ASSESSMENT OF OCCUPATIONAL SAFETY AND HEALTH PRACTICES IN SELECTED LABORATORIES AT SIRIM BHD SHAH ALAM

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DISSERTATION SUBMITTED IN FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF TECHNOLOGY ENVIRONMENTAL MANAGEMENT

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ABSTRACT

This study was aimed to assess the occupational safety and health practices in laboratory in SIRIM Berhad Shah Alam by Observation, Interview and questionnaire surveys. There are two type laboratories involves in this research which are chemical and biology laboratories. The method use to determine the compliance was by using Hazard Identification, Risk Assessment and Risk Control (HIRARC) procedure which make the identification, collection and analyze the parameter easier. Four laboratories has been selected which are (1) Applied Chemical Laboratory, (2) Analytical Biochemical Laboratory, (3) Microbial Isolation and Screening Laboratory and (4) Bacteriology Laboratory. Laboratory practise was reviewed and evaluated depends on its SOPs, MSDS, OSH awareness, implementation and practices and emergency response plan. The results shows that the laboratory related standard does not directly control what the employees are performing in their laboratories, instead it governs on how the employees execute their tasks. With this, the selected laboratories in IBRC at SIRIM Bhd Shah Alam in a way have committed towards quality in safety and health and hope to keep laboratories competent of providing a safe working environment. For future reference, the results from this assessment may also aid organisations in terms of monitoring and review of their existing occupational safety, health and emergency response in a workplace.

ABSTRAK

Kajian ini fokus kepada penilaian keselamatan dan kesihatan pekerjaan dalam makmal di SIRIM Bhd, Shah Alam melalui kaedah pemerhatian, seesi temu bual dan kaji selidik. Dua jenis makmal telah dipilih iaitu makmal kimia dan makmal biologi. Kaedah yang digunakan dalam menentukan pematuhan adalah dengan menggunakan kaedah HIRARC iaitu Pengenalpastian Hazard, Penaksiran Risiko dan Kawalan Risiko di mana ia dapat membantu dalam mengenalpasti, mengumpul dan menganalisis parameter pilihan Empat makmal telah dipilih iaitu, (1) Makmal Kimia Gunaan , (2) Makmal Analisis Biokimia , (3) Makmal Pengasingan dan Saringan Mikrob dan (4) Makmal Bakteriologi untuk proses tersebut. Amalan makmal yang dikaji semula dan dinilai adalah SOP , MSDS , kesedaran keselamatan dan kesihatan pekerjaan , pelaksanaan dan amalan pelan gerak balas kecemasan . Berdasarkan kajian, keputusan menunjukkan standard berkaitan makmal tidak mengawal perkara yang dilaksanakan oleh pekerja, tetapi sebaliknya ia mengawal bagaimana pekerja melaksanakan tugas-tugas mereka . Ini menunjukkan secara tidak langsung bahawa SIRIM Berhad komited dalam memastikan makmal-makmal yang terlibat mematuhi dan dapat menjamin keselamatan dan kesihatan pekerja di tempat kerja. Untuk rujukan masa depan, keputusan daripada penilaian ini juga boleh membantu organisasi daripada segi pemantauan dan kajian semula keselamatan, kesihatan serta tidak balas kecemasan yang sedia ada di tempat kerja.

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LIST OF ABBREVIATION

C_2H_6AsCl	Chlorodimethylarsine
C_6H_6	Benzene
DOSH	Department of Safety and Health
EPA	Environmental Protection Agency
ERP	Emergency Respond Plan
FAO	Food and Agriculture Organization
HIRARC	Hazard Identification, Risk Assessment and Risk Control
IBRC	Industrial Biotechnology Research Centre
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
KHF2	Potassium biflouride
MS	Malaysia Standard
MSDS	Material Safety Data Sheets
OHSAS	Occupational Health & Safety Advisory Services
OSH	Occupational Safety and Health
OSHA	Occupational Safety and Health Act
PPE	Personal Protective Equipment
SDS	Safety Data Sheets
SOP	Standard Operating Procedure
WI	Work Instruction

LIST OF EQUATION

CHAPTER 1

INTRODUCTION

According to The American Heritage® Dictionary of the English Language, Laboratory is a place, room or building equipped in a controlled environment for scientific experimentation or research. There are different types of laboratories for scientific research because of the various requirements of specific fields of science. It varies from a physics laboratory to a chemical or biological laboratory.

In most of the laboratories, the situation is more dangerous than in any other room. Various hazards are present in a laboratory, ranging from poisons; infectious agents; flammable, explosive or radioactive materials; moving machinery; extreme temperatures; or even high voltage. In laboratories where hazardous conditions exist, safety precautions are very important. Many workers are unaware of the potential hazards in their work environment, which makes them more exposed to hazards, which lead to injury. Rules and standards are available in order to minimise the risk, and safety equipment can be used to protect the workers or people connected to the laboratory from injury or to assist in emergency response.

Occupational Safety and Health (OSH) is an element concerned with protecting the safety, health and welfare of people at work. OSH in Malaysia always related to the Occupational Safety and Health Act 1994.The Occupational Safety and Health Act 1994 is an Act to make further provisions for securing the safety, health and welfare of persons at work, for protecting others against risk to safety or health in connection with the activities of persons at work, to establish the National Council for Occupational

Safety and Health, and matters to connect therewith (Occupational Safety and Health Act and Regulations, Act 514 (1994); Occupational Safety and Health Standards).

According to section 15 in OSHA 1994, the duties of an employer are

- To ensure the safety, health and welfare at work of all his employees and visitors,
- To formulate safety and health policies,
- To provide extra protection for the disabled etc.

In section 24 OSHA 1994, duties of an employee are

- To take reasonable safety and health measures for himself and other persons,
- To co-operate with his employer or any other persons in the discharge of any duty,
- To use and wear at all times, any protective equipment or clothing provided by the employer,
- To comply with any instruction or measure on occupational safety and health instituted by his employer.

In Malaysia, there is also a Biosafety Act and Regulation which is an important system under National Biosafety Board and it fall under the Ministry of Natural Resources and Environment (NRE). Biosafety guidelines mainly consist of regulation of Living Modified Organisms (LMOs) and product of LMOs. The objectives of the Act are to protect human, plant and animal health, the environment and also biological diversity and where there are threats of irreversible damage (Malaysian Biosafety Act, 2007).

Many companies have its own laboratory safety requirements. These might resolve the necessity to maintain the availability of SOPs, MSDS, and responses in case of emergencies which cover chemicals, microorganisms, equipment etc.

The implementation of Occupational Safety and Health (OSH) procedures in the workplace including laboratory, is important where they actually improve the safety of the working environment. Significant OSH practices would contribute to high motivation and confidence amongst workers, which leads to a safer working environment, free from any risk. A proper evaluation of OSH practices would help in recognising any risks that might occur in the workplace. A good evaluation programme also encourages the reduction and eliminates the risks involved in the working environment, to ensure the workers involved are free from any risk.

Other than laboratory safety, there is another clause of laboratories which is ISO/IEC 17025. ISO/IEC 17025 is the global quality standard for testing and calibration in laboratories. It is the basis for accreditation from an accreditation body (ISO/IEC 17025, 2005). Laboratory accreditation is the formal recognition of an organisation's competency to perform certain specific tests, classes or types of tests or instrument calibrations. Accreditation guarantees an industry and government assessment that accredited organisations are competent and their results can be relied on. The act, guideline, standards and procedures are inter-related in order to ensure the OSH at workplace is achieved.

Through settling a risk analysis (Clifton and Ericson, 2005), it will require a preparation of hazard identification to determine the nature of the potential hazard. The risk analysis

and hazard evaluation process are applied to identify and analyse the significance of a hazardous situation, which is related to both the process and/or activity (Leggett, 2012).

However, this system becomes a challenge when applied to a wide range of hazard depending on the specific areas of interest of each individual research group where it includes a cross hazard combination or mixture with chemicals, biological agents, radiation etc. (Marendaz et al., 2013). The lack of experienced or higher level educated staff to organise a large group of inexperienced employees may also lead to laboratory accidents (Marendaz et al., 2013).

Table 1.1 shows brief function of the legal Act that can be correlated between one another in OSH practices.

Table 1.1: OHSAS 18000, ISO 9001, ISO 17025 and ISO 14000 and its main function.

Act	OHSAS 18000	ISO 9001	ISO 17025	ISO 14000
Focus	Occupational Health and Safety	Quality Management	Testing and Calibration	Environmental Management
Published in	1999	1987	1999	1996
Function	Provides requirement for OHS management system and gave implementation guideline.	Provides guidance and tools for companies and organization to improve their products and meet customer's requirement.	Provides general requirements for the competence to perform test/calibration.	Provides practical tools for companies and organization to manage their environmental responsibilities in short and long term impact.

Based on the table above, we can see that the above act was made to manage the system systematically which will impact on better quality be it in products or services. It assured the safety of the surrounding, whether involving workers or environment. The interconnection between ISO 14000 and ISO 9000 is that both focus on the process of the product rather than to the product itself.

Derived from the regulations in above act, certain criteria from the above act can be applied to assess the occupational safety and health practices in selected laboratories in SIRIM Berhad, Shah Alam.

1.1 Industrial Biotechnology Research Centre (IBRC), SIRIM Bhd.

SIRIM Berhad is a wholly-owned company of the Malaysian Government under the Ministry of Finance Incorporated. SIRIM has been the government's mandated machinery for research and technology development, and the national champion of quality.

SIRIM played a major role in the development of the country's private sector focusing on discovering and developing new technologies to help businesses compete better through quality and innovation. With SIRIM's expertise and knowledge base, small and medium businesses collaborate with the scientists' every day in their quest for improvement in the manufacturing, technology and services sectors.

The research and development of industrially-viable technologies goes across four key areas: advanced materials, industrial biotechnology, environmental technology and renewable energy. The work may be contracted directly to SIRIM, or can be undertaken as a joint project with the organisation.

The Industrial Biotechnology Research Centre (IBRC) in SIRIM Bhd is involved in researching and developing useful products that take advantage of natural biological processes. Experts combine living organisms with other nutrients under specific optimal

conditions to make industrial bioproducts, biomedical devices and biosensors in their laboratories. SIRIM can also help design and develop pilot plants for biotechnological, biochemical and chemical processes.

This study focuses on the assessment of safety and health practices in selected microbiology and chemical laboratories in the Industrial Biotechnology Research Centre (IBRC) of SIRIM Bhd, Shah Alam, which consist of the Applied Chemical Laboratory, Analytical Biochemical Laboratory, Microbial Isolation and Screening Laboratory and Bacteriology Laboratory. These include hazard identification, risk assessment and emergency response plans. In this study area, IBRC SIRM Bhd implemented the OHSAS 18001. OHSAS 18001 is an Occupation Health and Safety Assessment Series for health and safety management systems.

1.2 Problem Statement

Problem statement:

In Malaysia, there were few laboratory accidents happened and it has been reported in the local newspaper. The laboratory accidents include hospitals, schools and also research laboratories due to many factors. Therefore, it shows that OSH practices are important in minimizing the effect and managing such incidents from occurred.

Currently, implementation of occupational safety, health and emergency response plan in chemical and biological lab are quite new. Biosafety Act and Regulation has only been put into practice on November 2010 even OSHA has been introduced on 1994. Hence, this study is to discover the implementation and effectiveness of existing OSH practices in selected chemical/microbiology laboratories in SIRIM Berhad, Shah Alam.

At present, there is no clear direction for the implementation of occupational safety, health and emergency response plans, as well as reassessment on the effectiveness of existing occupational safety and health practices in selected chemical and microbiology laboratories in SIRIM Bhd. Shah Alam.

1.3 Aim and Objectives of the Study

Aim:

This study focused on the assessment of the Occupational Safety, Health and Emergency Response Plans in selected laboratories of SIRIM Bhd, Shah Alam by using Hazard Identification, Risk Assessment and Risk Control (HIRARC) including Standard Operating Procedure (SOP), Material Safety Data Sheet (MSDS) and Emergency Response Plan (ERP). The outcomes will be used to promote knowledge, inspire, and promote problem solving among SIRIM's personnel and its affiliates.

Objectives:

1) To review and evaluate the compliance of standard operating procedures (SOP) covering safety precautions in Material Safety Data Sheets (MSDS), in mentioned laboratories.
2) To assess the awareness, implementation and practices of occupational safety, health and emergency response plans practiced among employees.
3) To evaluate the risk and safety practices, including the emergency response plans.

4) To propose the control measures in Occupational Safety and Health (OSH) hazards and risks according to Hazard Identification, Risk Assessment and Risk Control (HIRARC).

1.4 Scope of Study

The scope of this study focused on the assessment of occupational safety and health in selected microbiology and chemical laboratories in SIRIM Bhd, Shah Alam, based on priorities that are associated with the level of risk involved by using the Hazard Identification, Risk Assessment and Risk Control (HIRARC) procedure. SIRIM BERHAD has been chose based on the availability of both chemical and biological lab under one roof.

1.5 Research Outcome

Determine the HIRARC compliances by SIRIM Berhad in selected laboratories and evaluate SIRIM Berhad effort in implementing OSHA regulation to provide safety towards their employees.

CHAPTER 2

LITERATURE REVIEW

2.1 Occupational Safety and Health at the Workplace

The assessment of health and safety programme is an important part of any inspection. There are four basic elements that every workplace should have in place to protect employees from occupational hazards. The elements are (Small Business Handbook, 2005):

i. Management commitment and employee involvement.
ii. Worksite analysis.
iii. Hazard prevention and control.
iv. Health and safety training.

Typical laboratory biosafety guidelines have highlighted the best work practices, appropriate equipment, well-designed facilities, and also administrative controls to minimise risks of accident or injury for laboratory workers. The guidelines are also used to prevent any pollution and contamination of the environment. Although, chemical, as well as microbiological research laboratories may contain dangerous toxic and pathogenic biological material, there are only a limited number of articles which have been published on the safety for laboratory workers and others on these aspects (Richmond & Nesby-O'Dell, 2002; Society for The Science & The Public, 2012). However, there is an increase in the awareness and concern in these areas, particularly due to threats posed in terms of chemical or biological warfare (Richmond, & Nesby-O'Dell, 2002).

Basic elements to manage occupational safety and health at the workplace:

Hazard: Anything (e.g. condition, situation, practice, behaviour) that has the potential to cause harm, including injury, disease, death, environmental or property and equipment damage.

Hazard Identification: This is the process of examining each work area and work task for the purpose of identifying all the hazards which are "inherent in the job". Work areas include but are not limited to machine workshops, laboratories, office areas, agricultural and horticultural environments, stores and transport, maintenance and grounds, reprographics, and lecture theatres and teaching spaces. Tasks can include (but may not be limited to) using screen based equipment, audio and visual equipment, industrial equipment, hazardous substances and/or dangerous goods, teaching/dealing with people, driving a vehicle, dealing with emergency situations and construction.

Risk: The likelihood or probability that a hazardous event (with a given outcome or consequence) will occur.

Risk Assessment: Is defined as the process of assessing the risks associated with each of the hazards identified so that appropriate control measures can be implemented based on the probability, i.e. likelihood that harm, injury or ill health may occur and how severe the consequences of exposure might be. Risk assessment can be done by quantitative, qualitative or semi quantitative approaches

Quantitative analysis is where the estimation of risk value is connected with the application of hazard occurrence in the number of cases, and susceptibility by the value of the probability of its loss.

Qualitative analysis does not use any numerical data where it's presenting results in the form of words, descriptions and recommendations where potential severity will occur (Radu, 2009). The description of this technique usually relies on a prediction by expertise and previous experience to measure the severity and likelihood of the risk factor.

Semi-quantitative risk assessment provides a level between the textual evaluation of qualitative risk assessment and the numerical evaluation of quantitative risk assessment, by evaluating risks with a score (Radu, 2009). It offers a further consistent approach to assessing and comparing risks and risk management strategies than does qualitative risk assessment. It avoids some of the uncertainty that a qualitative risk assessment may produce. It does not involve the same mathematical ability as quantitative risk assessment, nor does it require the same amount of data, which means it can be applied to risks and strategies where precise data are missing (FAO *www.fao.org/docrep/012/i1134e/i1134e04.pdf* , 2010).

Risk Control: This is the process of identifying and implementing the most cost effective risk control measures having regard to the Hierarchy of Control Principle, legislative provisions, Australian Standards and other relevant information.

Monitoring and Review: This involves ongoing monitoring of the hazards identified, risk assessment and risk control processes and reviewing them to make sure they are working effectively.

2.2 Occupational Safety and Health Act (OSHA)

Occupational Safety and Health Act was introduced by Malaysian Parliament in 1994. Four principles in this act are:

i. to secure the safety, health and welfare of persons at work against risks to safety or health arising out of the activities of persons at work.

ii. to protect persons at a place of work other than persons at work against risks to safety or health arising out of the activities of persons at work.

iii. to promote an occupational environment for persons at work which is adapted to their physiological and psychological needs.

iv. to provide the means whereby the associated occupational safety and health legislations may be progressively replaced by a system of regulations and approved industry codes of practice operating in combination with the provisions of this Act designed to maintain or improve the standards of safety and health.

This act applies all over Malaysia to the industries that falls under First Schedule. By adopting this Act, it shows that Malaysia is serious in protecting the safety of the person at their workplace.

2.3 Biosafety Regulation

Biosafety Act and Regulation is an important system under National Biosafety Board and it fall under the Ministry of Natural Resources and Environment (NRE). The objectives of the Act are to protect human, plant and animal health, the environment and also biological diversity and where there are threats of irreversible damage (Malaysian Biosafety Act, 2007). The guidelines mainly consist of regulation of Living Modified Organisms (LMOs) and product of LMOs.

Biosafety act has come to force on 1 November 2010. This guideline was introduce to organization that working with LMO to execute it. Biosafety was present to fulfil the Cartagena Protocol on Biosafety rectified on 3 September 2003. The act consist of the establishment of Institutional Biosafety Committee (IBC), its role and function and the processes that must be followed when obtaining, using, transferring, storing or destroying LMOs/rDNA material. It is also for responsibility of the biological safety officers (BSO) and researchers, IBC membership, review done by IBC, action required for reporting of incidents and spills and other related information.

Objective of the biosafety regulation are to protect human, plant and animal health, environment and biological diversity, by regulate the release, importation, exportation and contained use of LMOs, and the release of products of such organisms. It requires the risk posed by or as a result of modern biotechnology be identified and managed through regulating activities involving LMOs. The Act allocates that where there are threats of irreversible damage, lack of full scientific evidence should not be used as a reason not to take action to prevent damage.

2.4 Occupational Safety and Health Standard

Occupational safety and health is considered as a key element in improving workplace safety and management. It is designed with the purpose of ensuring the safety, health and welfare of persons at work from hazards to safety and health arising from the activities of persons at work.

OHSAS 18001 is the most widely-used and recognised standard for Occupational Health and Safety Management Systems. In Malaysia, MS 1722 is a Malaysian Standard for Occupational Health and Safety Management Systems. Any organization in Malaysia can use these standards to show their commitment to safeguard the welfare of their employees from workplace injuries and illnesses. This is also important in committing with Occupational Safety and Health (OSH) legal requirements.

The benefits of OHSAS 18001 & MS 1722 Occupational Health and Safety Management System to an organisation are as follows (SIRIM QAS International, 2012):

i. Improve management of occupational health and safety risks, reducing the probability of accidents in the workplace.
ii. Continually improve safety and health performance, including compliance with regulatory requirements.
iii. Achieve cost reduction by minimising work-related hazards and injuries, thus boosting profitability.

2.5 Laboratory Accidents

Laboratory accidents happen. Employees drop things, problems may occur with equipment and errors in judgement are made- it is a fact of life. Laboratory investigation and demonstrations sometimes simply go incorrectly. Most laboratory spills and accidents are small in scope and have minimal consequences (Ashbrook, 2011). However, just because laboratory accidents happen does not mean that laboratory injury is either inevitable or unavoidable (Stroud, Stallings & Korbusieski, 2007).

In Chemical Heritage Magazine 2008's Summer Addition, Mark Michalovic wrote an article entitled Not-So-Great Moments in Chemical Safety. The article is about laboratory safety in history. Robert Burns Woodward (1917–1979) was always with his cigarette, even in the laboratory. He was also lucky that he was not killed in a smoking-related laboratory accident. After Humphry Davy (1778–1829) discovered potassium, Joseph-Louis Gay-Lussac (1778–1850), began studying the metal. In 1808, a potassium explosion temporarily blinded him. His eyesight was never fully restored.

Robert Bunsen (1811–1899) was known for climbing into the mouths of Icelandic geysers on the edge of eruption to measure water temperatures. It was back in his laboratory in Germany, in 1843, that a flask containing cacodyl chloride (C_2H_6AsCl) exploded in his face and permanently caused him to lose the use of his right eye. Bunsen was nearly killed after inhaling the compound's dangerous vapours.

Humphry Davy was the first to attempt to isolate fluorine. His work involved handling dangerous hydrogen fluoride. In an era before fume hoods, he suffered damage to both

his eyes and fingernails from the fumes. He actually never did isolate fluorine, as the gas was so reactive that it formed compounds with nearly everything it touched.

Irish brothers Thomas and George Knox took up the chase, and in the process both suffered severe hydrogen fluoride poisoning, which can damage the lungs, heart, kidneys, skin, and eyes. Two other chemists, Paulin Louyet and Jérôme Nicklès, died in their attempts to isolate the gas. In the 1860s, the English chemist George Gore caused several explosions when the fluorine he produced reacted violently.

French chemist Henri Moissan (1852–1907) used electrolysis to produce elemental fluorine from a solution of potassium hydrogen fluoride (KHF_2) and hydrogen fluoride. To keep the fluorine from reacting he used newly-available refrigeration techniques; this chilled his reaction mixture to –23ºC. Moissan certainly would have inhaled fluorine and hydrogen fluoride fumes during the course of his work, but he managed to avoid becoming a casualty of the halogen — not through any effective safety measures, but by pre-emptively dying of appendicitis just two months after his Nobel award ceremony.

Working without eye protection or fume hoods and casually producing violently reactive substances were just some of the dangerous things chemists used to do. On top of that, pipetting by mouth, tasting chemicals, and washing hands with benzene (C_6H_6), now known to be a carcinogen, were once common practices. To students and practicing chemists alike, the very real results of the lax of safety standards of days gone by should be powerful reminders that a lot of pain and hardship can be avoided by following the simple rules of laboratory safety and using common sense.

