicals hazards in French laboratories but this study focused mainly on chemical hazards, not chemical exposure (Bourrée et al., 2014). A zero ventilation model (tiered approach) developed for chemical exposure assessment (air concentration) of ethyl ether, n-hexane, and methylene chloride in a chemistry teaching laboratory during distillation and extraction exercises (Keil & Murphy, 20006) this exposure model can be a useful tool to assess the acceptability of chemical exposure, but this study cannot adopt as it is for whole chemical inventory of laboratories in universities. A model for identification of hazardous chemical hazards in biomedical laboratories proposed which can be useful only for health and epidemiological surveillance programs for laboratory workers (Apostoli et al., 1996). Recently a model named ''Chemical Hazard Evaluation for Management Strategies'' (CHEMS-1) used for the development of a framework for scoring of analytical laboratories solvents by calculating hazards values extracted from toxicological and exposure data (Tobiszewski & Namieśnik, 2015) A hazards mapping tool proposed for the classification of 28 specific laboratory hazards including chemical hazards named Assessment and Classification of Hazards in Laboratories (ACHiL) (Marendaz et al., 2013). This study useful only regarding classification and assessment of a broad range of diverse laboratories hazards. A methodology developed named "Laboratory Assessment and Risk Analysis" (LARA) based on the calculation of Lab Criticity Index (LCI) (Ouédraogo et al., 2011). LARA is useful to estimate the risk regarding the combination of severity, probability, detectability, worsening factors and research specificities. A systemic technique named "Laboratory at-risk behavior and improvement system" (Lab-ARBAIS) developed to monitor and control students' at-risk behavior in the laboratory (Shariff & Norazahar, 2011). Lab-ARBAIS can be useful to monitor students' at-risk behavior to ensure healthy workplace but deficient regarding amount or extent of risk. A broader concept of academic safety management proposed and discussed in a study named MICE (Management, Information, Control and Emergency). MICE approach also deals with chemical management in the universities (Meyer, 2012).

As earlier mentioned about the recognition issue of laboratory safety and fewer resources in the developing countries we tried to implement an approach as a preliminary step to create safety culture there. We applied chemical health risk assessment (CHRA) technique for the assessment of chemical risks in a Saudi university. Previously, this method was used in a Malaysian University for chemical health risk assessment of teaching and research labs in chemical and biochemical engineering department (Husin et al., 2012). This study explains the detail implementation of CHRA program.

A CHRA program instituted in the chemical laboratories. The purpose of the CHRA program is to identify and evaluate the risks and level of chemical exposure among laboratory staff (students and researchers). This program also evaluates the adequacy of existing control measures also of exposure chemical mitigations relatively.

2. Materials and Methods

For the implementation of CHRA, we adopted methodology from a manual named "Assessment of the Health Risks Arising from the Use of Hazardous Chemicals in the Workplace" developed by the department of occupational safety and health, Malaysian Ministry of human resources (CHRA, 2000). Flow chart of CHRA program with the five types of conclusions has been given in Figure 1. The purpose of a *CHRA* is to enable University top management for decision making of the protection of students and laboratory staff who may expose to occupational chemical exposure, based on appropriate control measures.

