

Implementation of Chemical Health Risk Assessment in Teaching Laboratories

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Abstract

The Department of Chemical & Process Engineering (JKKP) is committed and actively working to providing a safe lab environment for students and staff. Under the Occupational Safety and Health Act 1994, it is one of the main responsibilities of the employer to protect and safeguard employees or consumers from the adverse effects of chemicals at the work place. The objective of this study was to identify the risk and evaluate the level of exposure of chemicals involved. A Chemical Health Risk Assessment (CHRA) has been conducted on chemical usage at the teaching labs with the purpose to allow decisions to be made on appropriate control measures, training of employees, monitoring and health surveillance activities that may be needed to protect the health of staff and students who may be exposed to chemicals hazardous to health. Furthermore, it is also to evaluate the sufficiency of the current control measures practiced by the staff and students of the department. The procedure was carried out by detailed and qualitative assessment, based on site visit, observation of employees during task of handling chemicals, reviewing lab work procedures and manual, as well as other related documents and records. Results showed that hazards of the chemicals were determined through information obtained from a register of chemicals list and Material Safety Data Sheet (MSDS). Prevention and mitigation measures by a proactive approach were taken to minimize health risks during the learning and research process.

Keywords: CHRA, occupational safety and health, chemicals, risk rating, hazardous

1. Introduction

In the learning process, the use of chemicals is common among students and lab staff who are specifically involved in chemical research and management. The safety and health of individuals involved must always be safeguarded especially the students, researchers, technicians and lab assistants who are continuously exposed to hazardous chemicals. It is the general responsibility of an employer under the Occupational Safety and Health Act 1994 (514 Act), whereby the employer is required to provide a safe working environment for his employees and other related individuals.

The Department of Chemical and Process Engineering constantly ensures a safe and healthy working environment, other than improving the safety risk management system at the labs. The department's labs have also been audited by the National University's Internal Audit Unit, SIRIM and also, the Engineering Accreditation Council Malaysia (EAC). This is in tandem with the National University's Occupational Safety and Health Policy (2010), which is committed and strives to create a safe and healthy working environment for all, including its customers, through organized work culture that is supported by each and every employee and student. In order to continue the betterment of current safety management system, a chemical health risk assessment has been conducted on the use of chemicals at the teaching labs, especially those that pose a high risk to health. The risk assessment began its first phase on 19 May 2011, which is then followed by the second and third phase by a main consultant, Datuk Ir. Ahmad Nordeen bin Dato' Mohd Salleh from the Lloyd's Register Technical Services Sdn. Bhd., who is registered with the Department of Occupational Safety and Health Malaysia. Datuk Ir. Ahmad Nordeen is also a member of the Faculty Advisory Board at the department for the Chemical Engineering programme, between November 2009 until October 2011. The purpose of this assessment is to allow the identification and evaluation of the risks involved and the level of exposure to chemicals handled

at the labs. Furthermore, it is also to evaluate the sufficiency of the current control measures practiced by the staff and students to make sure that the chemical exposure limit is not exceeded.

2. Methodology

The chemical health risk assessment was a process that utilizes a systematic approach, namely identifying the hazards, processes in hazardous chemical use and management, evaluation of the hazard risk, the sufficiency and effectiveness of current control measures, and identifying the level of risk at the work place. Assessments were made during visits that were conducted in 3 phases, whereby 18 work units were involved as shown in Table 1.

Table 1. List of work unit

No.	Work Unit	Laboratory
1	JAR Test	Environmental Lab
2	Analysis of COD Removal	
3	Analysis of Ammonium Nitrogen Removal	
4	Analysis of Nitrate Nitrogen Removal	
5	Analysis of Phosphate Removal	
6	Protein Precipitation	Pilot Plant & Biotechnology Lab
7	Ascorbic Acid Determination in Fruit Juices	
8	Preparation of Synthetic Resin	
9	Preparation of Aspirin	New Teaching Lab
10	Hagen Equation	
11	Gas Absorption	
12	Chemical Reaction in Stirred-Tank In Series	
13	Chemical reaction in a Piston Flow Tank Reactor	
14	Decomposition of Cellulose into Simple Sugars	Biochemistry Teaching Lab
15	Culturing Yeast for the Production of Biomass	
16	Aeration Effect on Aspergillus Growth	
17	Appreciation of Microbiology Cells and Aseptic Concept	
18	Enzymes Kinetics	

Based on the CHRA report, the chemicals used were identified through a chemical register list and also through observations at the lab and interviews carried out with research staff and students who are directly exposed to the risk of chemicals. In addition, work procedures, training records, quality manual and personal protective equipment compliance were also examined.