Laboratory accidents and here are some that have been reported in literature:

i. (Freemantle, 2006) Mulhouse (France). Blast in the university's chemistry building leading to one death and several injuries.
ii. (Wu et al., 2007) Taipei City (Taiwan). Blindness after a chemical experiment at University of Technology.
iii. (Kemsley, 2009) Los Angeles (California, USA). Fire in a chemistry laboratory leading to one death.
iv. (Kemsley, 2010) Lubbock (Texas, USA). Explosion of perchlorate in a university's chemistry building leading to one severe injuries.

In Malaysia, there were a few laboratory accidents reported in the local newspapers. The laboratory accidents are as follows:

i. 7 May 2008 - Ammonia exploded in one of the laboratories of the Tunku Ja'afar Hospital in Seremban (The Star, May 8th, 2008).
ii. 10 June 2008 – Bromine spillage in a science laboratory at Sekolah Menengah Kebangsaan Westland in Georgetown (Berita Harian, June 12th 2008).
iii. 25 June 2009 – One of the laboratories belonging to the Institute for Medical Research at Jalan Pahang Kuala Lumpur caught on fire (The Star and Berita Harian, June 26th, 2009).

In order to avoid the laboratory accidents, for an example Faculty of Chemical Engineering of Universiti Teknologi Malaysia (UTM) come out with some laboratory general rules which includes :-

i. Make sure the paths inside and outside the laboratory are not obstructed by equipment, furniture, electrical wires, etc.

ii. Make sure that all equipment in the office are in working condition.

iii. Follow the manufacturer's equipment handling and maintenance rules.

iv. Use screen filters to reduce UV radiation from computer monitors.

v. Work at a minimum distance of 50 cm from the computer screen.

vi. Make sure the cabinet drawers are neatly closed after opening them.

vii. Be careful when moving heavy objects like cupboards, tables, equipment and boxes as to avoid manual handling injuries. Use trolley if necessary.

viii. Clean any spillage immediately even if it's just water.

ix. Report broken furniture or equipment to the related department.

x. Use a ladder to obtain items from tall racks.

xi. Make sure that nothing is obstructing the emergency exit.

xii. Make sure fire extinguishers are easily accessible.

xiii. Identify the location of the glass breaker for activating the fire alarm in case of a fire.

xiv. Rest for a while to relieve stress and recuperate. (Faculty of Chemical Engineering, University Technology Malaysia, Handbook of Laboratory Safety and Regulations, 2013)

2.6 Laboratory Practices

Working with dangerous materials in the laboratory requires extreme caution, as any accident or error can have serious consequences. However, there are various indicators in laboratories that may specify the presence of any danger. Under the OSHA 1994, there is one regulation on the Use and Standard of Exposure of Chemical Hazardous to Health (USECHH) Regulation 2000, which apply to all places of work where chemicals or preparation of hazardous to health are produced, processed, handled, stored,

transported, disposed, and treated (OSHA 1992). Labels may provide basic warnings about the contents of specific containers (Environment, Health and Safety Online, 2013). Signs posted in storage areas create awareness of the hazards that certain groups of chemicals present. The chemical manufacturer or supplier can be contacted to obtain material safety data sheets (MSDS). These may be used to describe the hazards that a chemical may present; list precautions to be taken when handling, storing or using the substances; and outline emergency and first-aid procedures.

In a normal situation, the employer may assume that simply providing MSDS to employees will enable them to understand all that is necessary for protection and that such actions will meet OSHA requirements (Phillips, Wallace, Hamilton, Pursley, Petty & Bayne, 1999). Others assume as indicated by current formats in use that the more information provided on the MSDS form, the better for the worker and the employer. Either assumption could result in worker avoidance or misunderstanding of the content of the MSDS that could lead to injury or death associated with unnecessary exposure to toxic chemicals or their reaction. No matter in what form the MDSD is provided, the ability to understand its content or message is of singular importance in protecting the health and safety (Phillips, Wallace, Hamilton, Pursley, Petty & Bayne, 1999).

Other than MSDS, a proper Standard Operation Procedure (SOP) is another important document in the safety of laboratories. According to FAO Corporate Document Repository, an SOP for a laboratory can be defined as a document which describes the regularly recurring operations relevant to the quality of the investigation. The purpose of an SOP is to carry out any laboratory process correctly and always in the same way (FOA Corporate Documentation Repository, 1998). An SOP should be available at the place where the work is done as the compulsory instruction. It gives an instruction for

proper lay-out, and steps to be taken during any related process in order to guarantee the integrity and consistency of raw data, calculations and notes pertaining to the laboratory work. SOPs are an important part of a quality system. For all duties related to operating procedures should be available at the workstation. It is important to guarantee that the correct version of the SOP is used.

SOPs must be specific to each laboratory operation. SOPs must be reviewed and approved by the laboratory supervisor. After approval, SOPs are then incorporated into or attached to written materials and methods. Laboratory personnel must be trained in the elements of the SOP before performing an experiment or operation. According to the Iowa State University Laboratory Manual 2012, at least, SOPs must include:

i. **Health and safety information on the materials used**- The list should briefly describe the chemical, biological, radiological and physical hazards associated with the operation. It should also identify available resources like safety data sheets (SDS) and specify where it can be accessed.

ii. **Hazard control measures**- Includes containment devices, ventilation, specific personal protection equipment, and hygiene practices as recommended by the MSDS.

iii. **Waste disposal practices**- Establish procedures for the safe and timely removal of laboratory waste.

iv. **Decontamination procedures-** Develop procedures to be used in contaminated areas with required frequency and duration.

v. **Spill/ release containment and clean up procedures**.

Developed SOPs must be readily available in the laboratory where the experiment or operation will be performed. SOPs should be reviewed and updated annually, especially when there is any change in the laboratory process.

Each data sheet for the test method should include sufficient information to determine the culture used (for tracing back from the initial process); all critical pieces of equipment used; all buffers, media and chemicals used; time and date of activities and the person that performed the work and date all information was reviewed (Sutton, 2010; The Importance of A strong SOP System In the QC Microbiology Lab). The advantage of this practice is that it will cut down on the worst source of variability in the laboratory work.

Specific procedures must be developed for work involving materials or equipment that includes a significant risk of exposure or injury to the human body. These can be prepared by following:

i. Authorised persons that are involve or are working with the material or equipment must receive training on the unique hazards of related materials or equipment before use.
ii. Establish and identify a designated use area (e.g. fume hood, glove box, laboratory bench) and by signs or postings and restrict access to the area only to authorised personnel.
iii. Specify special safety precautions for experiments or laboratory operations where these materials or equipment are used and identify specialised equipment, shielding, protection or security requirements to be used.

Safety in a microbiology laboratory is an important issue needed in order to prevent any infection that might be caused by the microorganisms being studied (Centres for Disease Control and Prevention). Even if the laboratory does not require the use of dangerous human pathogens, many types of microorganisms are potentially pathogenic. Thus, although the microorganism would not cause disease in a normal healthy host, it might be potentially dangerous if a large quantity of the microbes comes in contact with a compromised host, for instance from open wounds or cuts (James, 2008). Other than the microorganisms itself, there are some chemicals that are used in microbiology laboratories that are potentially harmful. Many other procedures involve the use of glassware, open flames, and sharp objects that can cause damage if used improperly.

Chemical laboratories occupy a special place in the research field and the industry. However, by the very nature of the laboratory work, it can be a place of danger if proper precautions are not taken into consideration. The usage of explosive, highly toxic, and carcinogenic substances particularly from research work performed, there can be certain unavoidable hazards associated with the use of a variety of chemicals (Safety in the Chemistry Laboratory; The Office of Environmental Health and Safety Chemical / Biological Safety Section, 2011). These conditions lead to different safety issues in the chemical and microbiological laboratories. Safety in a chemical laboratory focuses mainly on the chemicals used. Thus, occupational safety and health must be the main concern to every employee in the organisation, regardless of job position.

According to the National Research Council of The Nationals Academies, 2011, safety training should be seen as an important component of the laboratory safety programme within an organisation. Effective training is a critical component to facilitating a safe environment and for the prevention of laboratory accidents (UCLA, Laboratory Safety

Manual, 2011). This is due to the fact that the laboratory employees' main job does not involve laboratory emergency planning or chemical waste management (University of Vermont Risk Management Group, 2004). All employees must be trained in general safe work practices and also should be given specific instructions on hazards matches to their task.

2.7 Safety Training

At minimum, laboratory personnel are required to complete Environmental Health and Safety Training before deemed capable to work in the laboratory. In the IOWA State University Laboratory Safety Manual (October 2012), it states that all laboratory personnel must receive laboratory-specific training on:

i. Location and content of the Laboratory Safety Manual,
ii. Physical, chemical and biological hazards in the workplace, including signs and symptoms of exposure and allowable exposure limits,
iii. Location of references describing hazards and safety practices associated with laboratory material,
iv. Protective measure – to avoid exposure or injury,
v. Procedure for responding to laboratory emergencies,
vi. Method to detect the presence of contamination or the release of chemical, biological and radioactive materials,
vii. Procedures for obtaining medical care in the event of exposure or injury,
viii. Proper waste management and disposal procedures,
ix. Proper record keeping.

Refresher trainings are also important, according to the U.S. Department of Labor Occupational Safety and Health Administration (Training Requirements OSHA Standards and Training Guidelines, 1998). The Process Safety Management Standard requires the employer to evaluate or verify that employees comprehend the training given to them. Refresher training shall be provided to all laboratory personnel at least every three years, and more often if necessary, to each employee involved in operating a process to assure that the employee understands and remain to the current operating procedures of the process. The employer, in consultation with the employees involved in operating the process, shall determine the appropriate frequency of refresher training.

An evaluation of the training is important to check whether the training programme is accomplishing its goals or not. It should have one essential component or a method of measuring the effectiveness of the training. A plan for evaluating the training session(s), either written or thought-out by the employer, should be developed when the course objectives and content are developed. The evaluation will help employers to determine the quantity of learning achieved and whether an employees' performance on the job has improved (Guidelines on Occupational Safety and Health Management Systems, 2011).

The methods of evaluating training which includes (Guidelines on Occupational Safety and Health Management Systems, 2011):

i. Participants' opinions.
    a. Questionnaires or informal discussions with participants can help employers determine the relevance and suitability of the training programme.

ii. Supervisors' observations.

a. Supervisors are significant to observe an employees' performance before and after the training. The supervisor should note insufficiency or shortage and help in implementing improvements.

iii. Workplace improvements.

a. A successful training programme will reduce the risk, accidents and injuries in the workplace.

Evaluation of training can give employers the information necessary to decide whether the workers have achieved the desired results and whether the training should be offered again.

Additional employee training is required whenever a new hazard is introduced into the work environment, and must be provided within 30 days of receiving the MSDS or other safety information (Department of Industrial Relations Cal/OSHA Consultation ServiceResearch and Education Unit 2012). All training must be in the suitable language, educational level, and suitable and understanding words and terms for laboratory personnel (Herman, 1998). Employees also must be given the opportunity to ask questions during the training.

Malaysian Occupational Safety & Health Administration (OSHA) requires facilities with ten or more employees to have a written emergency plan (Occupational Safety and Health Act and Regulations, Act 514 (1994); Occupational Safety and Health Standards). However, in smaller facilities, the plan may be communicated orally. Nevertheless it is obvious that safety and health in a work environment require the

support and involvement of both the employer and the employees. With respect to this emergency response plans are absolutely essential in workplaces. It is the duty of employers to ensure that employees are physically capable of performing any assigned duties and are trained in the various aspects of safety.

2.8 Laboratories Emergency Plan

A Laboratory Emergency Plan should be developed and implemented to protect personnel, equipment, and laboratory facilities at any time to prevent any emergency event from distracting the laboratory operations. Based on example from OSHA requirement in Principal Emergency Response and Preparedness, Requirements and Guidance (USA, 2004), it is important to have a proper design and construction of exit routes. This requirement covers construction materials, opening dimensions, accessibility conditions and capacity of the workplace. Ensure that the number of exit routes is adequate based on the number of employees, the size of the building, its occupancy, and the arrangement of the workplace. Other than construction of exit routes, maintenance of all the exit route lighting, marking, and non-flammable material is also important. These two main elements will prepare the workplace for a successful emergency evacuation.

The other important indication by OSHA for good Emergency Response and Preparedness is to have proper medical services and adequate first aid supplies. The selection of these resources must be based on the types of hazards in the workplace. The exact selection of resources is important in order to handle potential workplace injuries. The other element that related to Emergency Response and Preparedness in the workplace is availability of fire extinguishers. An employee alarm system is essential

for a bigger organisation where it actually alerts employees to begin implementing emergency action. All of the elements will build up an excellent Emergency Action Plans and Fire Prevention Plans.

According to Assoc. Prof. Abdul Shukor's article entitled Important Issues Relating to Workplace Inspection (2009), a workplace inspection is a required and important part of a safety and health programme. It is because that the workplace is inspected closely on a regular basis to:

i. Identify and record potential and actual hazards associated with buildings, equipment, workplace environment, processes and practices;
ii. Identify any hazards which require immediate attention, including the unsafe conditions or unsafe acts;
iii. Ensure that existing hazard controls are functioning effectively.

A safety workplace inspection may consist of different type of inspections including (Roughton & Crutchfield, 2008):

i. General walk-around.
ii. Verification Review
    a. Conduct periodic and daily safety inspection,
    b. To ensure that the issues identified in previous reviews have been appropriately completed.
    c. To ensure that management systems are in place and that corrective action has been implemented and maintained.

iii. Focus Review

a. Conducted in conjunction with comprehensive or verification review, a result of a significant risk or hazard finding or enforcement action by a regulatory agency.

b. Its purpose is to concentrate on a particular process or audit component that needs bigger assistance in implementing an appropriate hazard control.

iv. Self-Assessment

a. Review the activities of management and employees or the operation process to ensure compliance with relevant audit components.

b. Should cover administrative management, baseline safety and health assessment, operations and industry practice that may impact the facility.

v. Document Review

a. Documents and records are inspected to verify what has been said will be documented, completed, properly stored and secured.

vi. Written Inspection Reports- necessary to record hazards identified, responsibility assigned for correction, and tracking of correction actions to completion. A well designed document will help to ensure that:

a. Responsible individuals are assigned to make sure that the hazard is corrected in a timely matter.

b. Methods of tracking corrective actions to completion are implemented.

c. Problems in a hazard control system are identified when the same type of hazard continues to occur after an action plan is completed and verified.

d. Problems are identified in the accountability system

e. Hazards where no preventive measure or control have been planned and identified.

There is no workplace that can be considered free from any hazards. Therefore, all workplaces within an organisation should be inspected. Workplace inspections should not be treated as isolated events or "once-and-for-all time" exercises. To be effective it must be conducted on a regular basis and be part of a systematic programme aimed at accident prevention (Shukor, 2009).

2.9 Hazard Identification, Risk Assessment and Risk Control (HIRARC)

In Malaysia, there are Guidelines for Hazard Identification, Risk Assessment and Risk Control (HIRARC) from the Department of Occupational Safety and Health (2008). Through HIRARC individual will be able to identify hazards, analyse and assess its associated risk, next apply the suitable control measures. These guidelines in line with one of the general duties as prescribed under the Occupational Safety and Health Act 1994 (Act 514) for the employer to provide a safe workplace for their employees. In the guidelines, the main purposes of HIRARC are:

i. To identify all the factors that may cause harm to employees and others (the hazards),

ii. To consider what the chances are of that harm actually be failing anyone in the circumstances of a particular case and the possible severity that could come from it (the risk), and

iii. To enable employers to plan, introduce and monitor preventive measures to ensure that the risk are adequately controlled at all time.

Laboratory safety often links with the Hazard Identification, Risk assessment and Risk Control (HIRARC) process. The risk assessment procedure can be best illustrated by the following way:

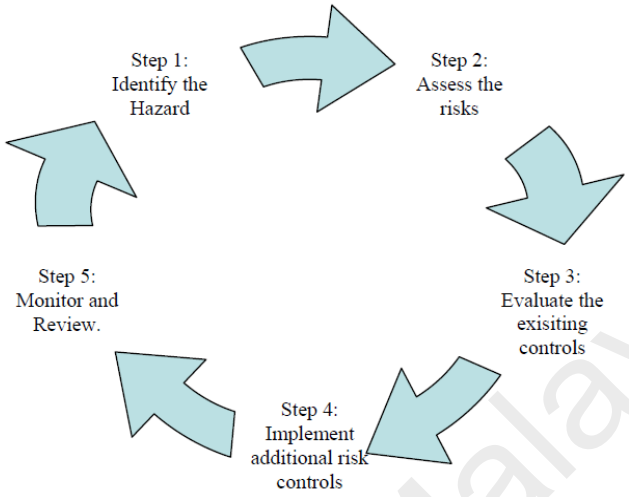

Figure 2.1 : HIRARC Procedure

Source: Hazard Identification, Risk Assessment and Control Procedure (2008).

Step 1: Hazard Identification requires:

i. Past incidents or accident to be examined to see what happened and whether it could happen again,
ii. Discussion with employees regarding their safety issues,
iii. Examination of working area and work in progress,
iv. Revision on information of equipment and materials.

Hazard identification process will always involve the workplace inspection. Periodic workplace inspections are important in general occupational health and safety programme. An inspection checklist helps in making clear inspection responsibilities where its control the inspection activities and provides reports on the activities.

Step 2: Assess the Risk

i. Identify factors that may have contributed to the risk,
    a. The workplace and working environment,
    b. The capability, skill, and experience of employee,
    c. The working system,
    d. The range of reasonably foreseeable condition.
ii. Review health and safety information that is reasonably available,
iii. Evaluate the likelihood of an injury occurring and the severity of an injury or illness that may occur,
iv. Identify the actions necessary to eliminate or control the risk,
v. Identify records that are necessary to keep to ensure that the risks are eliminated or controlled.

Step 3: Evaluation existing risk controls.

Allowing for the determination of any additional control measure requirement is necessary.

Step 4: Implementation of additional risk controls.

All hazards that have been assessed should be dealt with in order of priority in one or more of the following of controls as follows:

i. Source of Hazard

It is one of the control methods to control hazards by implementing the Elimination and Substitution factor in the laboratory.

a. **Elimination** - Getting rid of a hazardous job, tool, process, machine, chemical or substance is possibly the best way to protect workers.

b. **Substitution** – Replace the source of the hazard with non or less hazardous material to protect employees from recurring or any newly created hazards.

ii. Engineering Controls

Engineering controls are the mechanical modification of machinery or processes to prevent and reduce the release of hazards into the working environment. Depending on the types of hazards, different factors of engineering control can be applied in the laboratory. Table 2.1 shows some different types of engineering controls.

Table 2.1: Engineering Control Variables.

Variable	Remark
Redesign	Jobs and processes can be reworked for better safety. For example, containers can be made easier to hold and lift.
Isolation	If elimination or replacement is impossible, the hazard can sometimes be isolated, contained or kept away from employees.
Automation	Dangerous processes can be automated or mechanised.
Barriers	A hazard can be blocked before it reaches employees.
Absorption	Baffles can block or absorb noise. Lockout systems can isolate energy sources during repair and maintenance. Usually, the further a control keeps a hazard away from employees, the more effective it is.
Dilution	Some hazards can be diluted or dissipated.

Source: Department of Occupational Safety and Health Malaysia, 2008.

iii. Administrative Controls

Administrative controls comprise of a variety of policies and requirements that are accepted at the administrative level. Administrative controls are implemented by the relevant authority (Management, Safety Department, Safety Committee or Safety Officer). Following variables can be implemented as administrative controls to minimise and control risks in the working area (Table 2.2)

Table 2.2 Administrative controls Variables

Variables	Remarks
Safe work procedure	Workers can be required to use standardised safety practices. The employer is expected to ensure that employees follow these practices. Work procedures must be periodically reviewed with employees and updated.
Supervision and training	Initial training on safe work procedure and refresher training should be offered. Appropriate supervision will be assisting employees in identifying possible hazards and evaluating work procedures.
Job rotations	Reduce employees' exposure to a hazard. For example, employees can be rotated through jobs requiring repetitive tendon and muscle movements to prevent cumulative injuries. Noisy processes can be scheduled when no one is in the workplace.
Housekeeping, repair and maintenance programmes.	Housekeeping includes cleaning, waste disposal and spill cleanup. Well maintained tools, equipment and machinery are less likely to cause injury.
Hygiene	Hygiene practices can reduce the risk of toxic material absorption by an employee or the risk of carrying toxins home. Street clothing should be kept in separate lockers to avoid contamination by employee clothing. Eating areas must be isolated from toxic hazards. Eating should be banned in toxic work areas. Where applicable, an employee should be required to shower and change clothes at the end of the shift.

Source: Department of Occupational Safety and Health Malaysia, 2008.

iv. Personal Protective Equipment.

Personal protective equipment use is determined by hazards identified in hazard analysis. PPE should only be used as the last option, after exhausting all other controls or when more significant hazard controls are not viable or practicable

Step 5: Monitor and Review

A suitable and sufficient Risk Assessment should (Hughes & Ferret, 2010):

i. Identify the significant risk and pay less attention to the minor risk;

ii. Identify and prioritise the measure required to comply with any relevant legal condition;

iii. Remain appropriate to the nature of the work suitable over a practical period of time.

iv. Identify the risk arising from or in connection with the work where the level of details should be balanced with the risk.

Table 2.3 shows that some example of safety at laboratory research done in Malaysia.

Table 2.3: Laboratory Safety Research done in Malaysia.