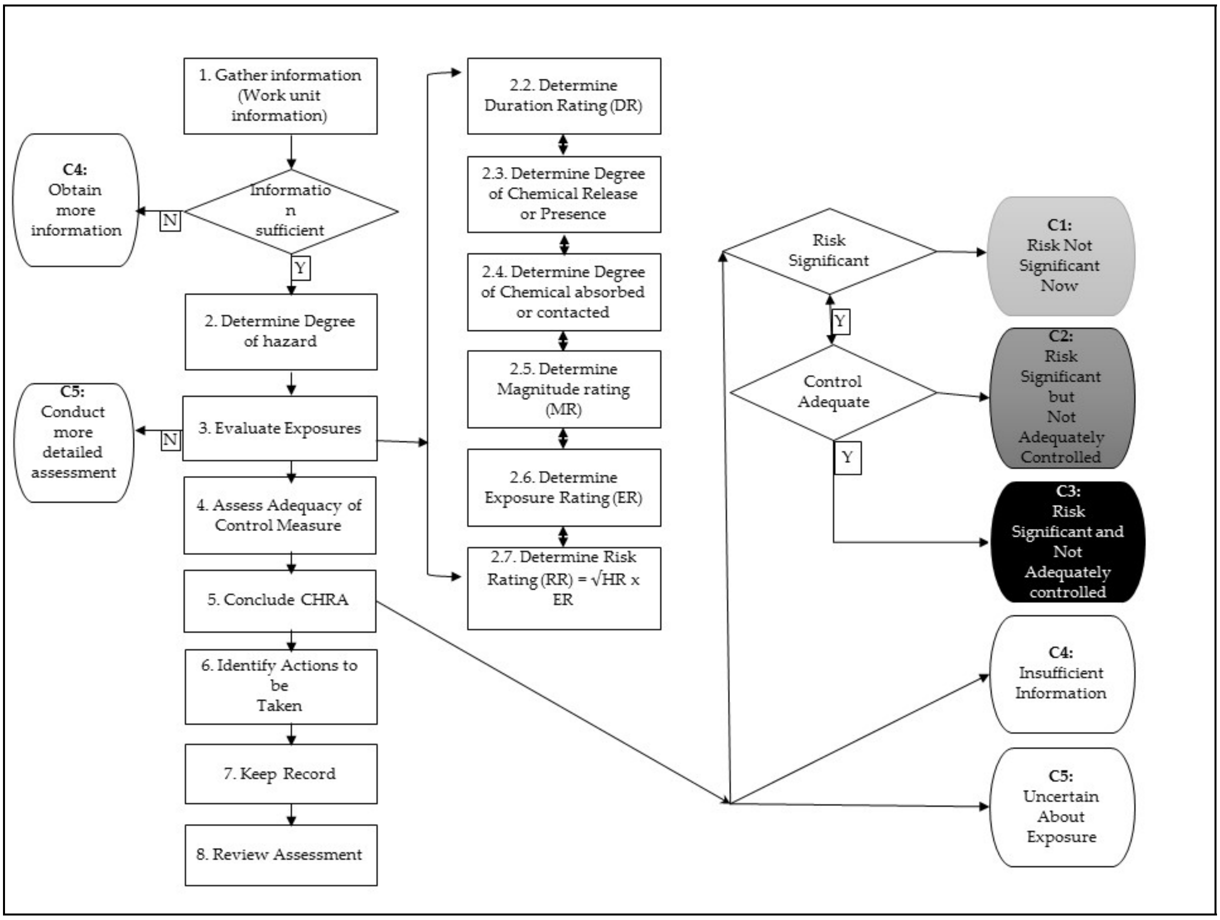

Figure 1. Flow chart of Chemical Health Risk Assessment (CHRA) adopted and modified from (CHRA, 2000)

We used the results of a preliminary study (Abbas et al., 2016) in order to select the worst chemical laboratories, and total 14 chemical laboratories have been chosen to conduct CHRA as Table 1 shows the details of chemical laboratories. Material safety data sheets (MSDS) from supplier used as primary source of information for chemicals exposure risk and related OHS information such as; Laboratory working hours, Personal protective equipment (PPE) programme, control equipment design parameter and maintenance (fume hood design parameters, local exhaust ventilation and inspection records) has been assessed during CHRA. We reviewed frequent laboratory tasks both routine and non-routine, production of one-off items to identify all potential risks. We conduct regular walk-through surveys to identify the risk of chemical exposure to laboratory staff.

