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Research Article

Chemical Health Risk Assessment (CHRA) in a Wet Assay and Fire Assay Laboratory (WAFAL)

Arif Susanto[1,2]*, Mila Tejamaya[3], Roro N Wulan[4] and Edi K Putro[2]

[1]*Doctorate Program in Environmental Science, School of Postgraduate Studies, Universitas Diponegoro, Indonesia*

[2]*Department of Health Safety and Environmental, Division of Concentrating, PT Freeport Indonesia, Indonesia*

[3]*Department of Occupational Health and Safety, Faculty of Public Health, Universitas Indonesia, Indonesia*

[4]*Department of Chemical, Faculty of Science and Technology, Universitas Islam Negeri Walisongo, Indonesia*

***Corresponding Author:** Arif Susanto, Doctorate Program in Environmental Science, School of Postgraduate Studies, Universitas Diponegoro, Indonesia.

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Abstract

Numerous chemicals with a variety of characteristic can be found in every laboratory, including in quality control in a wet assay and fire assay laboratory (WAFAL). Contact with those chemicals might pose health risks to workers and therefore this should be carefully controlled. Thus, chemical health risk assessment (CHRA) needs to be performed in any laboratory in order to recognize, assess, and control the risks arising from these chemicals. This study was aimed to semi-quantitatively assess the level of chemicals health risks from 11 chemicals that were used in WAFAL. Both the inhalation and dermal route of entry were evaluated. 7 chemicals were found as hazardous to inhalation route of entry, 8 chemicals to dermal contact, and three of them both hazardous to inhalation and dermal route of entry. Through inhalation, it was found that six chemicals were at moderate risk, and one chemical at low risk to human health. On the other hand, high health risks were shown by dermal contact of six chemicals, and other two chemicals were at moderate risk.

Keywords: CHRA; Chemical Risk; Laboratory; Risk Rating; Wet Assay; Fire Assay

Introduction

For employees working in a laboratory, chemicals are vital components inseparable from the working environment. They are used in analyzing copper and gold in ore and concentrates. Quality control (QC) [1,2], involves the use of most chemicals in the process of wet assay [3,4] and fire assay (Hoffman., *et al*. 1998; Sketchley, 1998). Workers may be exposed to hazards at any time, and, thus, carefulness and appropriate procedures are necessary to minimize detrimental effects on health [5].

An effective method applied to minimize detrimental health effects involves carrying out a Chemical Health Risk Assessment (CHRA) [6], which is an evaluation concerned with how hazardous chemicals are used in the workplace [7]. This technique is further applicable to their production, processing, handling, storage, transportation, movement, disposal, and management. This assessment evaluates the utility of chemicals and their health risk [8].

Protecting workers from the adverse effect of chemicals is a major task for employers under Law Number 1/1970 concerning Occupational Safety and Health. This involves the identification, evaluation, and control of any risky health factors associated with work that involves the use of chemicals. Employers obligated to assess potential health risks [9]. The decision to ensure appropriate action will depend on the risk rating of health and this is dependent

on the CHRA, which then guides the decision on appropriate control steps [5,6], including induction and training, the need to organize monitoring programs against exposure (Zainon and Ghazali, 2009), and the need for medical control programs as well [10]. They have the objective to identify resulting hazards, evaluate exposure rates and sufficiency of existing control actions, recommend consistent control steps, take action with a priority to prevent or minimize risk in workplace [11] and, furthermore, apply epidemiologic surveillance programs on laboratory workers [12].

Methods

A CHRA method developed by the Department of Occupational Safety and Health (DOSH) Malaysia (2018) was used in this study. Wet assay and fire assay (WAFA) analysis was chosen as an activity to be assessed since a variety of strong acids, bases, and organic solvents were used. The WAFA activity consisted of sample preparation and analysis. The assessment consisted of several steps (Figure 1) and the risk rating (RR) was assessed as a function of the hazard rating (HR) and exposure rating (ER).