Researcher	Laboratories	Method	Remarks
Siti et al. 2012	Teaching Lab	Chemical Health Risk Assessment, CHRA	To identified and evaluate risk involve and current practice of the staff and student.
Salasiah Zakaria 2012	Manufacturing Lab	CHRA	To determine potential hazard derived from the chemical and risk assessment.
Siti et al 2011	Chemical & Biochemical Engineering, UKM	Chemical Health Risk Assesment, CHRA	To identified and evaluate risk involve and current practice of the staff and student.
Shuaib et al 2009	Electrical & Electronics, Mechanical & Process, Material & Science, Computer & Software	HIRARC	To identified hazards, hazards evaluation process, control measure practices
Maazza 2008	Chemistry Lab	Modified OSHA	To assess risk from hazardous chemical

Two types of laboratories involved in Siti el al. 2011 studies which was chemical and biochemical laboratory. The evaluation was done by i) observation made of the staff while handling chemical, review of work procedures, manual and other related documents and records, ii) Interview research staff and student who are directly exposed. Other than that, work procedure, training records, quality manual and personal protective equipment compliance were also examined. Observation done was based on duration of staff/student expose to chemical. The risk rating was based on 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. Finding shows chemical exposure was well managed from the

cleanliness of the laboratories and provided personal protective equipment. If the rating was quite high, the person/department involved needs to identify precautions, taking measures, do some requirement for monitoring or health surveillance to maintain controls and minimize the exposures. Assessment can be rescheduled every 5 years or when it is necessary. These studies also give suggestion for improvement which includes Register of Chemicals Hazardous to Health, Obtaining the Original Material Safety Data Sheet (MSDS) from Supplier, Personal Protective Equipment (PPE), Emergency Response Plan (ERP), Chemical storage at the laboratory or Re-assessment every month.

Similar result was obtained by Siti et al 2012. Even the laboratories involved was different, the conclusion made was almost the same. The study was to evaluate sufficiency of the control measure practice by staff and student. Hazard was determined through MSDS obtained from the supplier. Assessment method was by identifying the hazards, processes in hazardous chemical use and management, evaluation of the hazard risk, identifying the level of risk at the work place and the sufficiency and effectiveness of current control measures. Result found that the department has taking preventive measures such as safety regulations are displayed at strategic locations in each lab and safety briefing by the expert. Siti et al. 2012 also suggested, to improve the safety is by making a decision on suitable control measures, provide employee's training and perform monitoring and health surveillance activities.

Research done by Shuaib et al 2009 was to evaluate risk level and measure current practices in UniMAP's laboratories. The method used is by, 1) classify lab/work activities, 2) Hazard Identification, 3) Risk Assessment, 4) Identify Control Action and 5) Recommendation for Improvement. Evaluation was carried out by observation on

staff and students. Result illustrates different risk level for different type of laboratories. Three types of laboratories exposed to medium risk except for computer and software which is low in risk rating. This due to fact less hazardous chemical and dangerous activities involved in that particular laboratory. Recommendations to improve are by enforcing or stringent the safety procedures in the laboratories, continuous equipment maintenance, adequate/larger laboratories, improving the equipment or device storage system and increasing management commitment.

Maazza 2008 has conducted assessment for 6 month to assess risk from hazardous chemical. Modified OSHA method was used as it showed additional credibility and reasonability when compared to conventional OSHA model owing to estimation of risk parameters in this case were based on physicochemical properties which directly influence the risk rating parameters. Result shows students could be in adverse health risks as a consequence of daily exposure to the hazardous chemicals, lack of knowledge regarding the use of material safety data sheets (MSDS), safety protective equipments and inadequate training on chemical handling or application of the correct safety parameters.

From all of the above researches, it can be concluded that there are still lack of safety precaution in laboratories in Malaysia. The basic foundation has been applied; the execution was still poor though. Therefore, HIRARC is an on-going process. As a result, regular review on the effectiveness of hazard assessment and control measure is important. Hazard identification needs to be carried out whenever there is a change in the workplace including any work systems, tools, machinery or equipment change. Provide additional supervision when new employees introduced to the workplace.

Proper documentation regarding control measures for safety, health and emergency response, together with the concept of monitoring and reviewing is needed in order to ensure that both the employee and the environment is safe. With a proper conceptual model and suitable recommendation, the hazards can be minimised, while a safe and healthy working environment can be maintained.

CHAPTER 3

METHODOLOGY

This study focused on the evaluation of occupational safety and health in selected microbiology and chemical laboratories in SIRIM Bhd, Shah Alam, based on priorities that are associated with the level of risk involved by using the Hazard Identification, Risk Assessment and Risk Control (HIRARC) procedure. The methodology used in this study can be divided into four sections, which include the inspection of hazard identification, risk assessment, existing control (if any) and risk control method in general by using the HIRARC form (Appendix A) that helps in identifying, collecting and analysing the parameters. These processes were carried out in four selected laboratories namely; the Applied Chemical Laboratory and the Analytical Biochemical Laboratory, which represents the chemical laboratories whereby, the Microbial Isolation and the Screening Laboratory and Bacteriology Laboratory represent the microbiology laboratories. The reason this laboratories was chosen is to have both chemical and biological laboratories involved in this assessment to see any differences between two.

The main activities in the Applied Chemistry Laboratory consist of the general research activity utilizing various types of chemical and instrumental. These activities includes, stirring/ mixing/ heating the solution/ media, Extraction using Supercritical fluid extraction (SFE) machine and also extraction by using soxhlet.

The core activities in the Analytical Biochemical Laboratory involve research activity utilizing different types of chemical, biological and instrumental. The research activity, includes the Synthesis process, Enzymes hybridization determination process and assay process which include, stirring/ sonicating / mixing/ heating the solution/ enzyme.

In the Microbial Isolation and the Screening Laboratory, the main research activities include media preparation, screening and isolation of microorganism, streaking of microorganism and inoculation process. It involves with different kind of chemicals and microorganism.

On the other hand, the main research activity in Bacteriology Laboratory involves media preparation for the microorganism growth, inoculum preparation, serial dilution, streaking of bacteria and inoculation/ transferring of bacteria into shake flask.

3.1 Review and Evaluation of Laboratory Practices

This review and evaluation process involved the process of reviewing and evaluating of Standard Operating Procedures (SOPs) and the use of Material Safety Data Sheets (MSDS). This procedure includes the element of workplace inspection and questionnaire survey. The Workplace Inspection is an open-ended and close-ended question while Questionnaire survey was evaluated and reviewed using Likert Scale (Strongly Disagree, Disagree, Neutral, Agree and Strongly Agreed) for attitude/opinion/awareness analysis. The ordered scale used was to measure respondents' attitudes by asking the extent to which they disagree or agree.

3.1.1 Workplace Inspection (Observation and Interview)

The workplace inspection includes the observed activity around the selected laboratories to identify the safety documents, files and condition. A general walk-around inspection of the workplace to identify conditions of non-compliance to

safety standards was also applied in this observation process. Other than that, data collection from semi-structured interviews with person in charge of the laboratories also applied in the workplace inspection process (Laboratory Health and Safety Self-Audit Checklist, Princeton University, 2003). The use of the checklist in this study is as a guideline where it breaks down a complex plans (inspection plan) into manageable actions steps that completes the inspections effectively.

In this study, the "Laboratory Inspection Checklist" contains a total of 105 items (Appendix B) separated in a few sections which are:

A. General Work Environment.
B. Emergency Planning
C. Required Information/Postings.
D. Personal Protective Equipment.
E. Electrical Hazards, Chemical Storage.
F. Waste Handling: Hazardous, Non-Hazardous & Biological.
G. Ventilation.
H. Security.
I. Training and Awareness.

Checklists used were based on other researches that were close and related to this study. The checklists were then customised so it meets the objective.

3.1.2 Questionnaire Survey

A questionnaire with the title "Assessment of Occupational Safety and Health Practices in Selected Laboratories at SIRIM Bhd, Shah Alam" (as in Appendix C) was given randomly to the related employees for data collection on the safety knowledge and practices among the employees. The questionnaire was given to the related laboratory employees randomly. The questionnaire used, was a compilation from several questionnaires that have similar activity and are closely-related to this study (Richards-Babb, Bishoff, Carver, Fisher & Robertson-Honecker, 2010). The compiled questionnaires were then customised according to the results from the observation and also workplace inspections on the related activities and working environment.

In this study, the questionnaire survey contains a total of 47 (closed and open ended) items separated in a few sections that include:

A. Personal Particulars
B. Safety Information Policy
C. Standard Operating Procedures (SOP) and Material Safety Data Sheets (MSDS)
D. Emergency Response Plans
E. Availability of Laboratory Safety Equipment
F. Chemical /Microbial Storage
G. Chemical / Microbial Waste Disposal

3.2 Determination of the Occupational Safety and Health Awareness, Implementation and Practices.

This study is to determine OSH awareness, implementation and practices including emergency response plans (ERP). These practices apply to both the employer and also employees. This procedure includes the element of workplace inspection and questionnaire survey same as in 3.1.1 and 3.1.2. Sections that were mainly used including A. General Work Environment, B. Emergency Planning, C. Information/Postings, D. Personal Protective Equipment, G. Ventilation, and I. Training and Awareness.

3.3 Evaluation of Safety Practices.

In this study, the evaluation of risk and safety practices included emergency response plans. This evaluation is important to ensure that occupational safety and practices are implemented effectively and factors of success in achieving the practices are identified. This procedure includes the element of workplace inspection and questionnaire survey same as in 3.1.1 and 3.1.2. Sections that were mainly used including, Section C. Information/Postings/Policy, D. Personal Protective Equipment, E. Electrical Hazard, G. Ventilation and section I. I. Training, while sections from questionnaire survey were mainly used including section D. Emergency Response Plan, F. Chemical and section G. Microbial Storage, Chemical and Microbial Waste Handling and Ventilation.

The method used in 3.1, 3.2 and 3.3 for Workplace Inspection and Questionnaire Survey were the same method. However the content of each section was different according to each objective.

3.4 Hazard Identification, Risk Assessment and Risk Control (HIRARC)

This study was carried out in four selected laboratories including the Applied Chemical Laboratory, the Analytical Biochemical Laboratory, the Microbial Isolation and Screening Laboratory and the Bacteriology Laboratory. Hazard identification in this study was done using a hazard identification checklist, workplace inspection checklist, observation and interview. The first step in developing hazard identification was by looking at the process flow of each laboratory, familiarising with the process, and collecting basic information to identify the hazards. In general the hazard can be divided into four different types including chemical hazards, biological hazards, physical hazards and also electrical hazards.

Hazard Identification - process of determining whether exposure to a stressor can cause increases in the incidence of specific adverse health effects and whether the adverse health effect is likely to occur in humans.

Risk assessment - process of evaluating the probability and consequences of injury or illness arising from exposure to an identified hazard.

Risk likelihood - probability that a risk can occur. The factors that should be taken into account in the determination of likelihood including: the source of the threat, capability of the source, nature of the vulnerability and existence and effectiveness of current controls. Likelihood can be described as high, medium and low.

- High: An event is expected to occur in most circumstances.
- Medium: An event will probably occur in many circumstances.

- Low: An event may occur at some time.

Risk impact - potential effect that a risk could have if it arises. The importance of impact also can be categorised as high, medium and low. Where:

- High: Serious impact on operation, reputation, or funding status.
- Medium: Significant impact on operations, reputation, or funding status.
- Low: Less significant impact on operations, reputation, or funding status.

The combination of likelihood and impact gives the value for each risk factor.

3.4.1 Risk Assessment

Risk assessment is the process of evaluating the probability and consequences of injury or illness arising from exposure to an identified hazard. Risk assessment can be done by **quantitative**, **qualitative** or **semi-quantitative** approaches. In this study, a mix of all the above methods was used.

Risk Matrix Ranking

Risk Matrix Ranking has ranges of severity and likelihood as the axes. The combination of a severity and likelihood range gives an estimate of risk or risk ranking.

a. Likelihood of an Occurrence

The Assessment of likelihood in the laboratory was based on the experience of employees, analysis or measurement. Likelihood levels ranged from "most likely" to "inconceivable". Table 3.1 explains in detail on the different ranges of likelihood with their rating.

Table 3.1: Likelihood Values.

Likelihood (L)	Explanation	Rating
Most likely	The most likely result of the hazard / event being realised	5
Possible	Has a good chance of occurring and is not unusual	4
Conceivable	Might occur at sometime in the future	3
Remote	Has not been known to occur for many years.	2
Inconceivable	Is practically impossible and has never occurred	1

Source: Department of Occupational Safety and Health Malaysia, 2008.

b. Severity of Hazard

The severity could be divided into 5 categories. Severity was based upon an increasing level of severity to an individual's health, the environment, or to property. Table 3.2 shows the rating of severities by giving an example.

Table 3.2: Indicate Severity.

Severity (S)	Explanation	Rating
Catastrophic	Numerous fatalities, irrecoverable property damage and productivity.	5
Fatal	Approximately one single fatality, major property damage if the hazard is realised.	4
Serious	Non-fatal injury, permanent disability.	3
Minor	Disabling but not permanent injury.	2
Negligible	Minor abrasions, bruises, cuts and first aid type injury.	1

Source: Department of Occupational Safety and Health Malaysia, 2008.

c. Risk Assessment

Risk could be presented in different techniques to indicate the results of the analysis. For risk analysis that uses likelihood and severity in the qualitative method, presenting the results in a risk matrix is an effective way to show the risk distribution in a workplace. Table 3.3 shows an example of risk matrix to identify the risk value.

Risk can be calculated using the following formula:

L x S = Relative Risk → Eq (3.1)

Where L = Likelihood

and S = Severity

Equation 3.1 : Relative Risk

Table 3.3: Risk matrix

Severity / Likelihood	5	4	3	2	1
5	25	20	15	10	5
4	20	16	12	8	4
3	15	12	9	6	3
2	10	8	6	4	2
1	5	4	3	2	1

High Medium Low

Source: Department of Occupational Safety and Health Malaysia, 2008.

To use this matrix, refer to the severity column, which best describes the outcome of the risk. Next, track the likelihood row to find the description that best fits the

likelihood in which the severity happened. The risk level is where the row and column intersects.

The relative risk value can be used as a guide for prioritised action needed in effective management control of workplace hazards. Table 3.4 explains the level of the risk in particular values.

Table 3.4 Risk Description.

Risk	Description	Action
15-25	High	A high risk situation requires immediate action to control the hazard as detailed in the hierarchy of control. Actions must be documented on the risk assessment form, including the date for completion.
5-12	Medium	A medium risk situation requires a planned approach to controlling the hazard and applies a temporary measure if required. Action taken must be documented on the risk assessment form, including the date for completion.
1-4	Low	A risk situation identified as low may be considered as acceptable and further reduction may not be necessary. However, if the risk can be resolved quickly and efficiently, control measures should be implemented and recorded.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Review and Evaluate the Compliance of Standard Operating Procedures (SOP) and the use of Material Safety Data Sheets (MSDS) In Mentioned Laboratories.

4.1.1 Review and Evaluate the Compliance of Standard Operating Procedures (SOP)

According to the Food and Agricultural Organization, A Standard Operating Procedure (SOP) for a laboratory can be defined as a document which describes the regularly recurring operations relevant to the quality. The purpose of an SOP is to carry out the operations or process correctly and always in the same way. An SOP should be available at the place where the work is done. On the other hand, an SOP is describes as written procedure to be followed routinely in doing a task (WHO, 2010). In the case of the laboratory, these describe in detail the guidelines a person doing specimen collection, testing, recording of results or other necessary lab tasks must follow.

However, there are some who confuse “procedures” with “work instructions”. In most cases, work instructions are called procedures. Knowing the difference can help a person to understand the documentation process better. It helps in developing a good documentation procedure. Procedures and work instructions are all part of the general ISO requirements. In general, a procedure summarises how to perform a process while a work instruction describes how to perform a task.

Based on the inspection done in the selected laboratories in this study, all four laboratories follow the ISO 9001 standards. This is to standardize the management's quality which will impact in better product's quality and always meets the customer's standards and needs. In addition, one of the laboratories which is the Bacteriology Laboratory also follows the ISO 17025 because this laboratory performs product testing activities. Below in Table 4.1 shows the standard involvement and compliances in each laboratories.

Table 4.1: Differences on Standard Applied to Each Laboratory.

Laboratory / Standard		Applied Chemical Laboratory	Analytical Biochemical Laboratory	Microbial Isolation and Screening Laboratory	Bacteriology Laboratory
ISO 9001		√	√	√	√
Procedure	SOP	General to the company	General to the company	General to the company	General to the company
Working Instruction	WI	Do not have specific working instructions for laboratory activities	Do not have specific working instructions for laboratory activities	Do not have specific working instructions for laboratory activities	Do not have specific working instructions for laboratory activities
Record	Research notebook	This laboratory is a research laboratory and concentrates on contract basis.	This laboratory is a research laboratory and concentrates on contract basis.	This laboratory is a research laboratory and concentrates on contract basis.	This laboratory concentrates on product testing. It follows the ISO 17025.
ISO 17025		**X**	**X**	**X**	√
Procedure	SOP				Standard operation procedure for Quality Manager
Working Instruction	WI				Working instruction depends on each test.
Record	Forms				Depending on WI and Quality Manual
OHSAS 18001		√	√	√	√
Procedure	SOP	General SOP for the centre	General SOP for the centre	General SOP for centre	General SOP for the centre
Working Instruction	WI	Do not have specific working instructions for laboratory activities	Do not have specific working instructions for laboratory activities	Do not have specific working instructions for laboratory activities	Do not have specific working instructions for laboratory activities
Record	Forms	Forms for documentation according to the related safety matter.	Forms for documentation according to the s related safety matter	Forms for documentation according to the related safety matter	Forms for documentation according to the related safety matter.

The table 4.1 above shows the different standards applied to the selected laboratories. ISO 9001 applies to all 4 laboratories. In the documentation process, the procedure for ISO 9001 follows the general SOP for the company. At the same time, the work instruction is not specific to any laboratory activities. It is because it focuses on the quality management system. Three of the laboratories; Applied Chemical Laboratory, Analytical Biochemical Laboratory and Microbial Isolation and Screening Laboratory are research-based laboratories where they concentrate on project or contract-based research activities. The working instruction depends on the each research. For the record-keeping process, employees from these three laboratories have their own research notebook to note down related results and information regarding the research/ project they are working on. It is the researchers' responsibilities to record in the research notebook daily activities related to the research project including any reference journal. The research notebook will be verified by the project leader. At the end of each project, the research note book(s) need to be submitted to the office for record keeping. On the other hand, the Bacteriology Laboratory is involved in product testing activities.

As shown in the above table 4.1, one (Bacteriology Laboratory) out of four laboratories follows the ISO 17025 standard for their product testing activities. The procedure for ISO 17025, follows the SOP for Quality Manual. The SOP describes who does what and when. Activities might be listed together with the positions responsible for the procedure. The work instruction for the Bacteriology Laboratory depends on the related testing method specific for each test. A work instruction describes how to complete a specific task. In the record-keeping process, the application of document forms depends on the Quality Manual and also the work instruction. Records are an important output of any procedure or work instruction. The benefits on following ISO 17025 is it can lessen

the knowledge discontinuity if the employees leave the lab. It can also assure that the laboratory is always in a systematically controlled (Karen et al. 2008)

The other related standard is OHSAS 18001, were applied to all four laboratories. However, the SOP for this standard is generally for the whole IBRC. This standard does not have any specific work instruction that is directly related to any laboratory research activities. Forms for documentation in OHSAS 18001 are according to the related safety matters. Benefit that can be gain by applying OHSAS 18001 are potential in reducing accidents, downtime and associated costs, public liability insurance costs and providing better management of health and safety risks for current and in future (Sampurna 2009).

The benefit can be seen during inspection in the selected laboratories in this study. It was found that each laboratory has their own WI according to the research, experimentation and/or laboratory activity involved. If there is any new laboratory activity involved, a new WI will be developed in order to comply with the activity. WI in IBRC laboratory helps the employees to understand their work better where it gives detailed instructions. WI also illustrates how to operate and handle instruments, apparatus and other equipment correctly (Sutton, 2010).

The details in WI standardise the process and provide step-by-step and how-to instructions that are especially important for testing-related laboratories. This will enable employees to perform the task in a consistent method. This will also allow employees to perform the task without request for directions, reassurance, or guidance. WIs helps in minimising the chances for miscommunication. On the other hand, a standard WIs assist this organisation to maintain their quality control and quality assurance processes especially in complying with ISO 17025.

In this study area, WIs were located in a file and placed in a cabinet where it is accessible to all employees for reference in the workplace or specific laboratory. When a new employee is positioned in a specific laboratory, the laboratory manager or any other competent person will briefly explain the WIs involved in the upcoming work that the person will be involved in. Other than that, every employee will normally keep their related WIs in their research notebook for their reference.

4.1.2. Safety Precaution in Material Safety Data Sheets (MSDS)

Material Safety Data Sheets (MSDS) are another important material in a laboratory process or its activities. In this study, by using the chemical list in each laboratory, an MSDS is given to each laboratory. Whenever a chemical is purchased from a supplier, it acts like a contract that the supplier will provide the chemical together with its MSDS, hardcopy or softcopy. It was placed in a file/shelve where can easily be found by all employees for their references. Whenever there is a new experiment, research and/ or activity done in the laboratory, the laboratory manager has the responsibility to update the MSDS file according to the needs.

MSDS provides employees with all the necessary information needed to ensure employees use a product correctly. An MSDS gives information to employees on ways how to protect themselves from the hazards of the product. The information included in MSDS contains safe handling and storage procedures, what to do in the case of an emergency or fire, and related the personal protective equipment (PPE) that should be worn while handling the product. These may be used to describe the hazards that a chemical may present; list precautions to be taken when handling, storing or using the

substances; and outline emergency and first-aid procedures. Furthermore, it states general knowledge regarding the product, including the colour, physical state, or flashpoint, which will help ensure a safer work environment for those involved.

The fact that the MSDS is too lengthy and difficult to understand (Phillips et al, 1999), each laboratory has their own HIRARC, according to their activity or process. In each HIRARC, each chemical used will be provided with information such as, the risk and hazards of using the chemical (as in Appendix D). The HIRARC also provides information on how to control the risk and kinds of PPE needed to be used while handling the chemical. The HIRARC is usually be the main reference for employees because it is less lengthy and easier to understand compared to the MSDS. The HIRARC summarises the MSDS according to the lab activity or process.

Based on the survey given to the employees regarding MSDS as in Table 4.2, in the first statement of "MSDS sheets are on file and readily available", 89% of the respondents are in agreement (stating strongly agree and agree) with the statement. However, for the second statement in this category, "MSDS are easy to read, understand and not too lengthy," only 51% of the respondents agreed. As shown in the third statement, 80% of the respondents are in agreement and 6% of the respondents disagree with the statement of "A chemical inventory list is maintained and updated". 93% of the respondents agreed that "Lists of hazardous chemicals are available" in their organisation and 73% of the respondents agreed that there was "A hazardous waste (chemical/microbial) management policy set up" in their organisation. From the results, we can see that on the MSDS part in terms of understandable, half of the employees still struggling in understanding it. This finding is similar to Phillips et al, 1999 studies.