Table 1. List of chemical laboratories

Lab	Chemical Laboratory	No. of frequently chemicals
L1	Analytical Chemistry Lab 1	16
L2	Natural Product Chemistry Lab	10
L3	Analytical Chemistry Lab 2	16
L4	Preparation lab	3
L5	Electrochemistry lab	11
L6	Organic chemistry lab	5
L7	Instrumental analysis lab	9
L8	Local Ores Lab	21
L9	Research Lab	15
L10	Analytical Chemistry Lab 3	8
L11	Solid waste Lab	17
L12	Nanotechnology research lab	15
L13	Plant Biotechnology Lab	3
L14	Microbiology Lab	4

L = Chemical laboratory

2.1 Determination of Duration Rating (DR)

Table 2 used for the determination of DR stratified with working hours. For example DR value 1 (< 1 hr. / 8 hrs. day or < 5 hours/ week) is minimum and DR value 5 (> 7 hrs. /day or > 35 hours/ week) is maximum).

Table 2. Duration rating (DR) assigning Criteria for chemical laboratories

Rating	% work hour	Duration per 8-hr shift or per 40-hr week		
5	> 87.5 %	> 7 hrs./ day	**or**	> 35 hours/ week
4	50-87.5 %	4 to 7 hrs./ day	**or**	20 to 35 hours/ week
3	25-50 %	2 to 4 hrs./ day	**or**	10 to 20 hours/ week
2	12.5-25 %	1 to 2 hrs./ day	**or**	5 to 10 hours/ week
1	< 12.5 %	< 1 hr. / 8 hrs. day	**or**	< 5 hours/ week

**Note: Total exposure duration per week (TD) =*

(Number of exposure per week) x (Average duration of each exposure)

2.2 Qualitative Estimation of Magnitude of Exposure

There are two main routes of entry for chemicals exposure i.e. inhalation route and dermal route. In the case of ingestion, if chemical exposure is significant, make the evaluation and recommend suitable actions to be taken. The magnitude of chemical exposure can be estimated through the assessment of absorbed chemicals dose via inhalation and skin absorption. Chemical exposure to skin or eye in the form of absorption is not only from direct contact with solvents; but it can also be through airborne gas, vapors or particulates. So for the qualitative estimation of the magnitude of chemical exposure, we determined the degree of a chemical release or presence and the degree of chemical absorbed or likely absorbed (contacted) in selected chemical laboratories (CHRA, 2000).

2.3 Determination of Degree of Chemical Release (Presence)

The degree of chemical release (presence) estimated based on the following information;

1. Physicochemical properties of chemicals availed through Material safety data sheet (MSDS) of chemicals
2. Characteristics of work process availed through description of chemical process
3. Chemicals used quantity availed through laboratory chemicals register
4. Methods of chemical handling availed through onsite personal observations
5. Atmospheric conditions availed through onsite observations of environmental conditions.

Table 3 used to assign the degree of chemicals release (presence) for inhalation exposure after onsite personal observations. For example, if clothing of a laboratory worker is getting frequently contaminated while using a non-volatile liquid (i.e. minor release into the air) but is lipophilic (high ability to dissolve fat and hence able to absorb through the skin), assigned degree of a chemical release or presence will be Moderate.

Table 3. Degree of Chemical Release or presence

Degree	Sample observation
Low	Low or little release into the air. No contamination of air, clothing and work surfaces, with chemicals capable of skin absorption or causing irritation or corrosion.
Moderate	Moderate release such as; a) Solvents with medium drying time in uncovered containers or exposed to work environment; b) The detectable odor of chemicals with odor thresholds exceeding the PELs. Evidence of contamination of air, clothing and work surfaces with chemicals capable of skin absorption or causing irritation or corrosion.
High	Substantial release such as; a) Solvents with fast drying time in uncovered containers; b) Sprays or dust clouds in poorly ventilated areas; c) Chemicals with high rates of evaporation exposed to work environment; d) A Strong odor of chemicals with odor thresholds exceeding the PELs. Gross contamination of air, clothing and work surfaces with chemicals capable of skin absorption or causing irritation or corrosion.