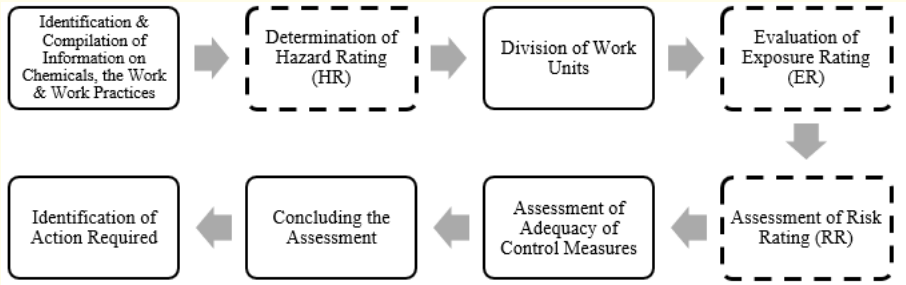

Figure 1: Flow chart of CHRA in WAFAL.

Hazard rating (HR)

Hazard Rating (HR)	Exposure Rating (ER) 1	2	3	4	5
1	1	2	3	4	5
2	2	4	6	8	10
3	3	6	9	12	15
4	4	8	12	16	20
5	5	10	15	20	25

	RR = 1 – 4	Low risk
	RR = 5 – 12	Medium risk
	RR = 15 – 25	High Risk

Figure 2: Five-cell matrix risk assessment for CHRA in WAFAL.

Hazard Rating (HR) was defined by recognizing the H-code of each chemical from a hazard classification online database, ECHA (European Chemicals Agency), which was used as a reference. HR allocation for the inhalation route of entry and dermal absorption can be seen in table 1 and table 2 respectively.

Exposure rating (ER) for the inhalation route of entry

Exposure Rating (ER) is a process evaluating the potential of chemicals entering the body. The higher the ER, the higher the potential of chemicals entering the body. Within this study, ER was evaluated using a semi-quantitative method. For the inhalation route of entry, ER was evaluated as a function of frequency and duration rating (FDR); as well as intensity or magnitude rating (MR). FDR was predicted by plotting the frequency rating (FR) toward the duration rating (DR) that is presented in table a. The definition of FR and DR can be seen in table 3.

Magnitude Rating (MR) was defined by estimating the degree of chemical release and degree of breathing rate (Table b), which was influenced by the physiochemical properties of the chemicals and human interaction during their handling.

HR	Health Effects	Hazard Classification	H-Code	Acute Toxicity
5	Injury of sufficient severity to threaten life; Causing fatality at low doses or concentration; Severe irreversible effects (damage to target organ e.g. central nervous system effects, kidney necrosis, liver lesions, anaemia or paralysis) after a single exposure; Known to have carcinogenic potential for humans; Known to induce heritable mutations in the germ cells of humans; Known human reproductive toxicant	Acute toxicity category 1 (inhalation)	H330	$LC_{50} \leq 0,5$ mg/l (vapours) $LC_{50} \leq 100$ ppmV (gases) LC_{50} 0,05 mg/l (dusts/mists)
		Carcinogenicity category 1A	H350, H350i	
		Mutagenicity category 1A	H340	
		Reproductive toxicity category 1A	H360, H360D, H360F, H360FD, H30Fd, H360Df	
		Specific target organ toxicity – single exposure category 1	H370	
4	Injury of sufficient severity to cause permanent impairment, disfigurement or irreversible change from single or repeated exposure. Very serious physical or health impairment by repeated or prolonged exposure; Serious damage to target organ from single exposure; Presumed to have carcinogenic potential for humans; Chemicals which should be regarded as if they induce heritable mutations in the germ cells of humans; Presumed human reproductive toxicant	Acute toxicity category 2 (inhalation)	H330	$0,5 < LC_{50} \leq 2.0$ mg/l (vapours) $100 < LC_{50} \leq 500$ ppmV (gases) $0.05 < LC_{50} \leq 0.5$ mg/l (dusts/mists)
		Carcinogenicity category 1B	H350, H350i	
		Mutagenicity category 1B	H340	
		Reproductive toxicity category 1B	H360, H360D, H360F, H360FD, H360Fd, H360Df	
		Effects on or via lactation	H362	
		Specific target organ toxicity – single exposure category 2	H371	
		Specific target organ toxicity – repeated exposure category 1	H372	
		Respiratory sensitization category 1	H334	
3	Serious damage to target organ from repeated exposure; Toxic effects after exposure; Suspected human carcinogens; Chemicals which cause concern for humans owing to the possibility that they may induce heritable mutations in the germ cells of humans; Suspected human reproductive toxicant. Effect to respiratory tract after single exposure.	Acute toxicity category 3 (inhalation)	H331	$2 < LC_{50} \leq 10$ mg/l (vapours) $500 < LC_{50} \leq 2500$ ppmV (gases) $0.5 < LC_{50} \leq 1$ mg/l (dusts/mists)
		Carcinogenicity category 2	H351	
		Mutagenicity category 2	H341	
		Reproductive toxicity category 2	H361, H361f, H361d, H361fd	
		Specific target organ toxicity – repeated exposure category 2	H373	
		Specific target organ toxicity – single exposure category 3 (respiratory tract irritation)	H335	