Table 4.2: Response Rate (In %) of the Subject Related To Standard Operating Procedures (SOP) and Material Safety Data Sheets (MSDS).

No	Statement/Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	MSDS sheets are on file and readily available.	-	-	11%	51%	38%
2	MSDS are easy to read, understand and not too lengthy.	-	-	49%	40%	11%
3	A chemical inventory list is maintained and updated.	-	6%	14%	58%	22%
4	Lists of hazardous chemicals are available.	-	-	8%	63%	29%
5	A hazardous waste (chemical/microbial) management policy is set up.	-	-	27%	57%	16%
6	SOPs are readily available and easily access by all employee.	-	-	19%	27%	54%

According to the United State of America's OSHA information, the MSDS must contend the:

i. Name of the chemical,
ii. Manufacturer's information,
iii. Hazardous ingredient/ identity information,
iv. Physical/ chemical characteristics,
v. Fire and explosion hazard data
vi. Precaution for safe handling and use, and
vii. Control measure.

The above information is usually prepared by the company that manufactured a certain chemical.

It is also important to ensure that all employees are able to use and understand the MSDS correctly. Moreover, employers may assume that by providing the MSDS to employees, it will allow them to understand the necessary information to protect them and meet the OSHA safety requirements (Phillips, 1999). Knowledge on the stability

of a product, especially under fire conditions, is able to help the fire fighters handle the emergency appropriately. Additionally, if someone accidentally inhaled or ingested a product, the medical personnel will be able to serve the patient correctly and quickly if they are aware of the data on the MSDS. The MSDS's availability for review will ensure that the critical information is available to the emergency responders who need it.

It is the responsibility of the employer to ensure that the MSDS is easily available to the employees and that they are knowledgeable as to their existence (EzineMark.com, 2010). Moreover, the employees must be informed on the hazards that they will be exposed to in the workplace while handling the substances.

There are two main advantages of having proper SOPs/WIs and also the MSDS in laboratories which include training documentation and audit preparedness.

i. Training documentation
    a. A newly-hired employee will need to be immediately trained in all the SOPs/WIs and MSDS concerned with documentation, laboratory hygiene and safety. Then the usage of WIs and MSDS will depend on their job function.

ii. Audit preparedness
    a. Having a complete and organised SOPs/WIs and MSDS system allows for easy analysis of audit compliance (Sutton, 2010). It is not the main reason for having those documents in the laboratory in particular, but it is certainly a useful benefit in the establishment of such systems.

However, based on the study, employees are actually aware of the existence of the MSDS, but they are not utilising it frequently, as much as they refer to WIs in their daily routine.

Figure 4.1: WIs and MSDS located where it is accessible to all employees for reference.

4.2 Awareness, Implementation and Practices of Occupational Safety, Health and Emergency Response Plans Practices among Employer and Employees.

The level of safety awareness can be from both employer and also employees. The employer is responsible for providing information, knowledge and also materials to ensure the safety of the employees. It is the responsibility of each employee to implement and practice occupational safety and health in the workplace.

4.2.1 General Work Environment

In the General Work Environment, a workplace inspection was carried out in four selected laboratories. The laboratories included the Applied Chemical Laboratory, the Analytical Biochemical Laboratory, the Microbial Isolation and Screening Laboratory and the Bacteriology Laboratory. The workplace inspection includes the observed activity around the selected laboratories.

Based on the results of workplace inspection (Appendix D), the working areas are illuminated in order to ensure the employees work in bright, clear and proper conditions. The illuminated exit signs are installed and alternate exits are available in most laboratories.

4.2.2 Information and Posting

Based on the observations done on the safety information and posting in all four laboratories in the study area, the requirements for safety information (as in Appendix D) were followed. This is except for the Microbial Isolation and Screening Laboratory, where the emergency numbers were posted on the entrance door, near the telephone. These safety information and postings (signs) must be easily recognisable, visually clear and require no explanation so that all who view them will be easily able to be comply with their warnings. They must be placed prominently and proximal to the dangerous areas (David H. Greenberg, 2012).

The Emergency Information and OSHA posters posted are accurate and current. The Building Evacuation Routes are posted and easily seen by all employees. Nevertheless, the importance of safety information and posting (signs) in the workplace can be neither overstressed nor underestimated.

Figure 4.2: Posters on the OSH and Quality Policy can also be used as a reminder to all employees regarding their quality and OSH policies.

Figure 4.3: The building evacuation plan is important to ensure all employees aware of their escape route in the case of an emergency.

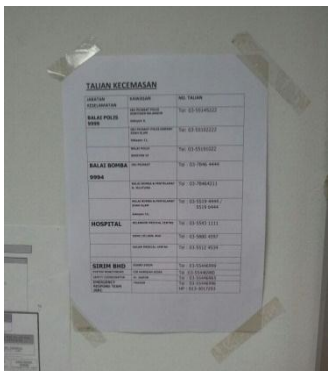

Figure 4.4: List of emergency numbers mounted near the telephone, which is important to make sure employees can easily make a phone call if there is an emergency.

4.2.3 Personal Protection Equipment

Based on the workplace inspection in this study, all four laboratories were provided with enough and appropriate PPE (as Appendix D). Protective gloves are available and matched to the hazards involved. Eye protection is also available and in use in laboratories. Respirators are provided when necessary, and selected on the basis of hazards present.

PPE including protective equipment for eyes, face, head, protective clothing, respiratory devices, and protective shields and barriers, shall be provided. It must be used, and maintained in a clean and reliable condition wherever it is necessary. It is important as hazards encountered may cause injury or harm in the function of any part of the body through absorption, inhalation or physical contact

In all laboratories, wearing open toe or/and heel shoes is prohibited. This is essential to prevent any slips or falls or any hazards while working in the laboratories. According to

the Iowa State University Laboratory Safety Manual, 2012, PPE appropriate for work condition at minimum must include:

i. laboratory coats (or other protective clothing such as apron, scrubs, coveralls),
ii. safety glasses or goggles,
iii. appropriate footwear (closed at the heel and toe).

4.2.4 Ventilation

According to OSHA 1994 (Use and Standards Exposure of Chemicals Hazardous to Health) Regulation 2000, subregulation 18(1), it is the responsibility of the employer to design, construct and commission of local exhaust ventilation equipment. A good ventilation system is important, especially in laboratories that involve chemicals. Based on the workplace inspection done in this study area (Appendix D), it shows that the fume hoods were certified within the last year. There are lines of yellow tapes to help employees indicate the length of 6 inches, as all work must done at least 6 inches inside the fume hood. Any experiments involving hazardous and toxic chemicals were prepared in the fume hoods.

The main functions of the fume hood are:

i. to protect the employees from inhaling toxic gases, include explosion protection, spill containment,
ii. to protect the product or experiment,
iii. to protect the environment.

In laboratories involving microbiological substances, a Class II Biological Safety Cabinet is used to perform the task. In this study area, in the Microbial Isolation & Screening and Bacteriology laboratory, the proper types of hoods were provided for different types of works being conducted. The types of hoods provided included the biological safety cabinet and laminar flow. All microbiological experiments were completed under these safety cabinets. The main purpose of a Biological Safety Cabinet is to provide protection to the laboratory worker, as well as the surrounding environment from pathogens. This is different to a laminar flow clean bench, which blows unfiltered exhaust air towards the user and is not safe for work with pathogenic agents. (Fume Hood and Biosafety Cabinets, University of California, 2014).

4.2.5 Types of Training

According to the National Research Council of The Nationals Academies, 2011, safety training should be seen as an important component of the laboratory safety programme within an organisation. The organisation should provide their employees with on-going safety activities or training that helps in promoting a safety culture in the workplace. Each employee should be self-assured to suggest or request training if they feel it would be useful.

In this study, in IBRC SIRIM Bhd, the company had given their employees enough training to improve the safety and health of their working environment. This action will lead to reduced hazards and accidents. Most of the training involved all employees; however, a few external training was participated by only some of the employees. **Table 4.3** shows the training programme in IBRC SIRIM Bhd.

Table 4.3: Training Programme in IBRC SIRIM Bhd.

NO.	COURSE TITLE	TARGET GROUPS
1.	Chemical Register Awareness.	All IBRC Staff.
2.	Safety Awareness.	New IBRC Staff (Permanent/ Contract/ temporary) including Practical Students.
2.1	Selection and Usage of Personal Protective Equipment.	
2.2	Safety in the Use of Chemical and Schedule Waste Handling.	
2.3	Handling of Biological Waste.	
2.4	Emergency Response Plan.	
3.	Evacuation Training.	All IBRC Staff.
4.	Schedule Waste Handling.	Two (2) Representatives.
5.	HIRADC.	All IBRC Staff.
6.	Permit to Work.	Two (2) Representatives.
7.	Application of OSH culture in the workplace.	Three (3) Representatives.
8.	Emergency Preparedness and Response.	One (1) Representative.
9.	Accident Investigation and Reporting Workshop.	ERP Team.
10.	USECHH Reg. 2000	All IBRC Staff.
11.	Safety in the Use of Chemical.	All IBRC Staff.
12.	Interpreting CHRA Report.	One (1) Representative.
13.	Selection and Usage of PPE.	All IBRC Staff.
14.	Routine Inspection.	Legal Team.
15.	Understanding and Implementing Environmental Management Systems and Procedure.	All IBRC Staff.
16.	Understanding and Implementing OSH Management Systems and Procedure.	All IBRC Staff.
17.	Understanding ISO 14001 requirements and internal auditing.	IBRC system monitoring.
18.	Understanding OHSAS 18001 requirements and internal auditing.	IBRC system monitoring.
19.	Safety Manual.	All IBRC Staff.
20.	Basic First Aid and Fire Fighting.	All IBRC Staff.

There were at least 20 lists of training programmes conducted by IBRC for their employees. During training, an employee is taught to be intentional about putting together an action plan that clarifies responsibilities and decide priorities. However, not all training programmes were attended by each and every employee, any programme would only be attended by two or even one employee. Training sessions were provided internally by professional and/ or competent trainers. During the training, hands-on scenario-based training was incorporated whenever possible, especially the in the Basic First Aid and Fire Fighting training.

After any external training attended, the representative should present the outcome, knowledge and/or input gained from the training attended to rest of the employees in the department. However, from the records, there are no productions of any formal presentations. They usually submit a report or copy of the notes given in the training for record keeping. The knowledge gained from the trainings is not being passed down to the rest of the employees. The training should be recorded and related documents must be maintained with organisational requirements (National Research Council of The Nationals Academies, 2011). It is useful to prepare an after action report for both exercises and actual emergencies. A formal assessment often is valuable information that can enhance the emergency response capability (Ashbrook, 2011).

Formal safety education for advanced laboratory personnel should be made as relevant to their work activities as possible. Training conducted simply to satisfy regulatory requirements may seem like compliance, and researchers may feel that the training does not have the leader's full support. Safety offices and researchers (employer and employees) can work together to deal with such concerns and to design training sessions that fulfil regulatory requirements, provide training as directly relevant to the researchers' work, and also provide hands-on experience with safety practices whenever possible.

Safety training is an on-going process, connected to the daily activities of laboratory personnel. As a new laboratory technique is formally taught or used, relevant safe practices should be included; however, informal training through interactions among colleagues is a good way to exchange safety information, provide guidance, and reinforce good work habits (National Research Council of The Nationals Academies, 2011). Newly-hired employees working in a specific laboratory should be required to

attend basic safety training as early as on their first day. Additional training should be provided to laboratory personnel as they move forward in their laboratory duties or when they are required to handle a chemical or use equipment for the first time.

4.2.6 Emergency Response Plan

A Laboratory Emergency Plan should be developed and implemented to protect personnel, equipment, and laboratory facilities at any time to prevent any emergency event from distracting the laboratory operations. Based on OHSAS 18001 requirements, a company shall establish, implement and maintain a procedure to identify the potential for emergency situations and to respond to such emergency situation.

In this study, IBRC SIRIM Bhd had conducted a few safety training as in table 4.3 for the employees. It includes training on the Emergency Response Plan and Emergency Preparedness and Response. The emergency numbers were located near each laboratory's telephone or door. These numbers including the nearest police station's number.

Building evacuation maps were located along the walkways, as well as in the laboratory so that it can easily seen by the employees (as in picture 4.5 below). It is the responsibility of each employee to identify the location of assembly points. In case of an emergency, essential employees would be expected to report to that assembly point whether or not they have received specific instructions.

Figure 4.5: Evacuation maps located at places where it can be easily seen by all.

Fire extinguishers are mounted near the doorways or escape route and away from the heating elements of each laboratory. All fire extinguishers were fully charged and inspected regularly. The locations of fire extinguishers were not obstructed. These situations mean the fire extinguishers can be easily seen by the employee and used in case of a fire emergency. A portable fire extinguisher can save lives and property. It works by putting out a small fire or controlling it until the fire department arrives. It is also the employees' responsibility to be aware of the location of fire extinguishers in each laboratory they are working in.

Figure 4.6: Fire extinguisher and evacuation map were mounted near doorways and inspected regularly. It is readily available in case of an emergency fire.

Eyewash and safety showers are available in all related laboratories and are not unobstructed. According from the result of workplace inspection, water pressure/flow

for eyewash in the Bacteriology Laboratory is low. This situation might cause some problems if any emergency happens. Similar to fire extinguishers, eyewash and safety showers are maintained and service according to its schedule. Details on the emergency response plan are as in Appendix D. These comply with the OHSAS 18001. where it says that emergency response equipment should be available in sufficient quantity and stored in a location where it is readily accessible, stored securely, protected from being damaged and should be tested regularly.

Basically, all employees have attended laboratory safety training and laboratory orientation. Along the years, the Emergency Preparedness and Response Team will conduct a Fire Drill Training where it requires all employees to evacuate the building. In the Fire Drill Training, employees will be aware of the emergency signal, how to respond and what should be done in case of emergency. Fire Drill Training usually involved officers from BOMBA which will give some briefing to the employees regarding emergency and fire. Employees also have an opportunity to learn hands-on techniques on how to use the fire extinguisher correctly. These actions fulfil the OHSAS 18001 requirement of the organisational responsibility to periodically test its procedures to respond to emergency situations, where practically involving relevant interested parties as appropriate. The Emergency Preparedness and Response procedure is applicable to all employees including other personnel's including clients, subcontractors, vendors, suppliers, maintenance contractors, cleaners and other visitors.

Although most laboratory personnel are prepared to handle incidental spills or minor chemical exposures, several other types of emergencies can affect a laboratory. Some may have long-term consequences and might severely affect the stability of the laboratory operation system. Regarding these issues, laboratory personnel should be

trained in how to respond to large-scale emergencies. Laboratory personnel can play a role in reducing the likelihood of some hazards that may lead to any emergencies and assisting in preparation and response for others.

According to Stony Brook University Laboratory Safety's 2013, the emergency plan should include the following information:

i. Emergency contact information
    a. Include the names and numbers of personnel in the laboratory. Make sure that main contact information is properly posted on laboratory doors. Establish a phone chain to relay information to all laboratory employees.

ii. Hazard information
    a. Include information on the types of hazardous materials and/or operations that take place in the laboratory, including specific information for emergency response employees.

iii. Safety equipment
    a. Ensure that all laboratory employees are familiar with the location and usage of safety equipment, including eye washes, safety showers, fire extinguishers, and chemical spill kits.

iv. Emergency notification
    a. Ensure that all lab employees know how to respond to emergencies, including fire alarm and emergency evacuation.

v. Laboratory shutdown procedures
    a. Make sure that laboratory employees are aware of procedures for safety materials and experiments during emergencies.

There are four major stages in managing any emergency which includes mitigation, preparedness, response, and recovery (National Research Council of The Nationals Academies, 2011):

i. Mitigation
    a. Efforts to reduce the likelihood that an incident will occur and to limit the effects of an incident that does occur. This stage will include the safety of materials stored to a good sprinkler system.

ii. Preparedness
    a. Processes of developing plans to manage any emergency and taking action to ensure that the laboratory is prepared in case of any emergency. This stage will include from ensuring that enough supplies are available to making sure all personnel are well trained.

iii. Response
    a. To manage the emergency as it occurs. It is more effective and efficient when those involved in any emergencies understand their roles, are well trained as to when perform their duties, and have the supplies needed.

iv. Recovery
    a. Include the possible activities taken to restore the laboratory and affected areas to point where the functions of the laboratory can be carried out safely. Usually, it restores the laboratory to its previous conditions: on the other hand, this stage provides an opportunity for improvement to the laboratory system.

The four stages in managing emergencies are interconnected. Effective mitigation helps in reducing the impact of the emergency and facilitates the response and the recovery

stages. The entire lesson learned during an emergency may lead to further mitigation and preparedness effort during recovery phase. Good planning in the preparedness stage eases the response and recovery stage. However, a plan is only offered guidance and helps prepare for emergencies.

4.3 Evaluation of Risk and Safety Practices Including the Emergency Response Plans.

Every employer is responsible for providing information and knowledge regarding occupational safety and health in the workplace. Employees are responsible to implement and practice the elements of occupational safety and health in the workplace. However, occupational safety and health concerns do not end at this point; it is the duty of both employers and employees to ensure that occupational safety and health in the workplace is being practiced well, according to the target. Evaluation for this study was done by interviewing and distributing questionnaire.

4.3.1 Safety Information, Posting and Policy

Based on the observations done on the safety information and posting in all four laboratories in the study area, the requirement for the safety information (as in the Appendix D) were followed. These safety information and posting (signs) must be easily recognisable, visually clear and require no explanation so that all who view them will be easily able to be compliant with their warnings. They must be placed prominently and proximal to the dangerous areas (David H. Greenberg, 2012).

This also agreed with employees (answer from the questionnaire as an Appendix E). The surveys were sent out to 40 laboratory employees in the study area. A total of 37 survey responses (92.5% rate of return) had been received. 81% of the respondents are in agreement (strongly agree and agree) with the statement that "A written safety policy is available and explained to all employees and signed by them". In the second statement, which is "There is a safety manual available to employee", 81% of the respondents have an agreement (strongly agree and agree) with the statement while 3% of them disagreed. The third statement in this category touches about the "Routine laboratory inspections are mandatory" where 97% of the respondents agreed (strongly agree and agree) with the statement. 70% of the respondents agreed (strongly agree and agree) of "The OSHA Laboratory Standard has been explained".

Table 4.4: Response Rate (In %) of the Subject Related to Safety Policy in the Organization.

No	Statement/Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	A written safety policy is available and explained to all employees and signed by them.	-	-	19%	51%	30%
2	There is a safety manual available to employee.	-	3%	16%	73%	8%
3	Routine laboratory ins pections are mandatory.	-	-	3%	78%	19%
4	Safety workshops to update safety programs are introduced to all employees.	-	-	19%	70%	11%
5	The OSHA Laboratory Standard has been explained.	-	-	30%	57%	13%
6	Accident reports are maintained.	-	-	43%	46%	11%

Supports from both observation and survey prove that the organisation has constantly educated and extended information regarding occupational, safety and health at the workplace through its Safety Information, Posting and Policy.

4.3.2 Availability of Laboratory Safety Equipment

Laboratory safety equipment includes PPE, eyewash, safety shower, safety cabinets, fume hood, chemical spill kit and laboratory coats. Based on the workplace inspection in this study, all four laboratories are provided with enough and appropriate PPE (as in Appendix D). Protective gloves are available and matched to the hazards involved. Eye protection is also available and in use in laboratories. Respirators are provided when necessary, and selected on the basis of hazard present.

All related laboratories are equipped with emergency showers and also eyewashes. However, in the Bacteriology laboratory, there was no emergency shower installed. It is because this laboratory does not involve itself with any hazardous chemical in the laboratory process. Nevertheless, water pressure/flow for the eyewash in the Bacteriology Laboratory is low, which might cause some problems if any emergencies happen. Both emergency shower and eyewash in all laboratories were inspected regularly. According to UCLA Laboratory Safety Manual (2011), all laboratories using hazardous chemicals must have immediate access to safety showers and eyewash stations with access within in 10 seconds or less for a potentially injured individual.

In the workplace inspection, laboratory coats are available and use in laboratories. Laboratory coats are only worn in the laboratory and are removed before entering offices, restrooms, conference/meeting rooms and other non-laboratory general use area. However, there are a small number of employees does not follow these rules. Dirty laboratory coats are stored in a covered container until removed for laundry. Laboratory coats used for microbial activities are autoclaved before being sent for laundry.

Based on the survey done to the employees (results as in **Table 4.5**), 97% of the respondents agreed that "An appropriate eyewash station is in working order and inspected on a regular basis". At the same time, 100% of the respondents agreed (strongly agree and agree) that "There is a safety shower in the laboratory and it is inspected on a regular basis". 97% of the respondents agreed that "Laboratory employees are required to wear chemical splash goggles/ face mask". 100% of the respondents agreed that "Availability of fire extinguishers in the laboratory". 95% of the respondents agreed that "An enclosed fume hood/safety cabinet is available in the laboratory and inspected on a regular basis". 76% of the respondents agreed that "Chemical spill kits are available in the laboratory and inspected on a regular basis". 95% of the respondents agreed that "Fire alarm procedures are posted and exits marked".

Table 4.5: Response Rate (In %) of the Subject Related to Availability of Laboratory Safety Equipment**.**

No	Statement/Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	An appropriate eyewash station is in working order and inspected on a regular basis.	-	-	3%	48%	49%
2	There is a safety shower in the laboratory and it is inspected on a regular basis.	-	-		49%	51%
3	Laboratory employees are required to wear chemical splash goggles/ face mask.	-	-	3%	48%	49%
4	Availability of fire extinguishers in the laboratory.	-	-		46%	54%
5	I have been trained and certified in first-aid and CPR.	-	27%	41%	27%	5%
6	An enclosed fume hood/safety cabinet is available in the laboratory and inspected on a regular basis.	-	-	5%	57%	38%
7	Chemical spill kits are available in the laboratory and inspected on a regular basis.	-	5%	19%	57%	19%

No	Statement/Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
8	Fire alarm procedures are posted and exits marked.	-	-	5%	55%	40%
9	Broken glass disposal boxes are available in the laboratory.	-	-		49%	51%
10	There is separate ventilation system for laboratory with other room.	-	-	22%	65%	13%

As per record, this organisation has provided enough and reliable safety equipment to all employees depending on their working environment needs.