The qualitative estimation of chemical exposure based on industrial hygiene professional judgment by following an exposure model given in Figure 2. Industrial hygiene judgment made on the basis that the amount of chemical absorbed (contacted) or in contact with laboratory staff body depends on the degree of a chemical release (presence) and the degree of reception (retention). Following factors can affect chemical inhalation exposure such as; contaminant release rate, quantity used or handled, air contamination, in the vicinity of the source and in enclosed/confined space where the contaminant is present (CHRA, 2000). Following factors can affect the degree of reception or retention such as; work practice, air intake, contaminated clothing & surfaces, workers awareness and personal hygiene.

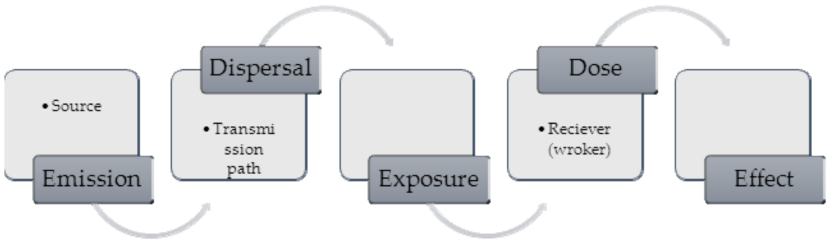

Figure 2. Outline of qualitative exposure model (CHRA, 2000)

2.4 Determination of Degree of Chemical absorbed (contacted)

The degree of chemical absorbed (contacted) determined by using Table 4. Organic solvents can absorb through the skin. Onsite observation of chemical laboratory made accordingly, and the degree of chemical absorbed or contacted assigned.

Table 4. Determination of Degree of Chemical absorbed or contacted

Degree	Sample observation
Low	Low breathing rate (light work > Sitting, moderate arm and trunk movements (E.g. desk work, typing) Source far from breathing zone Contact with chemical other than those described under "Moderate “and "High". A small area of contact with chemicals capable of skin absorption-limited to palm (intact skin). <2% or 0.04m2 No indication of any skin conditions. Intact/normal skin No contamination of skin or eyes
Moderate	Moderate breathing rate (moderate work > sitting, heavy arms and legs movement (standing, light work at machine or bench, some walking about, Standing, moderate work at machine or bench, Walking about, with moderate lifting or pushing) Source close to breathing zone Contact with eye or skin irritants, sensitizers or chemicals capable of skin penetration, except those described under ' High’. Moderate area of contact- one or both hands up to the elbows.

	Skin area >2% or $0.04m^2$ Skin dryness and detectable skin condition. Dry, red skin
High	High breathing rate (heavy work > Intermittent heavy lifting, pushing or pulling (E.g. pick and shovel work, Hardest sustained work). A source within breathing zone. Gross contamination of eye or skin with skin or eye irritants, Sensitizers or chemicals capable of skin absorption -skin soaked or immersed in chemical capable of skin penetration. Area of contact not only confined to hands but also other parts of the body. Skin area>50% or $1m^2$ Follicle rich areas. Skin damaged. Severe drying, peeling and cracking.

2.5 Determination of Magnitude Rating (MR)

Based on Table 3 and Table 4, we assigned the degree of a chemical release (presence) and the degree of chemical absorbed (contacted). For determining MR, we used Table 5. The first column belongs to the degree of a chemical release (presence), the second column belongs to the degree of chemical absorbed (contacted), and the third column belongs to the relevant MR numeric number (1= lowest, 5= highest).

2.6 Determination of Exposure Rating (ER)

ER is a product of DR and MR. Matrix for ER in Table 6 used to assign ER to each chemical laboratory.