2.1 Determination of Hazard Rating

The chemicals identified in the labs were compiled according to work units. The hazard rating is used to prioritised hazard based on the potential health effect of the chemical (CHRA Manual, 2000). The risk phrases and hazard information for the chemicals can be obtained from MSDS, "Schedule III: Risk Phrases" in the Occupational Safety and Health (Classification, Packaging and Labelling of Hazardous Chemicals) Regulation 1997 or from other literatures and references. The hazard of a chemical is rated on a 1 to 5 scale with a rating of 1 implying not hazardous and a rating of 5 implying most hazardous to health. Based on the toxicity data, health effect and risk phrases, the hazard of each chemical can be evaluated and assigned a hazard rating (HR).

2.2 Determination of Exposure Rating

The Exposure Rating (ER) assessment was based on qualitative observations made during visits to the laboratories and it indicates the chances of overexposure. The purpose of determining exposure rating was to assess the potential of chemicals being hazardous to health. Table 2 shows the Duration Rating (DR) used to evaluate chronic exposure or routine exposure, and also the significant effect of exposure. The total duration of exposure is the amount of exposure and the average duration of each exposure. Meanwhile, the minimum Duration Rating is 1 (exposure less than 12.5% of working hours) and the maximum is 5 (exposure more than 87.5% of working hours).

Table 2. Duration rating (DR)

Rating	Total Duration of Exposure	
	% Working Hours	Duration per 8 Working Hours
5	>87.5	>7 hours
4	50-87.5	4 to 7 hours
3	25-50	2 to 4 hours
2	12.5-25	1 to 2 hours
1	<12.5	<1 hour

Table 3. Degree of chemical release

Degree	Sample observation
Low	Low or little release into 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 solvents with medium drying time, detectable odour. Evidence of contamination of air, clothing and work surfaces, with chemicals capable of skin absorption or causing irritation or corrosion.
High	Gross contamination of air, clothing and work surfaces, with chemicals capable of skin absorption or causing irritation or corrosion.

Table 4. Degree of chemical absorbed

Degree	Sample observation
Low	Low respiratory rate (light work). No contamination/infection on skin or eyes.
Moderate	Moderate respiratory rate (moderate work) Source in close proximity of respiratory zone.
High	High respiratory rate (heavy work). Source within respiratory zone. Damage to skin.

Based on Table 3 and Table 4, the degree of chemical presence or release and the degree of chemical absorbed were also assessed. These were based on observations that showed the highest degree of chemicals released. This information can also be obtained from chemical's physicochemical properties, the process characteristic, quantity used, method of handling and atmospheric conditions.

Table 5. Magnitude rating (MR)

Degree of Emission	Degree of Permeability	Magnitude Rating(MR)
Low	Low	1
	Moderate	2
	High	3
Moderate	Low	2
	Moderate	3
	High	4
High	Low	3
	Moderate	4
	High	5

From the results, the Magnitude Rating (MR) as shown in Table 5 can be formulated (1 = lowest, 5 = highest).

However, the magnitude rating can be modified by other factors such as complaints of ill effects, monitoring or biological effect monitoring and poor personal hygiene (CHRA Manual, 2000). In addition, the Exposure Rating (ER) can be determined by using the matrix shown in Table 6.

Table 6. Matrix for exposure rating

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

Source: Assessment of the Health Risk Arising from the Use of Hazardous Chemicals in the Workplace (A Manual of Recommended Practice, 2nd Edition), Department of Occupational Safety and Health, 2000

2.3 Determination of Risk Rating

Referring to Table 7, the risk matrix was used to calculate Risk Rating (RR), which has been formulated as the square root of Hazard Rating (HR) times Exposure Rating (ER). The risk decisions were obtained from exposure assessment and adequacy of control measures. The adequacy of existing control measures were assessed by inspecting the existing control measures and checking records on inspection, testing, examination of control equipment such as the local exhaust ventilation system, enclosure and general ventilation.

$$RR = \sqrt{(HR \times ER)} \quad (1)$$

Table 7. Matrix for risk rating

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.