4.3.3 Safety Training

In this study, in IBRC SIRIM Bhd, the company had given their employees enough training to improve the safety and health of the working environment. This action also will lead in reducing hazards and accident. Most of the training involving all employees however a few external training only participated by some of the employees. **Table 4.3** shows the training programme in IBRC SIRIM Bhd.

In support of Safety Training, from the survey given to employees, 97% of the respondents have received various type safety training whereas only 3% of the respondents claim they have not received any safety training. While, 81% of the respondents agreed that "Safety workshops to update safety programmes are introduced to all employees". However, only 32% of the respondents agreed that they were trained and certified in first-aid and CPR.

4.3.4 Electrical Hazard

Electrical hazards in the laboratory may not seem like a problem, as it usually does not involve high voltage. However, both employers and employees need to put some effort to look at this matter before it could lead to any greater problem. In this study, the main concern is that none of the switches and electrical outlets has a cover plate. Other than that, the usage of extension cords in laboratories is not a good idea. It can lead to greater electrical hazards. Extension cords may also lead to the risk of slips, trips or falls in the laboratories. Cover plates are a great safety measure to avoid the exposure of electrical wiring and to keep fingers from getting into contact with energised parts.

These safety tips can help keep cords in good condition for safe operation according to The Canadian Center for Occupational Safety (2010):

i. Cords should be firmly plugged into outlets.
ii. Do not make modifications to a cord's plug at any time - do not clip off the third prong or attempt to file down a wider prong to fit into a different outlet.
iii. Extension cords are a temporary solution only, and their use should be minimised whenever possible.
iv. Use the proper weight and length of extension cord for the appropriate task, and be sure the cord is rated for indoor or outdoor use, whichever is required.
v. When unplugging a cord, pull on the cord at the outlet rather than tug on the cord itself.

Every cord has to plug into an appropriate electrical outlet, these electrical safety tips to keep outlets safe:

i. Do not overload outlets with multiple adaptors or power strips; relocate cords instead.
ii. Never put any object other than the appropriate size plug into an outlet.
iii. Keep all outlets properly covered with secure plates that cover all wiring

4.3.5 Chemical and Microbial Storage

Chemical and Microbial storage are one of important things in ensuring safety in laboratory. Science Lab.com (2005) suggested that chemical storage in laboratory should follow OSHA specification where:

i. Chemicals must be stored at an appropriate temperature and humidity level and not stored near heat sources or in direct sunlight.
ii. Chemicals should be dated when received and opened including the expiring date.
iii. Chemicals should not be stored on the bench work. Each chemical should have a specific storage area and be returned there after use.
iv. Large quantities of flammable materials should not be stored in the laboratory. Only the amounts needed should be kept in the laboratory.
v. Liquid or corrosive chemicals should never be stored on shelves above eye-level.
vi. Glass containers should not touch each other on the shelves. Secondary containers should be used for chemical storage whenever possible to minimise the flow of material should a spill.

vii. Adequate security must be provided so that unauthorised personnel do not have access to hazardous materials.

viii. Chemicals must never be stored on the floor, not even temporarily.

ix. Chemicals that are no longer to be used for research purposes should be properly disposed of or given to another research group that has a use for it.

x. All containers stored in the refrigerator must be properly labelled.

xi. Fume hoods should not be used as general storage areas for chemicals. This can weaken the ventilation system of the hood.

Based on the workplace inspection in all four laboratories, chemical storage in the laboratory is minimised as much as possible. The cabinets for storage of chemicals in each laboratory are clearly labelled. Chemicals bottles/ containers are clearly labelled with the chemical name(s) and kept closed at all times except during transfers. However, chemicals are stored according to alphabetical order not based on its hazardness level. Highly toxic and corrosive chemical are only allowed to be stored in a chemical store, which is safer both employees and the environment.

Table 4.6: Response Rate (In %) of the Subject Related to Chemical /Microbial Storage.

No	Statement/Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	A stockroom to store chemicals is available at my organization.	-	-	5%	33%	62%
2	Chemicals are stored so as to separate incompatible chemicals	-	-	11%	65%	24%
3	The stockroom is locked and not generally available to non-competent employee.	-	3%	8%	27%	62%
4	A proper place/ separate freezer/chillers are available for microbial storage.	-	-	5%	57%	38%
5	Microbial are stored so as to separate according to their type.	-	-	19%	54%	27%
6	The stockroom is tightly closed to avoid any inside/ outside contamination.	-	-	11%	40%	49%

In the survey given to the employees (refer **Table 4.6**), 95% of the respondents are in agreement (strongly agree and agree) with the statement that "A stockroom to store chemicals is available at my organization". While only 89% of the respondents agreed that "Chemicals are stored so as to separate incompatible chemicals". 89% of the respondents agreed that "The stockroom is locked and not generally available to non-competent employee". 95% of the respondents are in agreement (strongly agree and agree) with the statement that "A proper place/ separate freezer/chillers are available for microbial storage". However, out of 37 respondents, only 81% of them agreed that "Microbial are stored so as to separate according to their type". 89% of the respondents agreed that "The stockroom is tightly closed to avoid any inside/ outside contamination".

Figure 4.7: Minimum chemical storage in the laboratory, the chemical cupboards were kept closed at all times.

Figure 4.8: Limited chemical storage in the fume hood.

Storage is strictly limited in actively used fume hoods, only chemicals that relate to the research or the on-going experiment were allowed in the fume hood. One laboratory out of four which is the Bacteriology Laboratory can be assumed less toxic due to fewer flammable chemical in it because this laboratory does not involve with any high toxic chemical where only microbiological media are involved in the process. Most of the chemicals are kept in the chemical store, where only competent person can enter the storage room.

4.3.6 Chemical and Microbial Waste Handling

In this study, chemical and microbial waste is one of the critical safety issues that needed to be looked at. In this study area, containers of hazardous wastes are labelled properly with the date and name of person/or projects involve discarding the chemical waste. Biological wastes are appropriately marked with a biohazard symbol. All used syringes and other sharp waste are disposed into a sharps container and placed directly into a biohazard waste container. There are also separate containers for broken glass from other waste. Waste containers are appropriately tagged before being placed in the waste room. In the Microbial Isolation and Screening, as well as the Bacteriology laboratory, all working surfaces were cleaned with a disinfectant solution before and after every experiment/ research work completed. This is important to maintain a sterilised environment. There is some problem where, sometime employees tend to pour unwanted/ unused media agar or broth in the sink or drain system. This action could lead to some problem including clogging of the drainage system.

According to US EPA, Office of Resource Conservation and Recovery, 2012, to increase laboratory safety especially on waste management in the laboratory, there are a

few steps that can follow by both employers and employees in their daily laboratory routines are as follows:

i. Requiring hazardous waste determinations to be made by trained employees.
ii. Requires training for all laboratory workers.
iii. Laboratory clean-out incentives promote reduction of stockpiles of potentially dangerous old chemicals and waste stored in laboratories.
iv. Time-driven removals ensure hazardous waste is removed from laboratories on a regular basis.
v. Required Laboratory Management Plan ensures safer laboratory practices and increased awareness of hazardous waste management.

From the results of the surveys, out of 37 respondents, only 65% of them in an agreement (strongly agree and agree) with the statement "No liquid waste is disposed of in the sinks or the sewer". 84% of the respondents agreed that "Waste streams are separated as necessary: ex. Solid vs. liquid, hazardous vs. non-hazardous, halogenated, non-halogenated, etc." 92% of the respondents agreed to both statement "Waste containers are appropriately tagged before placing in waste room" and "Containers of hazardous waste are labelled properly with the date and name of person discarding waste". 92% of the total respondents agreed that "Biological waste is appropriately marked with a biohazard symbol". 87% of the respondents agreed that "Syringes and other sharp waste are disposed of into a sharps container and placed directly into biohazard waste container". However, no more than 62% of the respondents agreed that "Each waste has its own duration period of storage both in laboratory and waste storage area".

Table 4.7: Response Rate (%): Chemical / Microbial Waste Disposal.

No	Statement/Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	No liquid waste is disposed off in the sinks or the sewer.	-	-	35%	57%	8%
2	Waste streams are separated as necessary: ex. Solid vs. liquid, hazardous vs. non-hazardous, halogenated, non-halogenated, etc.	-	-	16%	62%	22%
3	Waste containers are appropriately tagged before placing in waste room.	-	-	8%	41%	51%
4	Containers of hazardous waste are labelled properly with the date and name of person discarding waste.	-	-	8%	46%	46%
5	Biological waste is appropriately marked with a biohazard symbol.	-	-	8%	39%	54%
6	Syringes and other sharp waste are disposed of into a sharps container and placed directly into biohazard waste container.	-	-	13%	45%	42%
7.	Each waste has its own duration period for storage both in laboratory and waste storage area.	-	9%	29%	53%	9%

Figure 4.9: Separate waste container for broken glassware.

Figure 4.10: Chemical and biological wastes were clearly tagged and marked before being removed to waste the room.

4.3.7 Ventilation

A good ventilation system is essential particularly in laboratory that involves chemicals. According to OSHA 1994 (Use and Standards Exposure of Chemicals Hazardous to Health) Regulation 2000, subregulation 18(1), it is the responsibility of the employer to design, construct and commission of local exhaust ventilation equipment. In this study area, the organisation has already separated the ventilation system for chemical activities and also microbial activities.

Fume hoods in the selected laboratories are certified within the last year. Storage inside of the hood is kept to a minimum. Any equipment that needs to be used in the fume hood does not interfere with the accurate functioning of the hood. However, some bad examples were shown in Figure 4.11 where some equipment was placed in the fume hood. All work done in the fume hood was at least 6 inches inside hood and there were yellow line tapes to indicate the length. Any experiments involving hazardous and toxic chemicals were prepared in the fume hoods.

In laboratories that involved with microbiological substances, a Biological Safety Cabinet Class II is used. In this study area, namely the Microbial Isolation & Screening and Bacteriology laboratory, the proper type of hoods were provided for different types of work being conducted. Type of hoods provided included a biological safety cabinet and laminar flow. All microbiological experiments are completed under these safety cabinets (as shown in Figure 4.11 below). The main purpose of a Biological Safety Cabinet is to provide protection the laboratory worker as well as the surrounding environment from pathogens. This is different to a laminar flow clean bench, which

blows unfiltered exhaust air towards the user and is not safe for work with pathogenic agents.

Figure 4.11: The picture on the left is a fume hood and is an example of the proper usage of a fume hood, where all the research material was kept within the limit and minimum chemicals are stored in the hood. The picture on the right is of a fume hood that shows a bad example, where more than the minimum number of chemical are stored and it is not well sanitised.

Figure 4.12: The flame burner was kept at a safe distance both from the employee and also the samples in a safety cabinet.

4.3.8 Emergency Response Plan (ERP)

According to Section 15 of OSHA 1994, "It shall be the duty of every employer and self- employed person to ensure; so far as is practicable, the safety, health and welfare

at work of all his employees". The availability of safety equipment in laboratories and safety training are also part of the ERP. Based on the workplace inspection done in the study area, all 4 laboratories are equipped with a fire extinguisher. Fire extinguishers are mounted near the doorways and are not obstructed. These fire extinguishers are also inspected and fully charged according to OSHA requirements. First aid kits are available in each laboratory. They can be easily seen by the employee and used in case of fire emergency. Spill control materials are available and adequate to cover anticipated spills. But, the spill control material is only available in the PPE storage cabinet not in each laboratory. However, employees are aware of the availability of the spill control kit.

Emergency numbers are posted near the telephones in each laboratory, except the Microbial Isolation and Screening Laboratory were the emergency numbers are posted on the entrance door. Building evacuation routes are available in each laboratory as well as the walkways.

Table 4.8: Response Rate (In %) of the Subject Related to Emergency Response Plans.

No	Statement/Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	Emergency number known by all employees.	-	3%	8%	54%	35%
2	Safety equipment and PPE is available and accessible.	-		3%	40%	57%
3	Have you ever experience any fire drill in your organization?	-	3%	8%	32%	57%
4	There are emergency response team in the organization.	-	-	11%	65%	24%
5	Everyone is aware of roles, responsibilities and authority of individuals during an emergency.	-	-	52%	43%	5%
6	The first-aid facilities is complete and at a strategic location.	-	-	5%	57%	38%
7	Procedures for cleaning up and disposal of waste are available and aware by all employees (chemical and microbiological waste).	-	-	19%	62%	19%

Based on the survey given to the employees (**Table 4.8**), in the first statement of "Emergency number known by all employees", only 89% of the respondents in the agreement state (strongly agree and agree) with the statement, 3% disagree and the rest of 8% in their natural state. 97% of the respondents agreed that "Safety equipment and PPE is available and accessible" in their organisation. Out of the 37 respondents, 89% of them have an experience any fire grill in the organisation. 89% of the respondents agreed that "There are emergency response team in the organisation". Only 48% of the respondents agreed that "Everyone is aware of roles, responsibilities and authority of individuals during an emergency". 95% of the respondents agreed that "The first-aid facilities is complete and at a strategic location". While only 81% of the respondents agreed that "Procedures for cleaning up and disposal of waste are available and aware by all employees (chemical and microbiological waste)".

Figure 4.13: A complete First Aid Kit was mounted near a laboratory doorway where it can be easily seen and used in case of emergency.

Figure 4.14: A building evacuation plan is important to ensure all employees aware of their escape route in case of emergency.

Figure 4.15: Fire extinguishers were mounted near doorways and inspected regularly. These are readily available in case of emergency fires

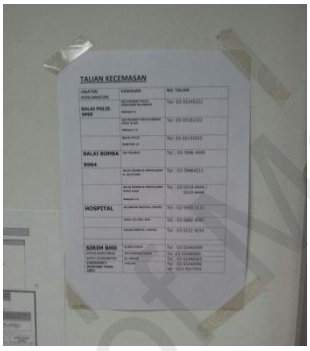

Figure 4.16: The list of emergency numbers is mounted near the telephone. It is important to make sure employees can easily make a phone call if there is an emergency.

According to Institutional Biosafety Committee of University of Malaya, an emergency response plan shall provide:

1. safety measures and procedures for the protection of human, plant and animal health, the environment and biological diversity against harm or damage caused directly or indirectly by living modified organisms or products of such organisms; and
2. all necessary measures to be taken in the event of an emergency

Based on the evaluation and the results, most of the employees are aware with the risk and safety practices in IBRC laboratories. IBRC has tried their best in providing and ensuring the safety of their stuff by abiding to the safety requirement. Hence, the safety can only be achieved by participation from both, employer and the employee.

4.4 Hazard Identification, Risk Assessment and Risk Control (HIRARC)

HIRARC is an integration tool used to identify, assess/measure and to control hazard and risk of any workplace and its activities. By implementing HIRARC in workplace, it will eliminate, reduce/control the possibility for any accidents to occur.

In this study, HIRARC was put into practice in each laboratory in order to identify the risk which then can lead to minimizing the accident to occur.

4.4.1 Chemical Laboratory 1

Diagram 4.1: The Applied Chemical Laboratory Process Flow in IBRC

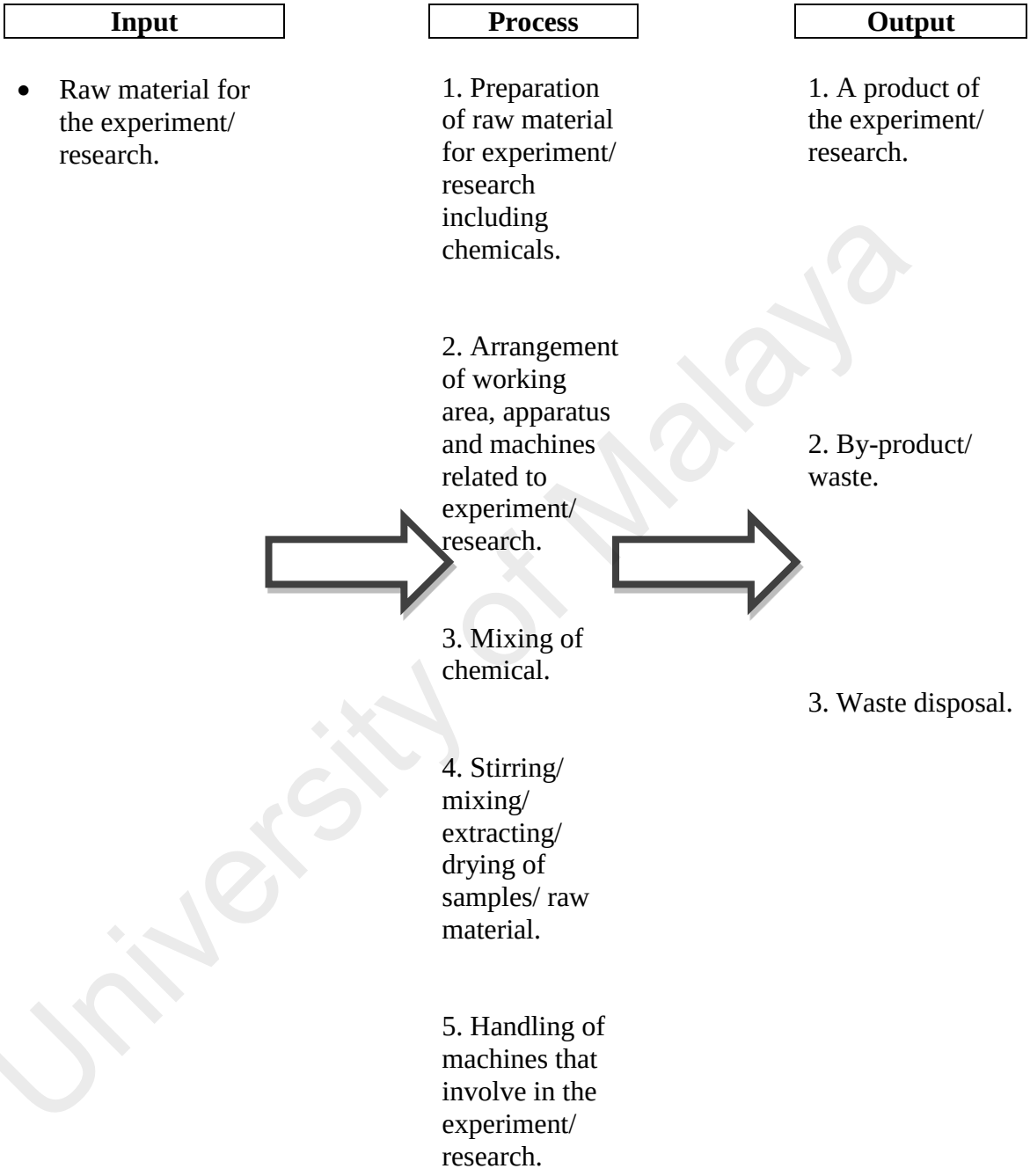

Table 4.9: The HIRARC for Chemical Laboratory 1: Applied Chemical Laboratory

Hazard Identification				Existing Risk Control	Risk Assessment			Control Measure
No	**Work Activity**	**Hazard**	**Risk**		**Likelihood**	**Severity**	**Risk Ranking**	**Recommended control measure**
1.0	Working with (broken) thermometer.	-Exposure to mercury spillage due to broken thermometer.	-At low levels of exposure - symptoms are mainly related to nerve and other stress-like symptoms. - Short-term contact with high levels of mercury can cause immediate health effects including loss of appetite, fatigue, insomnia, and changes in behaviour or personality. - Depends on the length or degree of exposure, other symptoms such as nausea, abdominal cramps, diarrhoea, eye irritation, weight loss, skin rashes, and muscle tremors may occur.	-To avoid the spillage spreading out, collect mercury into balls. Sprinkle sulphur onto the mercury spillage or use mercury spill kit.	2	3	6	Safe work practice by qualified personnel. Keep a thermometer after use and away from heat source. Do not use a thermometer if not in good condition. Always wear the proper PPE including goggles, gloves, proper shoes and laboratory coat whenever going any experiment in the laboratory.

Hazard Identification				Existing Risk Control	Risk Assessment			Control Measure
No	**Work Activity**	**Hazard**	**Risk**		**Likelihood**	**Severity**	**Risk Ranking**	**Recommended control measure**
2.0 2.1	Activities involve: stirring, mixing, heating solution/media, extraction using SFE machine/soxhlet **Common chemicals are:** Acetic acid	- Splashes and spillage. - Inhalation of vapour, gases or particles.	- Corrosive liquid. Cause severe burns to all body tissues. - Harmful if inhaled. -Flammable liquid and vapour.	-Use chemical with caution, read labels carefully. -Use PPE. -Use fume hood when preparing chemicals.	2	2	4	- Wear PPE which includes goggles, laboratory coat, glove, proper close shoe and respiratory protection. - Work under fume hood. - Always follow work instructions. -Refer MSDS especially when handling unfamiliar chemicals.
2.2	Chloro Acetic Acid	- Inhalation of vapour gases or particles.	- Cause severe burn, irritation, inflammations.	-Use chemical with caution, read labels carefully. -Use PPE. -Use fume hood when preparing chemicals.	2	2	4	-Wear protective clothing including glove, goggles, boots, and respiratory protection. -Work under fume hood. - Always follow work instructions. -Refer MSDS especially when handling unfamiliar chemicals.

Hazard Identification				Existing Risk Control	Risk Assessment			Control Measure
No	**Work Activity**	**Hazard**	**Risk**		**Likelihood**	**Severity**	**Risk Ranking**	**Recommended control measure**
2.3	DMSO - Dimethyl sulfoxide	- Splashes and spillage. - Inhalation of vapour, gases or particles. -Contact with or being absorbed through the body.	- May cause eye, skin, and respiratory tract irritation. -May cause mild lung irritant and respiratory tract irritation. -Slightly hazardous to skin (irritant, permeator), -Mild irritant to eye.	-Use chemical with caution, read labels carefully. -Use PPE. -Use fume hood when preparing chemicals.	2	2	4	- Wear protective clothing including glove, goggles, boots, and respiratory protection. -Work under the hood. -Remove all sources of ignition. - Always follow work instructions. -Refer MSDS especially when handling unfamiliar chemicals.
2.4	Glycolic acid	- Splashes and spillage. - Inhalation of vapour, gases or particles. -Contact with or being absorbed through the body.	- Harmful if swallowed or inhaled. - Cause severe irritation and burns to every area of contact. -May cause eye, skin and respiratory tract irritation.	-Use chemical with caution, read labels carefully. -Use PPE. -Use fume hood when preparing chemicals.	2	2	4	-Wear protective clothing including glove, goggles, respiratory protection. -Work under fume hood. - Always follow work instructions. -Refer MSDS especially when handling unfamiliar chemicals.