Table 5. Magnitude Rating (MR)

Degree of release	Degree of absorbed	MR
Low	Low	1
	Moderate	2
	High	3
Moderate	Low	2
	Moderate	3
	High	4
High	Low	3
	Moderate	4
	High	5

Table 6. Matrix for Exposure Rating (ER)

Duration Rating (DR)	Magnitude Rating(MR)				
	1	**2**	**3**	**4**	**5**
1	1	2	2	2	3
2	2	2	3	3	4
3	2	3	3	4	4
4	2	3	4	4	5
5	3	4	4	5	5

2.7 Determination of Hazard Rating (HR)

The purpose of HR calculations is to prioritize types of potential health hazards due to chemical exposure, rated on a scale range of 1-5 (1=not hazardous, 5=most hazardous). MSDS can be used to assign the risk phrases to each chemical for determination of HR. At first, we assigned HR to individual chemical and in the last column of Table 6 which is given in supplementary material. We assigned HR to the mixture of chemicals. All frequently used chemicals in a chemical laboratory, we consider it as a mixture or preparation to assign the accumulative HR. First of all, we classified chemical hazards, and risk phrases and Table 7 used to assign hazard rating. In the case of a mixture of chemical (like a laboratory use different types of chemicals), we assigned a single hazards based on the greatest degree of hazard.

3.4 Determination of Risk Rating (RR)

Risk rating (RR) is square root of HR times ER, formulated as;

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

Matrix for RR in Table 8 used to assign RR to each chemical laboratory. Two possible cases can be seen after determination of RR i.e. risk is significant or risk is not significant. For example, if there is no likelihood of chemical exposure or chemical is least hazardous (HR=1) or low chemical exposure (ER=1). Another possible scenario of nonsignificant risk can be such as; chemical with low toxicity (HR=2) and below 0.5 PEL exposure level (ER=2). So RR from 1 or 2 can be considered as non-significant.

Table 7. Hazard Rating Based on Risk Phrases

Effect	Acute/ Chronic	Routes of Exposure					HR
		Inhalation	Dermal		Ingestion	Not specified (all routes)	
			Skin	EYE			
Very Toxic	Acute	R26	R27		R28	R39	5
	Chronic	-	-		-	-	
Toxic	Acute	R23	R24		R25	R39	4
	Chronic	-	-		-	R48, R39	
Harmful	Acute	R20	R21		R22	R40	3
	Chronic	-	-		-	R48, R40	
Corrosive	Acute		R35				4
			R34				3
Irritant	Acute	R37	-	R41			3
		-	R38	R36			2
Sensitizing	Acute	R42	-				3
		-	R43				2
Carcinogenic	Chronic	R49(1)				R45(1)	5
		R49(2)				R45(2)	4
		-				R40(3)	3
Mutagenic						R46(1)	5
						R46(2)	4
						R40(M2)	3
Teratogenic						R47(1)	5
						R47(2)	4

Table 8. Matrix for Risk Rating (RR)

Hazard Rating (HR)	Exposure Rating (ER)				
	1	2	3	4	5
1	1	2	2	2	3
2	2	2	3	3	4
3	2	3	3	4	4
4	2	3	4	4	5
5	3	4	4	5	5

Risk not significant

Risk significant; category 1

Risk significant; category 2

2.8 Types of Conclusions of CHRA

Table 9 shows the conclusions of risk assessment for surveyed chemical laboratories and we used it for the identification and prioritising control measures. The degree of risk, the number of the person at risk and practicability of the control measures will determine the priority for implementing control measures.