2	Reversible effects not severe enough to cause serious health impairment; Changes readily reversible once exposure ceases Harmful effects after exposure	Acute toxicity category 4 (inhalation)	H332	$10 < LC_{50} \leq 20$ mg/l (vapours) $2500 < LC_{50} \leq 20000$ ppmV (gases) $1 < LC_{50} \leq 5$ mg/l (dusts/mists)
		Specific target organ toxicity – single exposure category 3 (narcotic effect)	H336	
1	Minimal adverse health effects	Chemical not otherwise classified	H333	$LC_{50} > 20$ mg/l (vapours) $LC_{50} > 20000$ ppmV (gases) $LC_{50} > 5$ mg/l (dusts/mists)

Table 1

Hazardous Properties	Description	Corresponding hazard classification and H-code
Irritation	Chemicals which is irritating to skin or eyes after contact	Skin corrosion or irritation category 2 (H315) Serious eye damage or eye irritation category 2 (H319)
Corrision	Chemicals which have damaging effect on skin or eyes after contact	Skin corrosion or irritation category 1 (H314) Serious eye damage or eye irritation category 1 (H318)
Sensitation	Chemicals which lead to allergic response following skin contact	Skin sensitization category 1 (H317)
Acute toxicity	Chemicals which cause adverse effect following dermal administration of a single dose of a chemical or multiple dose given within 24 hours	Acute toxicity (dermal) category (H310) Acute toxicity (dermal) category 2 (H310) Acute toxicity (dermal) category 3 (H311) Acute toxicity (dermal) category 4 (H312)
Skin absorption and other properties	Enter human body through dermal due to their physical chemical properties; Dermal application studies shown that absorption could cause systemic effect.	Specific target organ toxicity-single exposure category 1*(H370) Specific target organ toxicity-single exposure category 2*(H371) Specific target organ toxicity-repeated exposure category 1*(H372) Specific target organ toxicity-repeated exposure category 2*(H373) Carcinogenicity category 1*(H350) Carcinogenicity category 1*(H351) Germ cell mutagenicity category 1*(H340) Germ cell mutagenicity category 1*(H341) Reproductive toxicity category 1* (H360,H360D,H360F,H360FD,H360Fd,H360Df) Reproductive toxicity category 2* (H361,H361D,H361F,H361FD,H361Fd,H361Df)

Table 2: Hazardous properties relevant to dermal exposure.

Note: *to determine if hazard is due to dermal exposure.

Rating	Frequency	Duration per shift (x)
5	Frequent: exposure one or more time per shift or per day	x ≥ 7 hours
4	Probable: exposure greater than one time per week	4 ≤ x < 7 hours
3	Occasional: exposure greater than one time per month	2 ≤ x < 4 hours
2	Remote: exposure greater than one time per year	1≤ x < 2 hours
1	Improbable: exposure once per year or less	x < 1 hour

Table 3: Definition of frequency and duration rating.

		Frequency Rating (FR)				
		1	**2**	**3**	**4**	**5**
Duration Rating (DR)	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

Table a: Frequency-duration rating (FDR).

		Degree of Inhaled		
		Low	**Moderate**	**High**
Degree of Release (Presence)	Low	1	2	3
	Moderate	2	3	4
	High	3	4	5

Table b: Magnitude rating.

The degree of chemical released was assigned through observation, by looking at the evidence of contamination of air, clothing, and work surfaces, and chemical boiling points (Table 4). On the other hand, the degree of inhaled was estimated from the rate of breathing and distance of the chemical source from the breathing rate (Table 5). Use Table b to modify the MR before assigning the ER.

Once the FDR and MR have been assigned, the exposure rating (ER) can be appointed (Table c).

However, ER can be either positively or negatively modified by several factors such as work practice, personal hygiene, reported incidences, ill-health complaints, and pre-clinical symptoms related to chemicals, the presence of a susceptible person and cross-contamination potential (Table 6).