Hazard Identification				Existing Risk Control	Risk Assessment			Control Measure
No	**Work Activity**	**Hazard**	**Risk**		**Likelihood**	**Severity**	**Risk Ranking**	**Recommended control measure**
2.5	Isopropanol	- Splashes and spillage. - Inhalation of vapour, gases or particles, fire and explosion.	Highly flammable, irritating to eyes and skins. -Vapours may cause drowsiness and dizziness.	-Use chemical with caution, read labels carefully. -Use PPE. -Use fume hood when preparing chemicals. - Remove all sources of ignition.	2	2	4	- Wear protective clothing including glove, goggles, boots, and respiratory protection. -Take measures to prevent electrostatic charging, keep away from sources of ignition. - Always follow work instructions. -Refer MSDS especially when handling unfamiliar chemicals.

Hazard Identification				Existing Risk Control	Risk Assessment			Control Measure
No	**Work Activity**	**Hazard**	**Risk**		**Likelihood**	**Severity**	**Risk Ranking**	**Recommended control measure**
2.6	Methanol and Ethanol.	- Splashes and spillage. - Inhalation of vapour, gases /particles. - Manual handling repetitive work. -Fire and explosion.	- Flammable liquid and vapour. -May cause eye, skin, and respiratory tract irritation. -Inhalation of high concentrations may cause nausea, dizziness, unconsciousness, headache and coma.	-Use chemical with caution, read labels carefully. -Use PPE. -Use fume hood when preparing chemicals. -Remove all sources of ignition.	2	2	4	-Wear protective clothing including glove, goggles, boots, and respiratory protection. -Work under the hood. - Always follow work instructions. -Refer MSDS especially when handling unfamiliar chemicals.
3.0	Stirring/ mixing/ heating the solution/ media.	-Skin contact with the hot plate during heating of the raw material. -Spillage of hot solution, broken glassware as stirring blade might fall into the mixing beaker.	-Minor skin burns. -Minor Cuts	-Wear proper PPE. -Work with caution. -Wear proper PPE. -Work with caution. -Wear proper PPE.	1 1	2 1	2 1	-Wear proper PPE complete with goggle, laboratory coat, gloves and proper close shoes. -Follow working instruction. - Wear proper PPE including suitable gloves.

Hazard Identification				Existing Risk Control	Risk Assessment			Control Measure
No	**Work Activity**	**Hazard**	**Risk**		**Likelihood**	**Severity**	**Risk Ranking**	**Recommended control measure**
		-Broken pH probe during pH measurement.	-Slippery floor. -Minor Cuts.	-Work with caution. -Wear proper PPE.	2	1	2	- Wipes and clean the area immediately after occurrence.
		- Spillage of product solution during transfer from the container to another flask or cells.	-Slippery floor cause slip and fall.	-Work with caution.	1	1	1	-Wear proper PPE. - Follow working instruction. -Wipe and clean the area immediately after occurrence. -Always wear proper shoes while working in the laboratory. - Always follow work instruction including instruction to operate machines.

Hazard Identification				Existing Risk Control	Risk Assessment			Control Measure
No	**Work Activity**	**Hazard**	**Risk**		**Likelihood**	**Severity**	**Risk Ranking**	**Recommended control measure**
4.0	Handling of liquid nitrogen while filling into another tank or flask.	-Direct contact due to Liquid Nitrogen splashes. -Liquid Nitrogen boiling off during routine use.	Frostbite and burning skin. - Asphyxiation. (A condition where lacking supply of oxygen to the body that happen from being unable to breathe normally)	-Proper use of PPE including laboratory coat, suitable gloves, face shield and goggles. -Always handle liquid nitrogen with dry hands. -When dispensing liquid nitrogen, ensure that there is proper regular ventilation to remove excess nitrogen.	3 2	1 2	3 4	- Always practice good discipline in using the PPE. -Safe dispensing gadget should always be available. -Follow the proper work instruction. - Done by a competent person.
5.0	- Rotary evaporator/ freeze drying.	-Pressure explosion. -Spillage of liquid nitrogen.	-Injuries due to explode. - Injuries (frozen bites).	-Follow work instruction procedures and training including instruction to operate machines. - Wear PPE	1 2	2 1	2 2	- Wear suitable glove for handling liquid nitrogen and wear goggle.

Hazard Identification				Existing Risk Control	Risk Assessment			Control Measure
No	**Work Activity**	**Hazard**	**Risk**		**Likelihood**	**Severity**	**Risk Ranking**	**Recommended control measure**
6.0	Drying and grinding of the sample.	-Dust inhalation. -Mishandling of the grinder. -Small particle.	-Coughing/ wheezing. - Injuries (cut). -Eye irritation / injuries.	-Wear PPE. - Follow the work instruction procedure and training including instruction to operate machines	1 2 1	2 2 1	2 4 1	-Always ware proper PPE especially dust mask. - Wear goggles. -Done by competent persons.
7.0	Extraction using Supercritical fluid extraction (SFE) machine.	-Working with high pressure machine.	-Bodily harm	-Always use the automatic safety valve at the pressure vessel.	2	2	4	- Safe work practice by qualified personnel. - Follow work instruction procedure and training including instruction to operate machines. -Register the equipment with DOSH.

Hazard Identification				Existing Risk Control	Risk Assessment			Control Measure
No	**Work Activity**	**Hazard**	**Risk**		**Likelihood**	**Severity**	**Risk Ranking**	**Recommended control measure**
8.0	-Extraction (using soxhlet).	-Organic vapour. -Usage of flammable solvent. -Spillage of solvent.	-Drowsiness and dizziness. -Burn. -Skin irritation.	-Use fume hood and wear suitable respiratory mask. -Keep away from sources of ignition. - Follow the work instruction procedure and training including instruction to operate machines.	1 2 2	2 2 2	2 4 4	-Always wear PPE including suitable gloves and goggle. - Safe work practice by qualified personnel.
9.1	Chemical waste disposal - Spillage during filling of liquid chemical waste into 2.5 litre empty chemical bottles and transferring of solid waste.	-Fall due to slipper floor. -Skin contact with toxic chemicals. -Inhalation of toxic vapours and powders.	-Minor body injuries (scratch, swollen, broken). -Chemical burns (if acidic) and skin and eye irritation. -Coughing/ wheezing.	-Use funnel to transfer liquid waste or powder waste into the waste container with caution. -Wear glove and face mask.	2	1	2	-Always wear proper PPE including proper close shoes. - Ensure there is proper ventilation in the working area.

Hazard Identification				Existing Risk Control	Risk Assessment			Control Measure
No	**Work Activity**	**Hazard**	**Risk**		**Likelihood**	**Severity**	**Risk Ranking**	**Recommended control measure**
9.2	-Improper segregation of incompatible chemical (waste should be divided or separated into: - Organic solvent - Chlorinated waste -Acid/base -Flammable -Toxic material -Solid residue	- Unwanted chemical reaction.	-Oxidising which can cause fires.	-Wear cotton gloves. -Refer MSDS	1	2	2	- Label each bottle clearly. -Wear proper PPE including glove and face mask especially while handling with toxic chemicals. -Always practice a good chemical waste segregation.
9.3	- Overflowing of chemical waste container in the laboratory chemical waste storage area.	- It will mix up the new with the old chemical waste.	- It may reduce working/ accessibility space/ path which may lead to another hazard.	- Continuously transfer chemical waste container to the waste cabin.	1	2	2	- Properly label the chemical waste bottle especially the content and date.

Hazard Identification				Existing Risk Control	Risk Assessment			Control Measure
No	**Work Activity**	**Hazard**	**Risk**		**Likelihood**	**Severity**	**Risk Ranking**	**Recommended control measure**
10.0	Passengers and good lift - Moving / Transferring of chemical bottles using the trolley.	- Slippery floor surface. -Improper ventilation may cause less oxygen. -Stuck lift/ trapped by improper ventilation system or no electricity.	-Injury, abrasions, and broken bone. -Headache/ weakness/ dizziness. -Headache/ weakness/ dizziness.	-Conduct lifts maintenance and repair regularly.	2 1 1	3 2 2	6 4 2	-Wear fraction shoes. Avoid wearing slippers.
11.1	Repair and servicing Piping/ plumbing -Climbing and/ or standing on a ladder. - Maintenance of eye wash and emergency shower.	-Slipper surface, fall and slip. - Contaminated water source.	-Fractured/ bodily injury. - Eye and skin irritation. - Cut/ bodily injury.	-Properly wear safety boots, safety helmet, and a safety harness. - Weekly water checks by flushing out the water	2 1	2 2	4 2	-Wear suitable PPE including gloves and boots. - Safe work practice by qualified personnel.

Hazard Identification				Existing Risk Control	Risk Assessment			Control Measure
No	**Work Activity**	**Hazard**	**Risk**		**Likelihood**	**Severity**	**Risk Ranking**	**Recommended control measure**
	-Dismantling and fixing.	- An object falling from height.			2	2	2	
11.2	Electrical and mechanical. -Climbing and/or standing on a ladder. - Electrical and mechanical repairs.	-Slippery surface, fall or slip. -Electrical shock.	-Abrasion, acute/ chronic back or bodily injury. - Bodily harm.	- Ensure that the person in-charge is aware of the hazards. - Make sure all electrical connection put off before starting any maintenance activity. - Put notices and inform the related staff.	2 2	3 2	6 4	-Develop the “tag in tag out” method. - Always put on PPE including safety boots. - Safe work practice by qualified personnel.

Based on the result of the HIRARC for Chemical Laboratory 1 -Applied Chemical in IBRC SIRIM Bhd, risk assessment and risk control were then ranked according to priority. The following list details some of the main rankings, from the highest risk ranking to lowest risk ranking.

1. Chemical hazard from working with broken thermometer, which lead to mercury exposure.
2. Physical hazard while working to move/ transfer chemicals on a slippery floor surface in the passage and good lift.
3. Physical hazard while doing electrical and mechanical maintenance.
4. Mechanical hazard while working with machines.
5. Chemical hazard while working with specific chemicals from splashes and spills.
6. Chemical hazard while working with liquid nitrogen.
7. Physical hazard while working with heats that cause minor skin burns.
8. Physical hazard while working with sharp instruments that cause minor cuts.

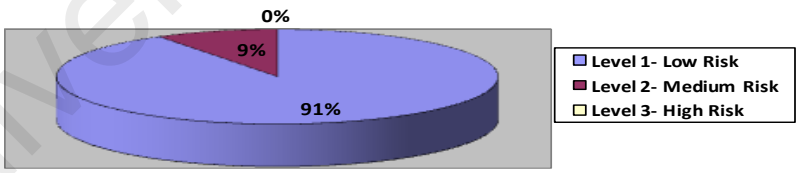

Figure 4.17: Percentage of three risk levels in Chemical Laboratory 1 -Applied Chemical.

The result of the risk assessment is presented in the percentage of the number of items as shown in Figure 4.17 above. The result is categorised into three levels with three degrees of hazards following the methodology of risk assessment. Based on this study

for Chemical Laboratory 1, 91% of hazards consider as low risk and the remaining 9% is at medium risk.

Based on the study and data collection from the selected laboratory, the main hazards were identified as chemical, physical, biological and electrical hazard. The result of hazard classification is presented in percentage of the number of items as shown in Figure 4.18 below.

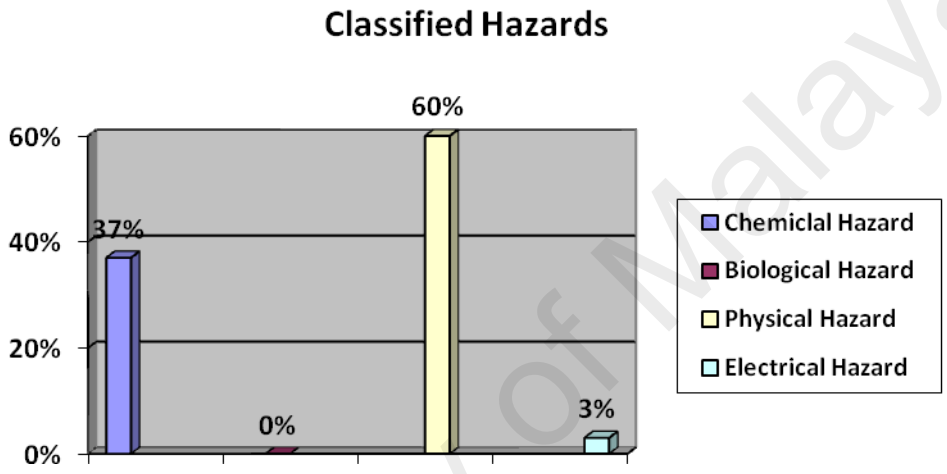

Figure 4.18: Percentage of four main classified hazards (Chemical Laboratory 1 - Applied Chemical).

The results of the bar chart based on the findings, shows that physical hazards at 60% is the main hazard that needs to be considered in finding the best way to identify the main cause, prevent and control method. It follows by chemical hazards at 37% and electrical hazards at 3%. In this laboratory, it does not involve any biological works, which puts the biological hazards at 0%.

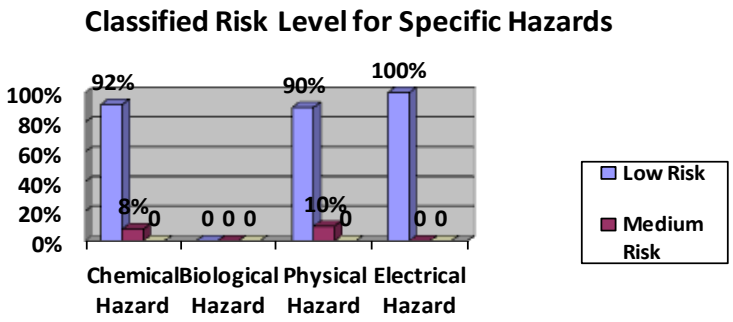

Figure 4.19: Classified three risk level results for four main hazards (Chemical Laboratory 1 -Applied Chemical).

According to Figure 4.19, the results for classified risk level for each specific hazard indicates 92% lower risk, 8% medium risk and no high risk from a total of 37% of chemical hazards. Physical hazards indicate 90% low risk, 10% medium risk and 0% of high risk from a total of 60%. The electrical hazards indicate 100% of low risk out of a total of 3% from classified risk. In general, the above data present all hazards and their risk level classification in Chemical Laboratory 1 -Applied Chemical in IBRC SIRIM Bhd.

4.4.2 Chemical Laboratory 2

Diagram 4.2: The Analytical Biochemical Laboratory Process Flow in IBRC

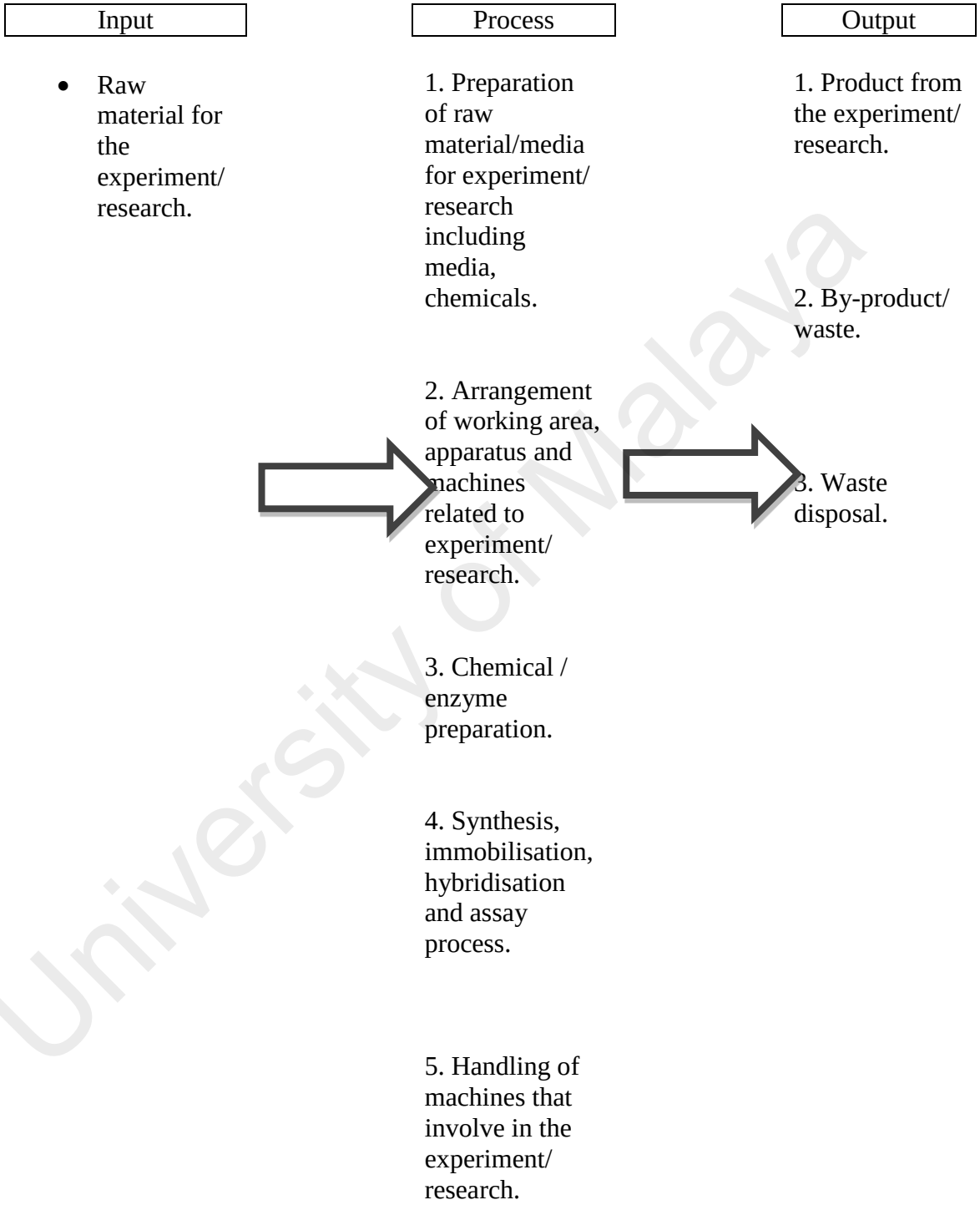

Table 4.10: HIRARC for Chemical Laboratory 2: Analytical Biochemical Laboratory

Hazard Identification				Existing Risk Control	Risk Assessment			Control Measure
No	Work Activity	Hazard	Risk		Likelihood	Severity	Risk Ranking	Recommended control measure
1.0	Working with (broken) thermometer.	-Exposure to mercury spillage due to broken thermometer.	-At low levels of exposure - symptoms are mainly related to nerve and other stress-like symptoms. - Short-term contact with high levels of mercury can cause immediate health effects including loss of appetite, fatigue, insomnia, and changes in behaviour or personality. - Depends on the length or degree of exposure, other symptoms such as nausea, abdominal cramps, diarrhoea, eye irritation, weight loss, skin rashes, and muscle tremors may occur.	-To avoid the spillage spreading out, collect mercury into balls. Sprinkle sulphur onto the mercury spillage or use mercury spill kit.	2	3	6	Safe work practice by qualified personnel. Keep a thermometer after use and away from heat source. Do not use a thermometer if not in good condition. Always wear the proper PPE including goggles, gloves, proper shoes and laboratory coat whenever going any experiment in the laboratory.