Table 9. Risk Assessment decision and Conclusions

Risk Decision	**Adequacy of current control measures**	**Conclusion**
Risks not significant now and not likely to increase in future	-	C1
Risk significant but already adequately controlled could increase in future.	Adequate (category 1)	C2
Risks significant now, and not adequately controlled	Not Adequate (category 2)	C3
Uncertain about Risk: Insufficient information	-	C4
Uncertain about Risk: Uncertain about degree and extent of exposure	-	C5

C1 *– End current assessment and review every 5 years or when required.*

C2 *– Determine precautions, measures, the requirement for monitoring or health surveillance that been taken to maintain controls and minimize exposures. Review assessment every 5 years or when required.*

C3 *– Identify precautions, measures, the requirement for monitoring or health surveillance that need to be taken to maintain controls and minimize exposures. Review assessment every 5 years or when required.*

C4 *– Obtain more information.*

C5 *– Conduct more detailed assessment.*

3. Results and Discussion

3.1 Duration Rating (DR)

Determination of DR used to investigate the nature of exposure i.e. chronic or routine. DR has a significant effect on chemical exposure to laboratory staff, like, 2 times the chemical exposure duration results in 2 time's chemical exposure as Table 10 shows the DR of chemical laboratories.

The total duration of chemical exposure is the product of chemical exposure and the average duration of each exposure.

Table 10. Duration rating (DR) of different occupational group

Lab	Chemical Laboratory	Occupational Group	DR
L1	Analytical Chemistry Lab 1	PhD Student	4
L2	Natural Product Chemistry Lab	PhD Student	4
L3	Analytical Chemistry Lab 2	PhD Student	4
L4	Preparation lab	PhD Student	4
L5	Electrochemistry lab	PhD Student	5
L6	Organic chemistry lab	Assistant Professor	2
L7	Instrumental analysis lab	PhD Student	4
L8	Local Ores Lab	Assistant Professor	5
L9	Research Lab	PhD Student	4
L10	Analytical Chemistry Lab 3	Assistant Professor	4
L11	Solid waste Lab	Master Student	4
L12	Nanotechnology research lab	PhD Student	5
L13	Plant Biotechnology Lab	PhD Student	4
L14	Microbiology Lab	PhD Student	5

3.2 Magnitude Rating (MR)

The results of MR based on the degree of a chemical release (presence) and the degree of chemical absorbed (contacted) observed moderate as Table 11 shows the degree of chemical release (presence), the degree of chemical absorbed (contacted) and assigned MR.

3.3 Exposure Rating (ER)

Chemical laboratories categories into two types regarding the result of ER as Table 12 shows 3 and 4 values of ER.

Table 11. Degree of Chemical Release (Presence), Degree in Chemical absorbed (contacted) and assigned Magnitude rating (MR)

Lab	Chemical Laboratory	Degree of Chemical Release	Degree of Chemical absorbed	MR
L1	Analytical Chemistry Lab 1	Moderate	Moderate	3
L2	Natural Product Chemistry Lab	Moderate	Moderate	3
L3	Analytical Chemistry Lab 2	Moderate	Moderate	3
L4	Preparation lab	Moderate	Moderate	3

L5	Electro chemistry lab	Moderate	Moderate	3
L6	Organic chemistry lab	Moderate	Moderate	3
L7	Instrumental analysis lab	Moderate	Moderate	3
L8	Local Ores Lab	Moderate	Moderate	3
L9	Research Lab	Moderate	Moderate	3
L10	Analytical Chemistry Lab 3	Moderate	Moderate	3
L11	Solid waste Lab	Moderate	Moderate	3
L12	Nanotechnology research lab	Moderate	Moderate	3
L13	Plant Biotechnology Lab	Moderate	Moderate	3
L14	Microbiology Lab	Moderate	Moderate	3

Table 12. Exposure rating (ER) of chemical laboratories

Lab	Chemical Laboratory	ER
L1	Analytical Chemistry Lab 1	4
L2	Natural Product Chemistry Lab	4
L3	Analytical Chemistry Lab 2	4
L4	Preparation lab	4
L5	Electrochemistry lab	4
L6	Organic chemistry lab	3
L7	Instrumental analysis lab	4
L8	Local Ores Lab	4
L9	Research Lab	4
L10	Analytical Chemistry Lab 3	4
L11	Solid waste Lab	4
L12	Nanotechnology research lab	4
L13	Plant Biotechnology Lab	4
L14	Microbiology Lab	4

3.4 Types of Conclusions of CHRA

Two types of conclusions were made base on RR value of 4 and 5 which can be associated with the worst situation there regarding health safety of workers as Table 13 shows the results of RR and relevant conclusion for each chemical laboratories.