Source: Assessment of the Health Risk Arising from the Use of Hazardous Chemicals in the Workplace (A Manual of Recommended Practice, 2nd Edition), Department of Occupational Safety and Health, 2000

Based on this calculation, a conclusion of the assessments can be obtained as shown in Table 8. Risk was evaluated as either significant or not significant.

Table 8. Conclusion of the assessments

Risk	Sufficiency of current control measures	Conclusion
Risk not significant	-	C1
Risk significant	Adequate (category 1)	C2
	Not Adequate (category 2)	C3
Insufficient information	-	C4
Uncertain about Exposure	-	C5

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

C2 – Determine precautions, measures, requirements for health monitoring or surveillance taken to maintain control and minimize exposure. Review assessment every 5 years or when required.

C3 – Identify precautions, measures, requirements for health monitoring or surveillance that need to be taken to

maintain control and minimize exposure. Review assessment every 5 years or when required.

C4 – Obtain more information.

C5 – Conduct more detailed assessment.

Source: Assessment of the Health Risk Arising from the Use of Hazardous Chemicals in the Workplace (A Manual of Recommended Practice, 2nd Edition), Department of Occupational Safety and Health, 2000)

3. Result and Discussion

From the observations made, the department has taken preventive and corrective measures to reduce the risk and hazard of chemical exposure to students and laboratory staff. Apart from that, the staff and students are regularly given safety training and briefings while safety regulations are displayed at strategic locations in each lab. A related safety briefing on the safety management of chemicals was also delivered by Datuk Ir. Ahmad Nordeen, the main consultant for the CHRA. Chemical exposure control was also managed by taking preventive measures such as ensuring that the lab environment is always clean and providing personal protective equipment to the lab staff.

The following are the results for the Hazard Rating (HR), shown in Table 9. From the evaluation made, it was found that hazard rating for most work units involved were 2 and 3, which means that the chemicals used effect the health in the corrosive, irritant, harmful and skin sensitizers category.

Table 9. Results of hazard rating

No.	Work Unit	Hazard Rating
1	JAR Test	3
2	Analysis of COD Removal	3
3	Analysis of Ammonium Nitrogen Removal	3
4	Analysis of Nitrate Nitrogen Removal	3
5	Analysis of Phosphate Removal	3
6	Protein Precipitation	2
7	Ascorbic Acid Determination in Fruit Juices	2
8	Preparation of Synthetic Resin	3
9	Preparation of Aspirin	3
10	Hagen Equation	2
11	Gas Absorption	2
12	Chemical Reaction in Stirred-Tank In Series	2
13	Chemical Reaction in a Piston Flow Tank Reactor	2
14	Decomposition of Cellulose into Simple Sugars	2
15	Culturing Yeast for the Production of Biomass	2
16	Aeration Effect on Aspergillus Growth	3
17	Appreciation of Microbiology Cells and Aseptic Concept	3
18	Enzymes Kinetics	2

Based on information in Table 10, the exposure rating of each work units is 3. The exposure was evaluated by assessing the likelihood of contact of the chemicals involved with personnels in the work units.

Table 10. Results of exposure rating

No.	Work Unit	Exposure Rating
1	JAR Test	3
2	Analysis of COD Removal	3
3	Analysis of Ammonium Nitrogen Removal	3
4	Analysis of Nitrate Nitrogen Removal	3
5	Analysis of Phosphate Removal	3
6	Protein Precipitation	3
7	Ascorbic Acid Determination in Fruit Juices	3
8	Preparation of Synthetic Resin	3
9	Preparation of Aspirin	3
10	Hagen Equation	3
11	Gas Absorption	3
12	Chemical Reaction in Stirred-Tank In Series	3
13	Chemical Reaction in a Piston Flow Tank Reactor	3
14	Decomposition of Cellulose into Simple Sugars	3
15	Culturing Yeast for the Production of Biomass	3
16	Aeration Effect on Aspergillus Growth	3
17	Appreciation of Microbiology Cells and Aseptic Concept	3
18	Enzymes Kinetics	3