Hazard Identification				Existing Risk Control	Risk Assessment			Control Measure
No	Work Activity	Hazard	Risk		Likelihood	Severity	Risk Ranking	Recommended control measure
2.0 2.1	Activities involve: Synthesis, enzyme hybridization, stirring, sonicating, mixing, heating solution/enzyme **Common chemicals are:** . Hydrochloric acid	- Splashes and spillage. - Inhalation of vapour, or gases.	- Liquid or spray mist may produce tissue damage particularly on mucous membranes of eyes, mouth and respiratory tract. -Skin contact may produce burns. -Inhalation of the Spray mist may produce severe irritation of the respiratory tract,	-Use chemical with caution, read labels carefully. -Use PPE. -Use fume hood when preparing chemicals.	2	2	4	- Wear PPE which includes goggles, laboratory coat, glove and respiratory protection. - Work under fume hood (preparing and experimenting). - Always follow work instructions. -Refer MSDS especially when handling unfamiliar chemicals.
2.2	Sulfuric Acid	- Inhalation of vapour gases or particles.	-Liquid or spray mist may produce tissue damage particularly on mucous membranes of eyes, mouth and respiratory tract. -Skin contact may produce burns, itching, scaling, and/or reddening.	-Use chemical with caution, read labels carefully. -Use PPE. -Use fume hood when preparing chemicals.	2	2	4	- Wear PPE which includes goggles, laboratory coat, glove and respiratory protection. - Work under fume hood (preparing and experimenting). - Always follow work

Hazard Identification				Existing Risk Control	Risk Assessment			Control Measure
No	Work Activity	Hazard	Risk		Likelihood	Severity	Risk Ranking	Recommended control measure
			-Inhalation of the spray mist may produce irritation of the respiratory tract, (coughing, choking, or shortness of breath).					instructions. -Refer MSDS especially when handling unfamiliar chemicals.
2.3	DMSO - Dimethyl sulfoxide	- Splashes and spillage. - Inhalation of vapour, gases or particles. -Contact with or being absorbed through the body.	- May cause eye, skin, and respiratory tract irritation. -May cause mild lung irritant and respiratory tract irritation. -Slightly hazardous to skin (irritant, permeator), -Mild irritant to eye.	-Use chemical with caution, read labels carefully. -Use PPE. -Use fume hood when preparing chemicals.	2	2	4	- Wear PPE includes goggles, laboratory coat, glove and respiratory protection. - Work under fume hood - Follow work instructions. -Refer MSDS especially when handling unfamiliar chemicals.
2.4	Glycolic acid	- Splashes and spillage. - Inhalation of vapour, gases or particles. -Contact with or being absorbed through the body.	- Harmful if swallowed or inhaled. - Cause severe irritation and burns to every area of contact. -May cause eye, skin and respiratory tract irritation	-Use chemical with caution, read labels carefully. -Use PPE. -Use fume hood when preparing chemicals.	2	2	4	- Wear PPE which includes goggles, laboratory coat, glove and respiratory protection. - Work under fume hood (preparing and experimenting). -Follow work instructions. -Refer MSDS especially

Hazard Identification				Existing Risk Control	Risk Assessment			Control Measure
No	Work Activity	Hazard	Risk		Likelihood	Severity	Risk Ranking	Recommended control measure
								when handling unfamiliar chemicals.
2.5	Uric Acid	- Splashes and spillage. - Inhalation of vapour, gases or particles, fire and explosion.	-May cause skin and eye irritation. Hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, of inhalation.	-Use chemical with caution, read labels carefully. -Use PPE. -Use fume hood when preparing chemicals.	2	1	2	- Wear proper PPE. - Work under fume hood (preparing and experimenting). - Always follow work instructions. -Refer MSDS especially when handling unfamiliar chemicals.
2.6	Ethanol.	- Splashes and spillage. - Inhalation of vapour, gases or particles. - Manual handling repetitive work. Fire and explosion.	- Flammable liquid and vapour. -May cause eye, skin, and respiratory tract irritation. -Inhalation of high concentrations may cause nausea, dizziness, unconsciousness, headache and coma.	-Use chemical with caution, read labels carefully. -Use PPE. -Use fume hood when preparing chemicals.	2	2	4	- Wear proper PPE which includes goggles, laboratory coat, glove and respiratory protection. - Work under fume hood (preparing and experimenting). - Always follow work instructions. -Refer MSDS especially when handling unfamiliar

Hazard Identification				Existing Risk Control	Risk Assessment			Control Measure
No	Work Activity	Hazard	Risk		Likelihood	Severity	Risk Ranking	Recommended control measure
								chemicals. -Remove all sources of ignition.
2.7	Phosphate Buffer Saline (PBS)	- Splashes and spillage. - Inhalation of particles. -Contact with or being absorbed through the body.	- May cause eye and skin irritation. - Inhalation of dust may cause respiratory tract irritation. - Ingestion of large amount may cause gastrointestinal irritation.	-Use chemical with caution, read labels carefully. -Use PPE. -Use fume hood when preparing chemicals.	2	2	4	- Wear PPE which includes goggles, laboratory coat, glove and respiratory protection. - Work under fume hood - Always follow work instructions. -Refer MSDS especially when handling unfamiliar chemicals.
2.8	Cadmium Chloride	- Splashes and spillage. - Inhalation of particles.	-May cause skin, eyes and respiratory tract irritation. -Very hazardous in case of ingestion	-Use chemical with caution, read labels carefully. -Use PPE. -Use fume hood when preparing chemicals.	2	2	4	- Wear PPE which includes goggles, laboratory coat, glove and respiratory protection. - Work under fume hood (preparing and experimenting). - Always follow work

Hazard Identification				Existing Risk Control	Risk Assessment			Control Measure
No	Work Activity	Hazard	Risk		Likelihood	Severity	Risk Ranking	Recommended control measure
								instructions. -Refer MSDS especially when handling unfamiliar chemicals.
2.9	Zinc chloride	- Splashes and spillage. - Inhalation of particles.	- Contact with skin may cause irritant, corrosive, permeator. - Contact with eyes may cause irritant, corrosive. - Inhalation may cause respiratory tract irritation. -The amount of tissue damage depends on the length of contract.	-Use chemical with caution, read label carefully. -Use PPE. -Use fume hood when preparing chemicals.	2	2	4	- Wear PPE which includes goggles, laboratory coat, glove and respiratory protection. - Work under fume hood (preparing and experimenting). - Always follow work instructions. -Refer MSDS especially when handling unfamiliar chemicals.
3.0	Stirring/ mixing/ heating the solution/ enzyme.	-Skin contact on the hot plate during heating of the raw material. -Spillage of hot solution, broken glassware as stirring blade might fall into	-Minor skin burns. -Minor Cuts	-Wear proper PPE. -Work with caution. -Wear proper PPE. -Work with caution.	1 1	2 1	2 1	-Follow working instruction. - Wear proper PPE including suitable gloves, mask, goggle, laboratory coat and proper covered shoes. - Wipes and clean the area immediately after occurrence.

Hazard Identification				Existing Risk Control	Risk Assessment			Control Measure
No	Work Activity	Hazard	Risk		Likelihood	Severity	Risk Ranking	Recommended control measure
		the mixing beaker. -Broken pH probe during pH measurement. - Spillage of product solution during transferring from the container to other flask or cells.	-Slippery floor. -Minor Cuts. -Slippery floor cause slip and fall.	-Wear proper PPE. -Work with caution. -Wear proper PPE. -Work with caution.	2 1	1 1	2 1	- Follow working instruction. -Wipe and clean the area immediately after occurrence. -Always wear proper shoes while working in the laboratory. - Always follow work instruction including instruction to operate machines.
4.0	Synthesis process.	Inhalation of gasses and/ vapour.	-May cause mild lung irritant and respiratory tract irritation. -Lung damage, chocking, unconsciousness or even fatal if exposed for a long period.	-Wear proper PPE including Nitrile gloves, respiratory protection, goggles, and laboratory coat. - Work under fume hood.	2	2	4	- Follow the work instruction. -Always refer to MSDS. -Ensure there is proper ventilation in the working area.

Hazard Identification				Existing Risk Control	Risk Assessment			Control Measure
No	Work Activity	Hazard	Risk		Likelihood	Severity	Risk Ranking	Recommended control measure
5. 0	Enzymes hybridization determination process.	-Splashes and spillage.	- May cause eye, skin, and respiratory tract irritation	-Wear proper PPE including Nitrile gloves, respiratory protection, goggles, and laboratory coat.	1	1	1	-Follow the work instruction. -Always refer to MSDS. -Ensure there is proper ventilation in the working area.
6.0	Immobilization process.	-Splashes and spillage. -Inhalation of gasses and/ vapour.	- May cause skin, and respiratory tract irritation.	-Wear proper PPE including Nitrile gloves, respiratory protection, goggles, and laboratory coat. - Work under fume hood.	2	2	2	- Follow the work instruction. -Always refer to MSDS. -Ensure there is proper ventilation in the working area.
7.0	Hybridization and assay process.	-Splashes and spillage. -Inhalation of gasses and/ vapour.	- May cause skin, and respiratory tract irritation -Nausea and vomiting if exposed for a long period.	Wear proper PPE including Nitrile gloves, respiratory protection, goggles, and laboratory coat. - Work under fume hood.	2	2	4	- Follow the work instruction. -Always refer to MSDS. -Ensure there is proper ventilation in the working area.

Hazard Identification				Existing Risk Control	Risk Assessment			Control Measure
No	Work Activity	Hazard	Risk		Likelihood	Severity	Risk Ranking	Recommended control measure
8.1	Chemical waste disposal - Spillage during filling of liquid chemical waste into 2.5 litre empty chemical bottles and transferring of solid waste.	-Fall due to slipper floor. -Skin contact with toxic chemicals. -Inhalation of toxic vapours and powders.	-Minor body injuries (scratch, swollen, broken). -Chemical burns (if acidic) and skin and eye irritation. -Coughing/ wheezing.	-Use funnel to transfer liquid waste or powder waste into the waste container with caution. -Wear glove and face mask.	2	1	2	- Always wear proper PPE including proper close shoes. - Ensure there is proper ventilation in the working area.
8.2	-Improper segregation of incompatible chemical (waste should be divided or separated into: - Organic solvent - Chlorinated waste -Acid/base -Flammable -Toxic material -Solid residue	- Unwanted chemical reaction.	-Oxidising which can cause fires.	-Wear cotton gloves. -Refer MSDS	1	2	2	- Label each bottle clearly. -Wear proper PPE including glove and face mask especially while handling with toxic chemicals. -Always practice a good chemical waste segregation.
8.3	- Overflowing of chemical waste container in the laboratory chemical waste storage area.	- It will mix up the new with the old chemical waste.	- It may reduce working/ accessibility space/ path which may lead to another hazard.	- Continuously transfer chemical waste container to the waste cabin	1	2	2	- Properly label the chemical waste bottle especially the content and date.

Hazard Identification				Existing Risk Control	Risk Assessment			Control Measure
No	Work Activity	Hazard	Risk		Likelihood	Severity	Risk Ranking	Recommended control measure
9.0	Passengers and good lift - Moving / Transferring of chemical bottles using the trolley.	- Slippery floor surface.	-Injury, abrasions, and broken bone.	-Conduct lifts maintenance and repair regularly.	2	3	6	-Wear fraction shoes. Avoid wearing slippers.
		-Improper ventilation may cause less oxygen.	-Headache/ weakness/ dizziness.		1	2	2	
		-Stuck lift/ trapped by improper ventilation system or no electricity.	-Headache/ weakness/ dizziness.		1	2	4	
10.1	Repair and servicing Piping/ plumbing							
	-Climbing and/ or standing on a ladder.	-Slipper surface, fall and slip.	-Fractured/ bodily injury.	-Properly wear safety boots, safety helmet, and a safety harness.	2	2	4	- Wear suitable PPE including gloves and boots. - Safe work practice by qualified personnel.
	- Maintenance of eye wash and emergency shower.	- Contaminated water source.	- Eye and skin irritation.	- Weekly water checks by flushing out the water	1	2	2	
	-Dismantling and fixing.	- An object falling from height.	- Cut/ bodily injury.		2	2	4	

Hazard Identification				Existing Risk Control	Risk Assessment			Control Measure
No	Work Activity	Hazard	Risk		Likelihood	Severity	Risk Ranking	Recommended control measure
10.2	Electrical and mechanical. -Climbing and/or standing on a ladder.	-Slippery surface, fall or slip.	-Abrasion, acute/ chronic back or bodily injury.	- Ensure that the person in-charge is aware of the hazards.	2	3	6	- Ensure that the person in-charge is aware of the hazards. -Develop the "tag in tag out" method.
	- Electrical and mechanical repairs.	-Electrical shock.	- Bodily harm.	- Make sure all electrical connection put off before starting any maintenance activity. - Put notices and inform the related staff.	2	2	4	- Always put on PPE including safety boots. - Safe work practice by qualified personnel.

Based on the result of HIRARC for Chemical Laboratory 2 –Analytical Biochemical in IBRC SIRIM Bhd, risk assessment and risk control were then ranked according to priority. The following list details some of the main rankings from the highest risk ranking to lowest risk ranking.

1. Chemical hazard from working with broken thermometer which lead to mercury exposure.
2. Physical hazard while doing electrical and mechanical maintenance.
3. Mechanical hazard while working with machines.
4. Chemical hazard while working with specific chemicals.
5. Physical hazard while working with heats that cause minor skin burns.
6. Physical hazard while working with sharp instruments that cause minor cuts.
7. Chemical hazard from overflow chemical waste.

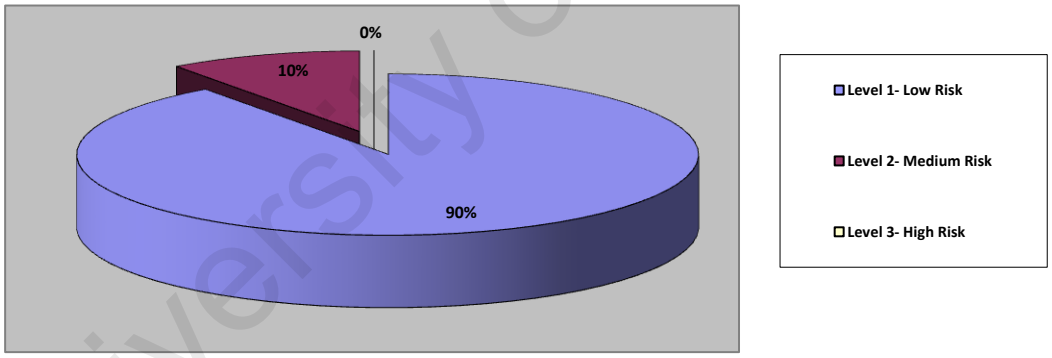

Figure 4.20: Percentage of three risk levels in Chemical Laboratory 2 - Analytical Biochemical.

The result of risk assessment is presented in percentage of the number of items as shown in Figure 4.20 above. The result is categorised into three levels with three degrees of hazards following the methodology of risk assessment. Based on this study for Chemical Laboratory 2, 90% of hazards consider as low risk and the remaining 10% is at medium risk.

Based on the study and data collection from the selected laboratory, the main hazards were identified as chemical, physical, biological and electrical hazard. The result of hazard classification is presented in percentage of the number of items as shown in Figure 4.21 below.

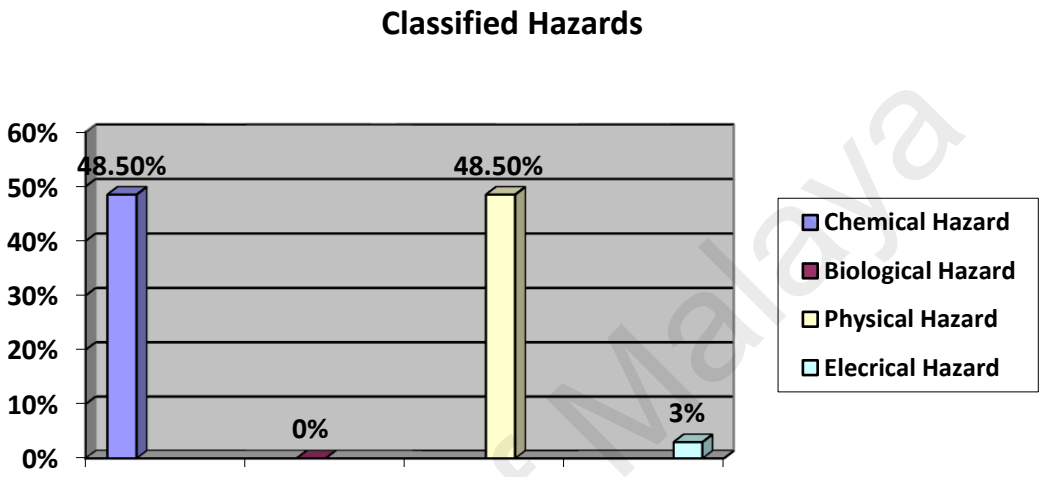

Figure 4.21: Percentage of four main classified hazards (Chemical Laboratory 2 - Analytical Biochemical).

The results of the bar chart which is based on the findings show that both chemical and physical hazards at 48.5 % where can be considered as the main hazard that need to be considered in finding the best way to identify the main cause, prevent and control method. The electrical hazards 3%. In this laboratory, it does not involve any biological works which put the biological hazards at 0%.

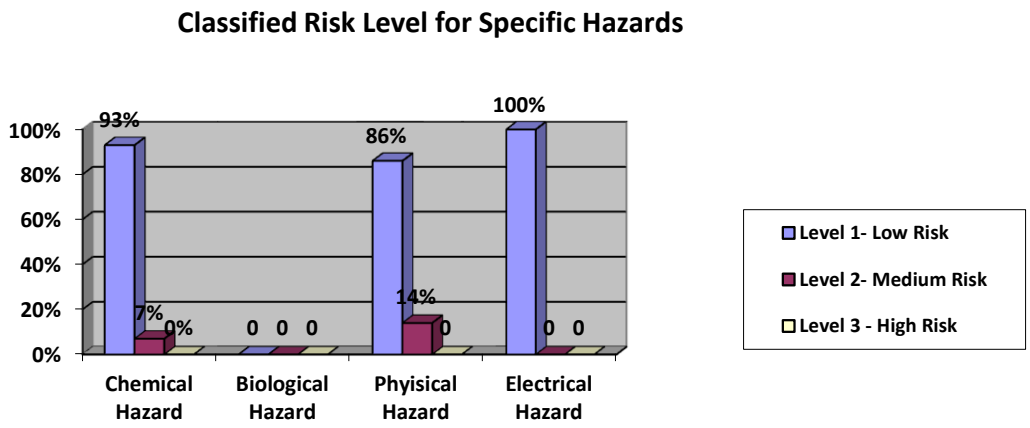

Figure 4.22: Classified three risk level results for four main hazards (Chemical Laboratory 2 - Analytical Biochemical).

According to Figure 4.22, the results for classified risk level for each specific hazard indicates 93% lower risk, 7% medium risk and no high risk from a total of 48.5% of chemical hazards. Physical hazards indicate 86% low risk, 14% medium risk and 0% of high risk from a total of 48.5%. The electrical hazards indicate 100% of low risk out of a total of 3% from classified risk. In general, the above data presents all hazards and their risk level classification in Chemical Laboratory 2 - Analytical Biochemical in IBRC SIRIM Bhd.

4.4.3: Microbiology Laboratory 1.

Diagram 4.3: The Microbial Isolation and Screening Laboratory Process Flow in IBRC

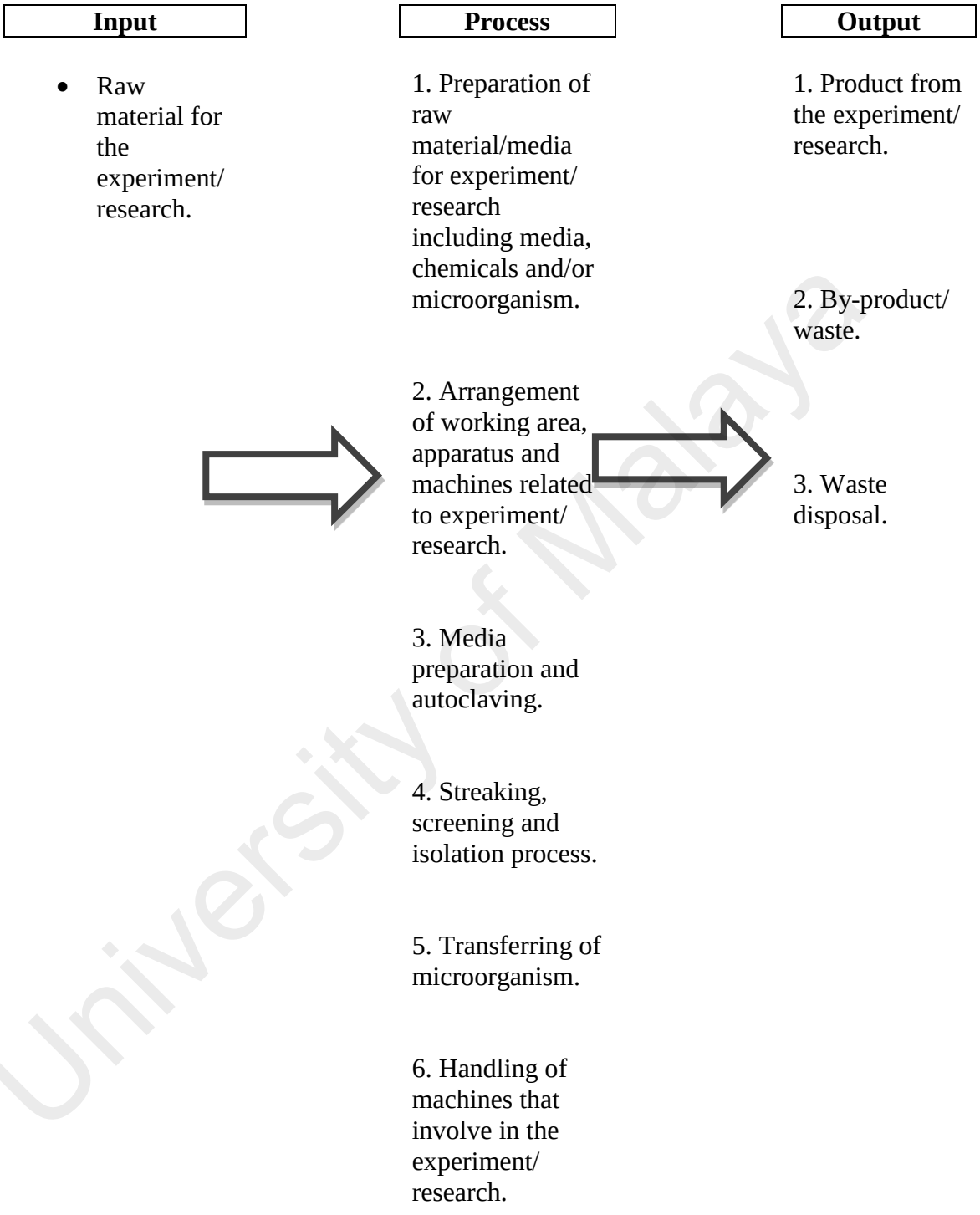

Table 4.11: HIRARC for Microbiology Laboratory 1: Microbial Isolation and Screening Laboratory

Hazard Identification				**Existing Control Measure**	**Risk Assessment**			**Control Measure**
No	**Work Activity**	**Hazard**	**Risk**		**Likelihood**	**Severity**	**Risk Ranking**	**Recommended control measure**
1.0	Screening and isolation of microorganism -Preparation of media and reagent	-Chemical hazards while handling with chemical in media / reagent preparation process.	-Irritation to the skin (itching , redness) eye, nose and/ or respiratory system	-Always refer to MSDS of the chemical and media before starting the experiments. - Wear suitable PPE including laboratory coat, gloves, goggles, respiratory mask.	1	2	2	-Always follow work instruction. -Always wear proper shoes especially while working in the laboratory. - Always practice good discipline in using the PPE.
		- Spillage of preparation causing slip, trip and/or fall.	-Abrasion, broken bones, concussions, acute/ chronic back or bodily injury.	-Clean any spillage immediately.	1	2	2	
2.0	-Autoclaving of media.	- Heat exposure from hot plate and/or autoclave machine.	-Burn caused during handling of hot media and/or spillage of hot media	- Wear proper PPE including laboratory coat and wool gloves. - Use insulated baskets when transferring hot media. -Proper labelling of equipment when they are still hot.	1	2	2	-Follow the work instruction procedure and training including instruction to operate machines. - Always practice good discipline in using the PPE.