Table 13. Conclusions of Risk assessment for chemical laboratories

Lab	Chemical Laboratory	Risk rating (RR)	Conclusion
L1	Analytical Chemistry Lab 1	5	C3
L2	Natural Product Chemistry Lab	5	C3
L3	Analytical Chemistry Lab 2	5	C3
L4	Preparation lab	4	C2
L5	Electro chemistry lab	4	C2
L6	Organic chemistry lab	4	C2
L7	Instrumental analysis lab	4	C2
L8	Local Ores Lab	5	C3
L9	Research Lab	5	C3
L10	Analytical Chemistry Lab 3	5	C3
L11	Solid waste Lab	5	C3
L12	Nanotechnology research lab	4	C2
L13	Plant Biotechnology Lab	4	C2
L14	Microbiology Lab	4	C2

The results of CHRA program shows that the risk of chemical exposure is significant in the selected chemical laboratories and there is need to improve existing control measure for the healthy working environment in the university. Involvement of top management in vital for the development of safety culture in the university. The results can be useful to mitigate the risk of chemical exposure by choosing suitable controlling measures among laboratory staff such as; Safety training, posting of safety regulations in the laboratories, departmental safety management, good housekeeping services, and use of personal protective equipment.

Table 13 shows the RR for all chemical laboratories in the selected university, half of the chemical laboratories found with RR=5 and half of the chemical laboratories found with RR=4 and concluded as C3 and C2 respectively. There is a strong relationship between R-phrases and H statements, as laboratory chemical hazards used to rate base on the R-phrases. Provided information in the SDS such as; toxicological data, health effects used to assigned R-phrases to each chemical or mixture of chemicals. So risks significantly now, and not adequately controlled in half of the chemical laboratories which need to address C3 which stipulates that the adequacy of current control measures be “not Adequate (category 2)” as Table 13 shows the categories of risk assessment decision and control measures. Chemical laboratories with RR=5 considered as intolerable and need to eliminate hazardous chemicals at first. Alternatives such as; substitution of hazardous chemicals with low toxic chemicals; proper chemical management and handling; isolation of work can adopt to reduce hazardous chemical exposure among laboratory staff. For C3 immediate measures required to prevent from exposure such as; identification of measures and procedures to control accidental emission of hazardous chemicals; longer term control strategies; reschedule CHRA after 5 years or change in the laboratory settings. Programs of laboratory staff training and health surveillance should also be determined.

On the other hand "risk significant but already adequately controlled could increase in future" found in next half of the chemical laboratories with "Adequate (category 1)" current control measures. Chemical laboratories with C2 conclusion need to strengthen adequacy of control measures because the increase of RR can be possible in case of failure or deterioration of control measures. Regarding control measures, there is a need to control risks below permissible exposure limits (ALARP). The severity of risk, laboratory staff knowledge about risk, accessibility and appropriateness of eliminating or mitigating the risk and its costs can be crucial in the case of C2 conclusion. Factors that can be responsible for the increase of risk such as; improper use of control measures; human error due to insufficient knowledge, changes in workflow and a random rise in the chemical quantities usage. For C2, assessment can reschedule after 5 years or change in the laboratory settings. Determination of precautions and additional measures to reduce risks should be identified and evaluate their effectiveness. A previous study from Malaysia about the CHRA in chemical and biomedical engineering laboratories found RR=3 and concluded with the C3 decision (Husin et al., 2012). However, this study reveals the worst situation comparatively. So the proposed mitigation in that study can be useful for lowering of RR in the chemical laboratories.