Degree of chemical release	Observation
Low	Low or little release into the air. No contamination of air, clothing and work surfaces with chemicals. Low volatility with the boiling point more than 150°C at room temperature (20°C). Low dustiness such as pellet like solids that do not break up. Little dust is seen during use e.g. PVC pellets, waxed flakes.
Moderate	Moderate release such as: Solvents with medium drying time in uncovered containers or exposed to work environment; Detectable odour of chemicals. Check the odoir threshold. Medium volatility with the boiling point at 50 to 150°C at room temperature (20°C). Medium dustiness such as crystalline, granular solids. When used, dust is seen, but settles out quickly. Dust is left on surfaces after use e.g. soap powder. Evidence of contamination of air, clothing and work surfaces with chemicals.
High	Substantial release such as: Solvents with fast drying time in unconvered containers; Sprays or dust clouds in poorly ventilated areas; Chemicals with high rates of evaporation exposed to work environment; Detectable odour of chemicals with odour threshold at/above/PEL/OEL. High volatility with the boiling point less than 50°C at room temperature (20°C). High dustiness such as fine, light powders. When used, dust clouds can be seen to form and remain in the air for several minutes e.g. cement, carbon black, chalk dust. Gross contamination of air, clothing and work surfaces with chemicals.

Table 4: Degree of chemical release or presence.

Degree	Observation/ Condition	Physical Activities
Low	Low breathing rate (light work) Source far from breathing zone	**Light Work:** Sitting, moderate arm and trunk movements (e.g. desk work, typing) Sitting, moderate arm and leg movements (e.g. hand soldering and QC inspection) Standing, light work at machine or bench, mostly arms
Moderate	Moderate breathing rate (moderate work) Source close to breathing zone	**Moderate Work:** Sitting, heavy arms and legs movement Standing, light work at machine or bench, some walking about Walking about, with moderate lifting or pushing (e.g. machine operator)
High	High breathing rate (heavy work) Source within breathing zone	**Heavy Work:** Intermittent heavy lifting, pushing, or pulling (e.g pick and shovel work) Hardest sustained work

Table 5: Degree of chemical inhaled (breathing rate) and physical activities.

MR Modifying factors	Criteria
+1 (maximum MR not to exceed 5)	Bad work practice Poor personal hygiene Reported cases of chemical exposure incidences Widespread complaints of ill health related to chemical exposure Reported cases of workers with preclinical symptoms related to chemical exposure Susceptible person in work unit Cross airborne contamination
-1 (minimum MR not less than 1)	Small quantity used in the process

Table 6: Modifying factors.

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

Table c: Exposure rating (ER) assignment.

Exposure Rating (ER) for dermal route of entry

For dermal exposure, RR was also a function of HR and ER. ER of the dermal route of entry was assessed by understanding the body area of contact and the duration of exposure. RR can be seen in table 7 and is categorized into low risk (L), moderate risk (M1 and M2), and high risk (H1 and H2). The level of risk is categorized into the following:

1 = Low risk (L)

2 = Moderate risk (M1 and M2)

3 = High risk (H1 and H2).

A combination effect is for chemicals classified as acute toxicity (dermal) category 1 or 2, and skin corrosion or irritation category 1 (1A/1B/1C). Other properties indicate if a skin absorption/effect is due to dermal exposure; thus M2 and H2 indicating a higher risk compared to M1 and H1 should be consider when deciding the priority of action to control exposure.

Dermal exposure is illustrated as exposure to chemicals hazardous to health through contact or direct absorption. Some chemicals could cause a localized effect and others could cause a systemic effect. Width and duration of contact are the factors that were considered when evaluating dermal exposure level as shown in table 7.

Results

Quality control of ore, product, and concentrate at mining industries consists of three steps *i.e.*, sample preparation, fire assay, and wet assay analysis, as illustrated in figure 3. In sample preparation step, rock sample from mine will be crushed by using a Jaw Crusher and Boyd Crusher, while wet-muck sample from mill will be heated to remove its water content. Both types of samples will be pulverized in order to get very soft powder phase for further analysis, which are fire and wet assay. For rock sample, preparation will takes about 3 - 4 hours and 6 - 8 hours for muck sample.