Table 11. Conclusions of the assessments

No.	Work Unit	Risk Rating(RR)	Conclusion	C
1	JAR Test	3		
2	Analysis of COD Removal	3		
3	Analysis of Ammonium Nitrogen Removal	3		
4	Analysis of Nitrate Nitrogen Removal	3		
5	Analysis of Phosphate Removal	3		
6	Protein Precipitation	3		
7	Ascorbic Acid Determination in Fruit Juices	3		
8	Preparation of Synthetic Resin	3	Risk significant, control measure not adequate	3
9	Preparation of Aspirin	3		
10	Hagen Equation	3		
11	Gas Absorption	3		
12	Chemical Reaction in Stirred-Tank In Series	3		
13	Chemical Reaction in a Piston Flow Tank Reactor	3		
14	Decomposition of Cellulose into Simple Sugars	3		
15	Culturing Yeast for the Production of Biomass	3		
16	Aeration Effect on Aspergillus Growth	3		
17	Appreciation of Microbiology Cells and Aseptic Concept	3		
18	Enzymes Kinetics	3		

Findings based on Table 11 showed that the risk rating for all teaching labs at the Department of Chemical & Process Engineering was 3 and therefore, concluded with a C3, which stipulates that the department needs to

identify precautions, measures, requirements for health monitoring or surveillance that need to be taken to maintain control and minimize exposure. Assessment can be rescheduled every 5 years or when it is necessary.

Also, based on the results obtained, several suggestions for improvement have been proposed to minimize chemical health hazard, which will ultimately increase the occupational safety and health performance at the department.

3.1 Register of Chemicals Hazardous to Health

All chemicals must be registered in a form known as the Register of Chemicals Hazardous to Health based on the Guideline for the Preparation of a Chemical Register. The chemical register provide information on the trade and common names, chemical composition, quantities used and locations where chemicals are used or stored. Rule 5 (1), Occupational Safety and Health Regulations (Use and Standards of Exposure of Chemicals Hazardous to Health, 2000) stipulates that an employer shall identify and record in a register of all chemicals hazardous to health used at work. The purpose of this chemical register is to serve as a reference for the staff on hazards of the chemicals available at their work place and preventive measures that need to be taken in the case of an accident.

3.2 Obtaining Original Material Safety Data Sheet (MSDS) from the Supplier

The department needs to obtain the latest information on chemicals purchased from a Material Safety Data Sheet (MSDS) in order to be informed of the general chemical hazards involved prior using it. Such information is crucial in ensuring proper and adequate preparation is done for the possibility of an accident occurring. Meanwhile, suppliers will update the information on materials they supply once every 5 years based on the latest research findings. And so, a MSDS that is over 5 years needs to be renewed from the supplier.

3.3 Personal Protective Equipment (PPE)

Personal protective equipment provided is located at an open and easy-to-access location. Therefore, each and every staff is provided with a bag to store their personal protective equipment. This way, every staff wears their own personal protective equipment and avoids contamination.

3.4 Emergency Response Plan (ERP)

An emergency response plan needs to be prepared and training must be given to the staff, especially in the event of an emergency or accident involving chemical spill or even fire. This will educate the staff on the best way to handle an emergency situation.

3.5 Chemical Storage at the Laboratory

Chemical storage shelves available at the lab were found to be unsuitable for the event of spillage. The department needs to provide secondary containers to store liquid chemicals to reduce the risk of accidents caused by chemical leakage or spills. Liquid chemicals also need to be handled in a second container to avoid spills on tables or floor, whereas highly toxic chemicals must be handled in a fume chamber. Other than that, chemical storage procedures need to be further organized by complying with safety practices such as the following:

- 1) Not keeping chemicals that exceed the expiry date shown on the bottle.
- 2) Separate chemicals alphabetically and according to their possible hazards.
- 3) Not keeping chemicals with no labels or blurry labels.
- 4) Not keeping chemicals above the eye level.

3.6 Re-assessment

The department needs to carry out a re-assessment of chemical exposure after the proposed control measures have been taken. The Lab Safety Committee at the department will conduct monthly inspection on the labs involved so that the labs can be continually improved.

4. Conclusion

This Chemical Health Risk Assessment was done strictly according to the standards and guidelines set by the Department of Occupational Safety and Health (DOSH). The assessments conducted showed that the risk of hazardous chemicals at the laboratories is significant and the current control measures can be further improved in the effort to provide a working environment that is safe for both the students and lab staff. To be a world class centre of academic and research in the field of chemicals and natural resources, the department would have to require excellent management practices of its teaching & research laboratories, when using chemicals hazardous to health, the ways being as described above.

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