Adaptation of Globally Harmonized System of Classification and Labelling of Chemicals (GHS) is important for the reduction of chemical risk in laboratories. Globally Harmonized System of Classification and Labelling of Chemicals (GHS) has been developed for hazard communication in 1992 by United Nations Conference on the Environment and Development (UNCED). In GHS, chemicals are classified by physical, health, toxicological and environmental hazards. Harmonized labeling of chemicals and safety data sheets (SDS) use for hazards communication in the laboratories (Pratt, 2002). In a study from Taiwan, it was investigated that the perception of students towards chemical labeling and lower perception found under GHS regardless of high agreement level for chemical labeling. In the same study, students have a high perception on chemical labeling, who attended training sessions regarding hazard communication accordingly and curriculum modification was also suggested accordingly (Su & Hsu, 2008).

Safe experiments in the chemical laboratories require safe work practices to reduce chemical exposure risk as Prudent Practices in the Laboratory, Handling and Management of Chemical Hazards book mentioned four fundamental principles for sound laboratory safety culture such as; a) Plan ahead for the determination of potential chemical hazards b) Minimum chemical exposure by using laboratory hoods, ventilation devices and personal protective equipment c) avoid underestimation of chemical hazard or related risk by treating new chemicals with unknown toxicity d) be ready for accidents during laboratory work so integrate yourself with all available laboratory safety resources such as PPEs, emergency numbers etc. (NRCC, 2011). A recent study found five factor model solution for chemical safety in academic laboratories; 1) availability of laboratory safety documents, 2) maintenance of fume hood, 3) proper chemical storage, 4) proper use of fume hood for chemical handling and 5) laboratory safety labelling (Abbas et al., 2016).

It is obligatory for an employer to provide hazards free workplace to his workers. Declaration of Occupational Safety and Health Administration (OSHA) Laboratory Standard (29 CFR § 1910.1450) upraised laboratory safety culture in the industrial, governmental and educational sector (NRCC, 2011), which obligate the appointment of Chemical Hygiene Officer (CHO) and Chemical Hygiene Plan (CHP). Laboratory safety guidelines developed by OSHA states that an employer must inspect workplace in case of chemical exposure above the action level. Laboratory safety provisions related to safety training, chemical exposure inspection, medical consultation, suitability of personal protective equipment (PPE), control measures, and specific guidelines for hazardous chemicals must be covered in the CHP and CHO is the prime responsible for all these provisions (OSHA, 2011).

4. Conclusion and Recommendations

In conclusion, chemical laboratories found with significant risk of hazardous chemical exposure. Regarding control measures, the risk of chemical exposure was not controlled adequately in half of chemical laboratories and either it was controlled in next half of the chemical laboratories but could increase in future. So, there is need to extend the current control measures to reduce risk hazardous chemical exposure among laboratory staff. Effective laboratory safety management practices are crucial for any renowned university. Results of this study and the application of CHRA program can be useful to do it in the university laboratories of other developing countries. The findings of present study proposed following suggestion which can improve occupational health and safety status of chemical laboratories in the selected university;

- Updating of hazardous chemicals registers and supplier MSDS
- Reduction of skin exposure through suitable personal protective equipment
- Assigned place for personal protective equipment
- Practical reduction of exposure to carcinogens or respiratory sensitizers
- Mandatory use of respiratory protection irrespective of absorbed dose or airborne concentration
- Proper chemical management in chemical laboratories
- Immediate notification related to new unsafe practice from chemical laboratories
- Development of emergency response plan and its follow-up training
- Implementation of employee exposure monitoring program
- Development of health surveillance programs for laboratory staff
- Development of laboratory safety training programs and evaluation
- Reassessment of CHRA after the implementation of suggested control measures

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Glossary

CHRA: Chemical Health Risk Assessment

DR: Duration Rating

MR: Magnitude Rating

ER: Exposure Rating

HR: Hazard Rating

RR: Risk Rating