Properties of Hazardous	H-Code	Duration and Extent of Skin Contact			
		Short term (<15 min)		Long term (≥ 15 min)	
		Small area	Large area	Small area	Large area
Irritation	H315	L	M1	M1	M2
	H319	M1		M2	
Corrosive	H314	M1	H1	H1	H2
	H318	H1		H2	
Sensitization	H317	L	M1	M2	H1
	H312	M1	M1	M1	H1
Acute toxicity	H311	M1	M1	M2	H1
	H310	H1	H1	H1	H2
Combination effect	H310 with H314	H1	H1	H1	H2
Skin absorption and other properties	H351	M1	M1	M2	H1
	H350	H1	H1	H1	H2
	H341	M1	M1	M2	H1
	H340	H1	H1	H1	H2
	H361, H361f, H361d, H361fd	M1	M1	M2	H1
	H360, H360F, H360D, H360FD, H360Fd, H360fD	H1	H1	H1	H2
	H370	H1	H1	H1	H2
	H371	M1	M2	M2	H1
	H372	M1	M1	M2	**H1**
	H373	L	M1	M2	M2

Table 7: Dermal exposure risk matrix.

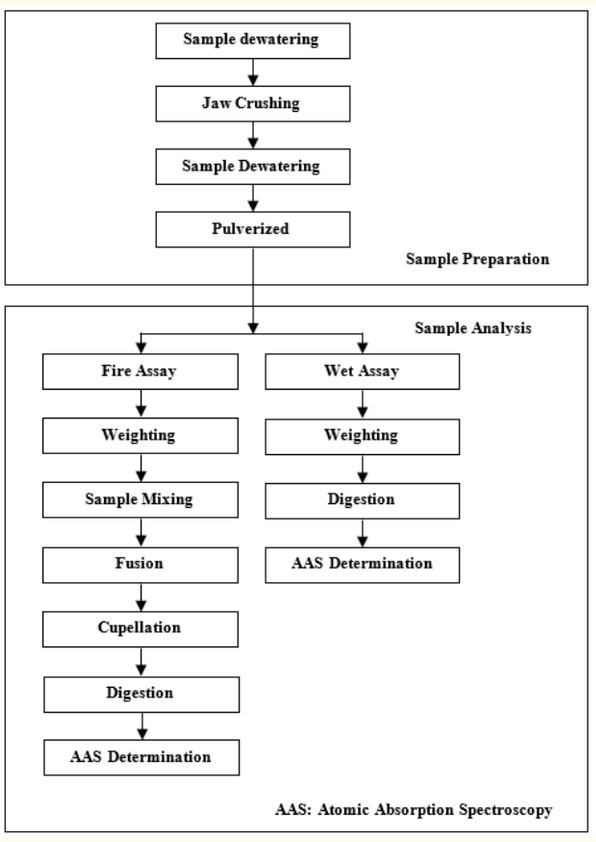

Figure 3: Work Unit of WAFAL.

Fire assay analysis is a quantitative method for determination of precious metal content such as gold, silver, and platinum through extraction with fusion and uses flux (Hoffman., *et al*. 1998; Sketchley, 1998). Wet assay, on the other hand, is a method is called wet chemical because most analyses are conducted in the liquid phase. Wet Assay in this laboratory is used to analyze the levels of Pb, Zn, Ag, S, Fe, As, and Cu [3,4]. Usually fire assay is conducted between 4-5 hours, while wet assay only takes 1 hour at maximum (Table 8).

In a day, WAFA laboratory analyzes 3 to 8 batches of sample and each batch consist of 20 samples. To conduct chemical analyses of those samples, 11 chemical were found to be used in WAFA laboratory, consist of acid, alkaline, oxidizer and solvent. Those chemicals may pose health risk to the workers. Therefore, health risk associated with inhalation and dermal contact with those chemicals were assessed.

A total of 7 out of 11 chemicals were identified as agents of inhalation hazard and associated with a range of health outcomes such as acute toxicity; specific target organ toxicant (STOT), aspiration toxicity, and reproduction toxicant. Those chemicals are barium chloride, potassium chlorate, hydrogen peroxide, n-heptane, propionic acid, toluene, and TBN solvent. For dermal hazard, 8 out of 11 chemicals were identified, and these were nitric acid, perchloric acid, sodium hydroxide, sulfuric acid, n-heptane, propionic acid, and toluene. Only three chemicals were found as both inhalation and dermal hazards, they are n-heptane, propionic acid, and toluene. The summary of hazard rating (HR) is presented in table 8.

Name of Chemical	Health Hazard Classification	Hazard category	H-code	Hazard Rating	
				Inhalation	Dermal
Barium chloride	Acute toxicity	Category 3	H301	4	x
	Acute toxicity	Category 4	H332		
Nitric acid	Skin corrosion	Category 1A	H314	x	1
Perchloric acid	Skin corrosion	Category 1A	H314	x	1
Potassium chlorate	Acute toxicity	Category 4	H302	4	x
	Acute toxicity	Category 4	H332		
Sodium hydroxide	Skin corrosion	Category 1A	H314	x	1
Sulfuric acid	Skin corrosion	Category 1A	H314	x	1
Hydrogen peroxide	Skin corrosion	Category 1A	H314	x	1
	Acute toxicity	Category 4	H332	2	x
	Acute Toxicity	Category 4	H302		
n-Heptane	Skin irritation	Category 2	H315	3	2
	Aspiration Toxicity	Category 1	H304		
	STOT	Category 3	H336		
Propionic acid	Skin corrosion	Category 1B	H314	3	1
Toluene	Aspiration Toxicity	Category 1	H304	3	2
	Skin irritation	Category 2	H315		
	STOT	Category 2	H373		
	Reproduction	Category 2	H361d		
	STOT	Category 3	H336		
TBN Solvent	Aspiration Toxicity	Category 1	H304	1	x

Table 8: Determination of HR in a WAFAL.

Exposure Rating was assessed by evaluating the frequency and duration of contact of those chemicals with the workers at WAFA Laboratory. Hydrogen peroxide and TBN solvent were found as the most frequent chemicals that contact with the workers at more than once during a shift work. Frequency of contact of other chemicals with the workers were less than once in a day but more than once in a week, so the frequency rating was determined as probable. Duration of contact of hydrogen peroxide and TBN solvent was also more than 7 hours per shift, as the longest amongst other chemicals, so duration rating (DR) was assigned as 5 for both hydrogen peroxide and TBN solvent. Duration of contact with other chemicals was less than 7 hours but more than 4 hours per day, except n-hexane. Duration of contact with hexane was the shortest, between 2-4 hours per shift, so the n-hexane DR was assigned as 3.

Magnitude rating (MR), a parameter that is defined by degree of chemical release and inhaled, is another variable that was considered in exposure rating determination. In this study, the boiling point of the chemical was used as a variable for assigning the degree of chemical release while the physical activity of laboratory work was used for assigning the degree of chemical inhaled. As n-heptane, propionic acid, toluene, and TBN solvent boiling points were between below 150°C, the degree of chemical release for those chemicals was classified as moderate and the rest were classified as low release. The physical activity performed by laboratory workers can be classified as moderate with a medium breathing rate because it includes standing, walking about, and light work with instrumentation. Thus, the degree of chemical inhaled was assigned as moderate.

According to the description above, risk rating of 7 chemicals that pose health risks via inhalation route of entry was evaluated (Table 9). The risk of all of those chemicals was acceptable, in the range of low risk for TBN solvent and moderate risk for other chemicals.

Chemical Name	HR	Exposure Rating						ER	RR
		Frequency-Duration Rating			Boiling Point (°C)	Magnitude Rating			
		FR	DR	FDR		Degree of Release	Degree of Inhaled	MR	
Barium chloride	4	4	4	4	1560	Low	Moderate	2	3	12
Potassium chlorate	4	4	4	4	400	Low	Moderate	2	3	12
Hydrogen peroxide	2	5	5	5	150.2	Low	Moderate	2	4	8
n-Heptane	3	4	3	4	98.42	Moderate	Moderate	3	4	12
Propionic acid	3	4	4	4	141.2	Moderate	Moderate	3	4	12
Toluene	3	4	4	4	110.6	Moderate	Moderate	3	4	12
TBN solvent	1	5	5	5	80	Moderate	Moderate	3	4	4

Table 9: Results of inhalation risk rating of chemicals in WAFAL.

Risk assessment for dermal contact

The risk rating for the dermal route of entry was evaluated qualitatively. Besides hazard rating, the extent and duration of dermal contact determined the level of exposure. As mentioned in table 9, both the extent of contact and duration of contact were grouped into two categories, which are small (limited to palm with no indication of skin disorders) and large area of contact (hand and other parts of the body come into contact with chemicals accompanied by skin dryness or other forms of skin disorders), and short (≤15 minutes) and long term (≥15) contact.

At the WAFAL, 8 out of 11 chemicals have the potential for dermal contact; they are nitric acid, perchloric acid, sodium hydroxide, sulfuric acid, hydrogen peroxide, n-Heptane, propionic acid, and toluene. The condition of contact between workers and chemicals is indirect, as their hands or other body parts are always covered by PPE (Figure 4). This practice has been implemented by workers in accordance with company safety procedures at the WAFA Laboratory, and almost no accidents have been caused by chemicals. Risk rating assessment of those 8 chemicals via dermal contact were assessed (Table 10).

Table 10 describes that skin contact duration was long-term because it was ≥15 minutes per shift. Hence, if this was recurrent, the duration of exposure to relevant chemicals during shifts had to be determined. This had to be determined to efficiently eliminate chemicals causing corrosion or irritation or sensitivity for skin.

Chemical Name	HR	Extent	Duration	RR
Nitric acid	H314	Small	≥ 15 **min**/shift	H1
Perchloric acid	H314	Large	≥ 15 min/shift	H2
Sodium hydroxide	H314	Large	≥ 15 **min**/shift	H2
Sulfuric acid	H314	Large	≥ 15 min/shift	H2
Hydrogen peroxide	H317	Large	**≥ 15 min/shift**	H1
n-Heptane	H315	Small	≥ 15 min/shift	M1
Propionic acid	H314	Small	≥ 15 min/shift	H1
Toluene	H315	Small	≥ 15 min/shift	M1

Table 10: Results of risk rating (RR) establishment for dermal contact in WAFAL.

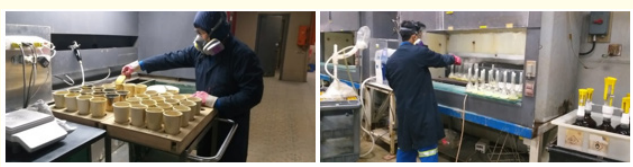

Figure 4: Condition of contact between workers and chemicals.

Discussion

This study assessed the level of health risks associated with inhalation and dermal rout of entry of range of chemicals used in WAFA Laboratory. Health risks of 7 chemicals that shows potential of inhalation route of entry were found to be acceptable. Good housekeeping, adequate ventilation system and consistency in wearing PPE were positively modifying the risk level into lower

rating. During observation, the evidence of air, clothing and surface contamination were also not found.

On the other hand, the risks associated with dermal contact mostly felt into high risk category. Strong acids such as nitric acid, perchloric acid and sulfuric acid; as well as alkaline were used in the laboratory, with irritation and corrosion hazard category. High risk of dermal contact was found from 6 out of 8 chemicals. Thus, control measure is proposed and described in following paragraph.

Control measures

Various control measures can be taken to prevent and minimize the risk of hazardous chemicals to health. Control practice principles, which could be done in WAFAL, are as follows:

- To design and operate processes and activities to minimize emission, release, and distribution of chemicals hazardous to health
- To consider all relevant routes of exposure including inhalation, skin absorption, and the possibility to swallow when developing control steps in practice or work method described in details in standard operating procedures (SOPs)
- To control exposure with proportional steps to health risks, establishing the most effective and reliable control selection, minimizing the distribution of chemicals, prevention of cross-contamination with room isolation and ensuring effective ventilation, the combination of other control measures, and the consistent use of personal protective equipment (PPE)
- To examine effectiveness regularly and sustainably and review all elements of control measure
- To inform and train all workers on hazard and risk of chemicals in WAFAL, and, furthermore, the use of control action was improved to minimize risk
- To ensure that control action did not increase the risk for health and safety.

Ensuring adequate control of chemicals hazardous to health had to be carried out by practicing good techniques to control hazardous chemicals. Furthermore, ensuring that limit of workplace exposure did not exceed the Indonesia MoW Regulation [13] and ensuring protection from exposure to hazardous chemicals, which cause diseases [14]. It is recommended that control actions be established to appropriately monitoring exposure and if the assessment shows necessary control measures, to prepare a plan and procedure to manage the incidence and emergency as a part of chemical hygiene plan [15-19].

Conclusion

The determination of risk rating using a CHRA method in the WAFA Laboratory utilizing 11 hazardous chemical samples that contribute to health showed the following results: The risk rating (RR) of inhalation route of exposure was acceptable, where 6 out of 7 chemicals were posing moderate risk and another chemical was low risk. Skin exposure of 8 chemicals were categorized as high risk (6 chemicals) and moderate risk (2 chemicals).

Conflict of Interest

The authors declare that there is no conflict of interest.

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