Hazard Identification				Existing Control Measure	Risk Assessment			Control Measure
No	**Work Activity**	**Hazard**	**Risk**		**Likelihood**	**Severity**	**Risk Ranking**	**Recommended control measure**
3.0	-Screening and isolation process.	Biological hazard while handling with the microorganism. -Inhalation of any particles' origin from microorganism. Chemical hazard VOC emission in the air such as organic vapour use as disinfectants (70% ethanol) and solution used in the isolation.	- Disease cause by pathogen through contact with skin or mucus membranes inhalation or accidental ingestion. -Dizziness, nausea, irritation to eye or respiratory system	Wear proper PPE including laboratory coat, gloves and a respiratory mask. - Handle all potential pathogenic materials in the biological safety cabinet. -Avoid eating and drinking in the laboratory. -Wash hands and contaminated clothing etc. with disinfectants before leaving the laboratory. -Clean contaminated work bench with disinfectants at all time. -Make sure all gas is turned off after using and hose disconnected from the gas tank.	1 1 1	2 3 2	2 3 2	-Follow the work instruction procedure. - Always practice good discipline in using the PPE. -Always practice good disinfectants practice especially while handling with the microorganism.
4.0	Streaking of microorganism	-Spillage of microorganism stock. -Flame form Bunsen burner.	-Skin penetration through a cut or eyes and causing fever or other infection. -Skin burned, irritating	Wear gloves, mask, goggle and laboratory coat. -Disinfecting spray should be prepared whenever handling with bacteria/ microorganism. -Wear a laboratory coat, gloves and goggle.	2 2	2 1	4 2	- Follow the work instruction procedure. - Always practice good discipline in using the PPE. -Always practice good disinfectants practice especially while handling with the microorganism.

Hazard Identification				Existing Control Measure	Risk Assessment			Control Measure
No	**Work Activity**	**Hazard**	**Risk**		**Likelihood**	**Severity**	**Risk Ranking**	**Recommended control measure**
		-Flame/heat from Bunsen burner/apparatus and alcohol (use as disinfected).	to eyes. - Cause fire, skin burned.	- Follow the work instruction and procedure and training. -Fire extinguishers.	2	2	4	
5.0	Inoculation/ transferring of microorganism into shake flask.	Spillage of microorganism broth. Flame from Bunsen burner Broken glassware.	-Get into the skin through a cut and fever or other infection. -Burned, irritating to eyes. -Cuts.	-Wear gloves, mask, goggle and laboratory coat. -Wear a laboratory coat, gloves and goggle	2 2 2	2 1 1	4 2 2	- Follow the work instruction procedure. - Always practice good discipline in using the PPE. -Always practice good disinfectants practice especially while handling with the microorganism. -Wear glove, put extra caution whenever handling with glasses.
6.0	Biological waste disposal- Solid and liquid waste.	A disease caused by pathogens through skin contact or mucus membrane inhalation or accident ingestion.	Penetration into the body system which may cause symptoms such as breathing difficulty, respiratory and skin illness	Wear suitable protective clothing and PPE. Handle potential pathogenic material in a biological safety cabinet. Avoid eating in laboratory and/ or while handling with biological	2	2	4	- Always practice good discipline in using the PPE. -Always practice good disinfectants practice especially while handling with the microorganism.

Hazard Identification				Existing Control Measure	Risk Assessment			Control Measure
No	**Work Activity**	**Hazard**	**Risk**		**Likelihood**	**Severity**	**Risk Ranking**	**Recommended control measure**
				waste. Always exercise good disinfection practices. Always autoclaved all biological waste before proceeding with disposal process.				
7.0	Passengers and good lift. - Moving / Transferring of biological waste using the trolley.	- Slippery floor surface. -Improper venting may cause less oxygen -Stuck lift/ trapped with improper venting or no electricity.	-Injury, abrasions, and broken bone. -Headache/ weakness/ dizziness. -Headache/ weakness/ dizziness.	-Conduct lifts maintenance and repair regularly.	2 2 2	3 2 2	6 4 4	-Wear fraction shoes. Avoid wearing slippers.
8.1	Repair and servicing Piping/ plumbing -Climbing and/ or standing on a ladder.	-Slipper surface, fall and slip.	-Fractured/ bodily injury	-Properly wear safety boots, safety helmet, and a safety	2	2	4	-- Wear suitable PPE including gloves and boots.

Hazard Identification				Existing Control Measure	Risk Assessment			Control Measure
No	**Work Activity**	**Hazard**	**Risk**		**Likelihood**	**Severity**	**Risk Ranking**	**Recommended control measure**
				harness.				
	- Maintenance of eye wash and emergency shower.	- Contaminated water source.	- Eye and skin irritation.	- Weekly water checks by flushing out the water	1	2	2	- Safe work practice by qualified personnel.
	-Dismantling and fixing.	- An object falling from height.	- Cut/ bodily injury.		2	2	4	
8.2	Electrical and mechanical.							
	-Climbing and/or standing on a ladder.	-Slippery surface, fall or slip.	-Abrasion, acute/ chronic back or bodily injury.	- Ensure that the person in-charge is aware of the hazards.	2	3	6	- Ensure that the person in-charge is aware of the hazards. -Develop the "tag in tag out" method.
	- Electrical and mechanical repairs.	-Electrical shock.	- Bodily harm.	- Make sure all electrical connection put off before starting any maintenance activity. - Put notices and inform the related staff.	2	2	4	- Always put on PPE including safety boots. - Safe work practice by qualified personnel.

Based on the result of HIRARC in Microbiology Laboratory 1 - Microbial Isolation and Screening in IBRC SIRIM Bhd, risk assessment and risk control were then ranked according to priority. The following list details some of the main rankings from the highest risk ranking to lowest risk ranking.

1. Physical hazard while working to move/ transfer chemicals on a slippery floor surface in the passage and good lift.
2. Physical hazard while doing electrical and mechanical maintenance.
3. Biological hazard by spillage of bacterial stock or broth.
4. Biological hazard while handling with biological waste.
5. Chemical hazard while handling with chemical reagents.
6. Physical hazard while working with flames and/or heats that cause minor skin burns.
7. Physical hazard while working with sharp instruments or broken glasses that cause minor cuts.

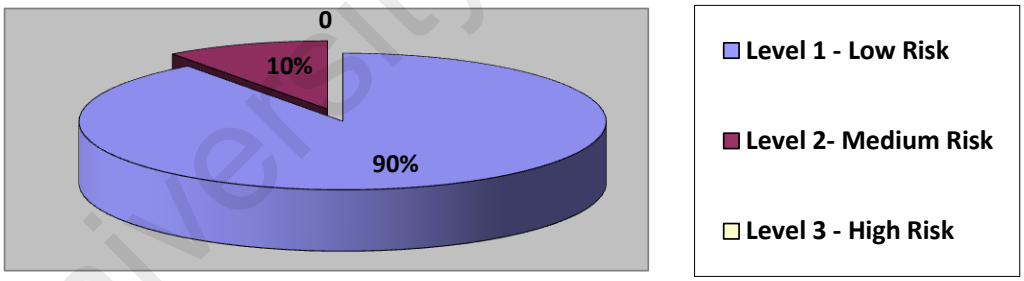

Figure 4.23: Percentage of three risk levels in Microbiology Laboratory 1: Microbial Isolation and Screening Laboratory.

The result of risk assessment is presented in percentage of the number of items as shown in Figure 4.23 above. The result is categorised into three levels with three degrees of hazards following the methodology of risk assessment. Based on this study

for Microbiological Laboratory 1, 90% of hazards consider as low risk and the remaining 10% is at medium risk.

Based on the study and data collection from the selected laboratory, the main hazards were identified as chemical, physical, biological and electrical hazard. The result of hazard classification is presented in percentage of the number of items as shown in figure 4.24 below.

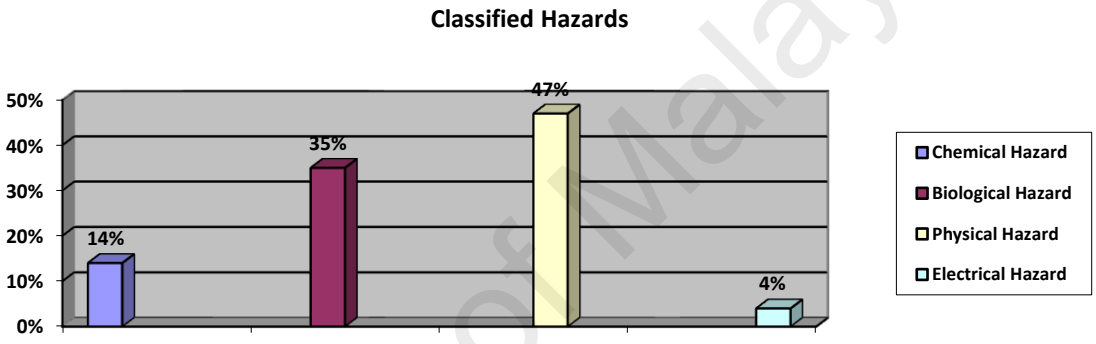

Figure 4.24: Percentage of four main classified hazards (Laboratory 1: Microbial Isolation and Screening Laboratory)

The results of the bar chart, which is based on the findings, shows that physical hazards at 47% is the main hazard that needs to be considered in finding the best way to identify the main cause, prevent and control method. It follows by biological hazards at 35%, chemical hazards at 14% and electrical hazards at 4%.

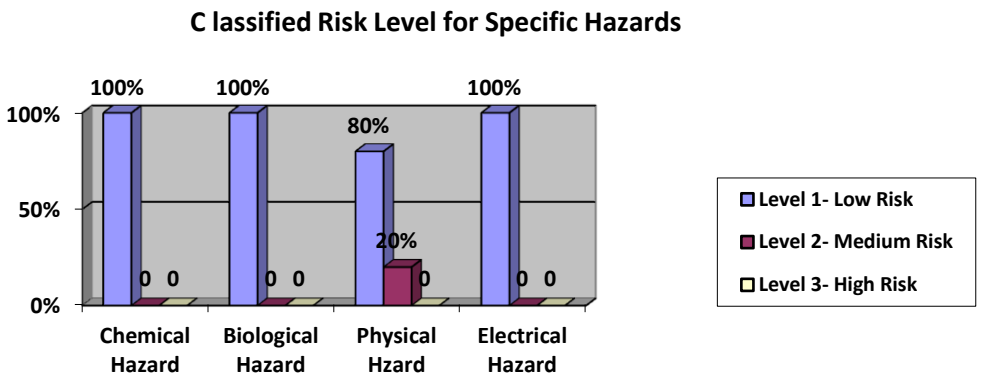

Figure 4.25: Classified three risk level results for four main hazards (Laboratory 1: Microbial Isolation and Screening Laboratory)

According to Figure 4.25, the results for classified risk level for each specific hazard indicates 100% lower risk with no medium high risk from a total of 14% of chemical hazards. Biological hazards indicate 100% lower risk, with no medium and high risk of total of 35%. Physical hazards show 90% low risk, 10% medium risk with no high risk from a total of 47%. The electrical hazards indicate 100% of low risk out of a total of 4% from classified risk. The above data presents all hazards and their risk level classification in Microbiology Laboratory 1- Microbial Isolation and Screening Laboratory in IBRC SIRIM Bhd.

4.4.4 Microbiology Laboratory 2

Diagram 4.4: The Bacteriology Laboratory Process Flow in IBRC

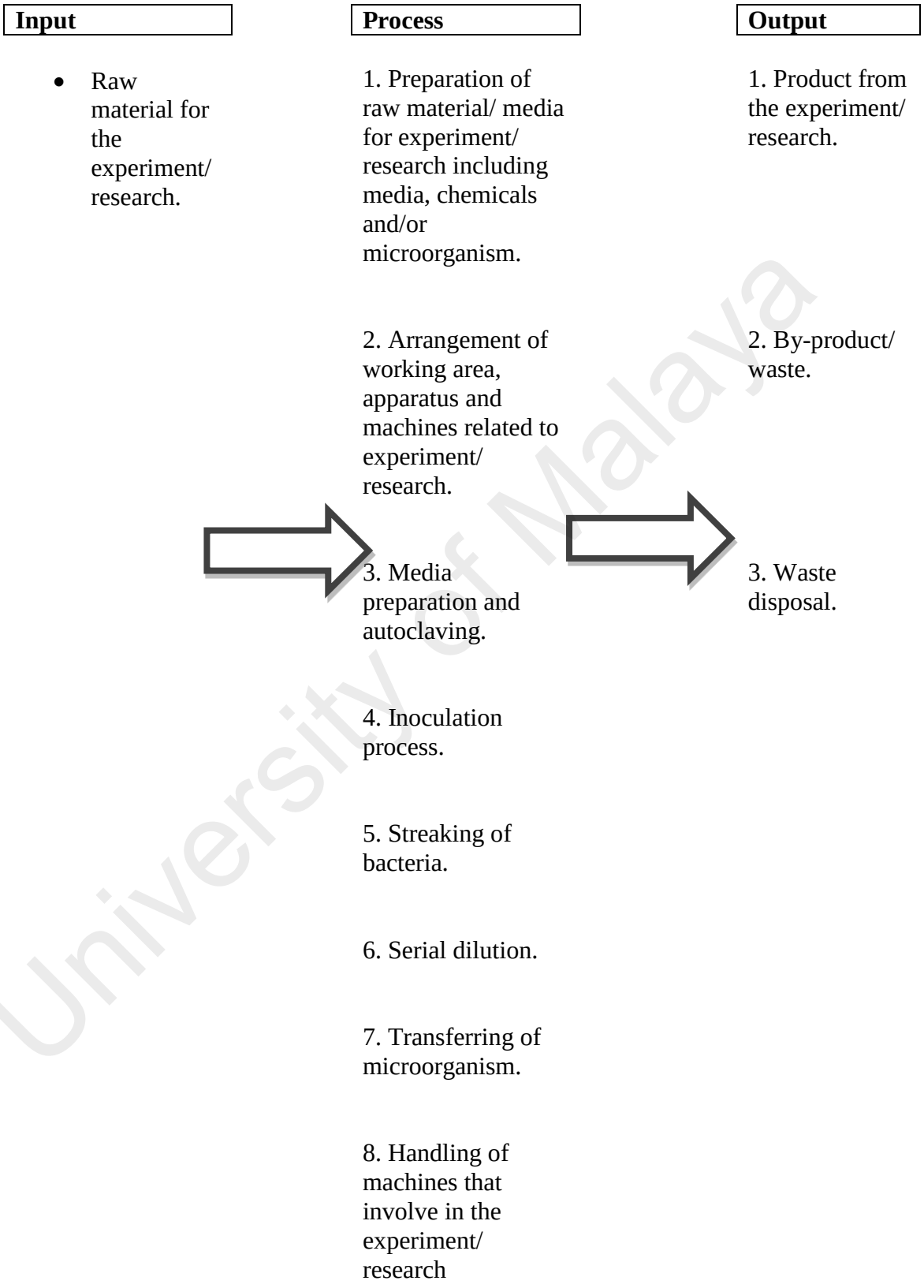

Table 4.12: HIRARC for Microbiology Laboratory 2: Bacteriology Laboratory

Hazard Identification				**Existing Risk Control**	**Risk Assessment**			**Control Measure**
No	**Work Activity**	**Hazard**	**Risk**		**Likelihood**	**Severity**	**Risk Ranking**	**Recommended control measure**
1.0	Microbial testing - Media Preparation	- Skin contact with chemical use in the media preparation process. -Spillage of chemical, acid and/ or alkali. -Skin contact with high pressure and temperature devices (autoclave and /or Bunsen burner).	- Skin irritation. -Skin and/ or eye irritation (depends on the type of chemical used) -Injuries/ skin burn.	- Wear proper PPE including laboratory coat, face mask and gloves. - Follow the work instruction and procedure including instruction to operate machines.	2 1 2	1 2 2	2 2 4	-Safe work practice by qualified personnel. - Refer MSDS (both for chemicals and media used). - Always practice good discipline in using the PPE. -Always practice good disinfectants practice especially while handling with the microorganism
2.0	Inoculum preparation	-Skin contact/ inhalation of microbial mass.	-Penetration into the body system which may cause symptoms such as breathing difficulty.	- Wear proper PPE, including laboratory coat, face mask and gloves.	1	2	2	- Follow the work instruction and procedure proper. - Always practice good discipline in using the PPE.

Hazard Identification				Existing Risk Control	Risk Assessment			Control Measure
No	**Work Activity**	**Hazard**	**Risk**		**Likelihood**	**Severity**	**Risk Ranking**	**Recommended control measure**
		-Spillage of microbial mass -Skin contact with high temperature devices (Bunsen burner).	- Penetration into the body system which may cause symptoms such as breathing difficulty. -The spill may cause slippery floor which can lead to slip and fall. -Injuries/ skin burn.	-Work in a Biological Safety Cabinet and properly use disinfectant	1 1	2 1	2 1	-Always practice good disinfectants practice especially while handling with the microorganism. -Work with caution especially while working with high temperature devices.
3.0	Serial Dilution	-Skin contact and / or inhalation of microbial mass -Spillage of microbial mass. -Skin contact with high temperature devices (Bunsen burner).	-Penetration into the body system which may cause symptoms such as breathing difficulty. - Penetration into the body system which may cause symptoms such as breathing difficulty. - Injuries/ skin burn.	-Wear proper PPE, including laboratory coat, respiratory mask and gloves. -Work in a Biological Safety Cabinet, use disinfectant.	1 1 1	2 2 1	2 2 1	- Follow the work instruction and procedure proper. - Always practice good discipline in using the PPE. -Always practice good disinfectants practice especially while handling with the microorganism. -Work with caution especially while working with high temperature devices.

Hazard Identification				Existing Risk Control	Risk Assessment			Control Measure
No	**Work Activity**	**Hazard**	**Risk**		**Likelihood**	**Severity**	**Risk Ranking**	**Recommended control measure**
4.0	Streaking of bacteria	-Spillage of bacteria stock. -Flame form Bunsen burner. -Flame/heat from Bunsen burner/apparatus and alcohol (use as disinfected).	-Skin penetration through a cut or eyes and causing fever or other infection. -Skin burned, irritating to eyes. - Cause fire, skin burned.	Wear gloves, mask, goggle and laboratory coat. -Disinfecting spray should be prepared whenever handling with bacteria/ microorganism. --Fire extinguishers.	2 2 2	2 1 2	4 2 4	- Follow the work instruction and procedure proper. - Always practice good discipline in using the PPE. -Always practice good disinfectants practice especially while handling with the microorganism. -Work with caution especially while working with high temperature devices.
5.0	Inoculation/ transferring of bacteria into shake flask.	Spillage of bacteria broth. Flame from Bunsen burner Broken glassware.	-Get into the skin through a cut and fever or other infection. -Burned, irritating to eyes. -Cuts.		2 2 2	2 1 1	4 2 2	Wear gloves, mask, goggle and laboratory coat. Wear a laboratory coat, gloves and goggle Wear glove, put extra caution whenever handling with glasses.

Hazard Identification				Existing Risk Control	Risk Assessment			Control Measure
No	**Work Activity**	**Hazard**	**Risk**		**Likelihood**	**Severity**	**Risk Ranking**	**Recommended control measure**
6.0	Biological waste disposal- Solid and liquid waste.	A disease caused by pathogens through skin contact or mucus membrane inhalation or accident ingestion.	Penetration into the body system which may cause symptoms such as breathing difficulty, respiratory and skin illness	Wear suitable protective clothing and PPE. Handle potential pathogenic material in a biological safety cabinet. Avoid eating in laboratory and/ or while handling with biological waste. Always exercise good disinfection practices. Always autoclaved all biological waste before proceeding with disposal process.	2	2	4	- Always practice good discipline in using the PPE. -Always practice good disinfectants practice especially while handling with the microorganism.
7.0	Passengers and good lift. - Moving / Transferring of biological waste using the trolley.	- Slippery floor surface. -Improper venting may cause less oxygen	-Injury, abrasions, and broken bone. -Headache/ weakness/ dizziness.	Conduct lifts maintenance and repair regularly.	2 2	3 2	6 4	-Wear fraction shoes. Avoid wearing slippers.

Hazard Identification				Existing Risk Control	Risk Assessment			Control Measure
No	**Work Activity**	**Hazard**	**Risk**		**Likelihood**	**Severity**	**Risk Ranking**	**Recommended control measure**
		-Stuck lift/ trapped with improper venting or no electricity.	-Headache/ weakness/ dizziness.		2	2	4	
8.1	Repair and servicing Piping/ plumbing -Climbing and/ or standing on a ladder. - Maintenance of eye wash and emergency shower. -Dismantling and fixing.	-Slipper surface, fall and slip. - Contaminated water source. - An object falling from height.	-Fractured/ bodily injury - Eye and skin irritation. - Cut/ bodily injury.	- Properly wear safety boots, safety helmet, and a safety harness. - Weekly water checks by flushing out the water	2 1 2	2 2 2	4 2 4	- Wear suitable PPE including gloves and boots. - Safe work practice by qualified personnel.

Hazard Identification				Existing Risk Control	Risk Assessment			Control Measure
No	**Work Activity**	**Hazard**	**Risk**		**Likelihood**	**Severity**	**Risk Ranking**	**Recommended control measure**
8.2	Electrical and mechanical. -Climbing and/or standing on a ladder. - Electrical and mechanical repairs.	-Slippery surface, fall or slip. -Electrical shock.	-Abrasion, acute/ chronic back or bodily injury. - Bodily harm.	- Ensure that the person in-charge is aware of the hazards. - Make sure all electrical connection put off before starting any maintenance activity. - Put notices and inform the related staff.	2 2	3 2	6 4	- Ensure that the person in-charge is aware of the hazards. -Develop the "tag in tag out" method. - Always put on PPE including safety boots. - Safe work practice by qualified personnel.

Based on the result of HIRARC in Microbiology Laboratory 2 – Bacteriology in IBRC SIRIM Bhd, risk assessment and risk control were then ranked according to priority. The following list details some of the main rankings from the highest risk ranking to lowest risk ranking.

1. Physical hazard while working to move/ transfer chemicals on a slippery floor surface in the passage and good lift.
2. Physical hazard while doing electrical and mechanical maintenance.
3. Biological hazard by spillage of bacterial stock or broth.
4. Biological hazard while handling with biological waste.
5. Chemical hazard while handling with chemical reagents.
6. Physical hazard while working with flames and/or heats that cause minor skin burns.
7. Physical hazard while working with sharp instruments or broken glasses that cause cuts.

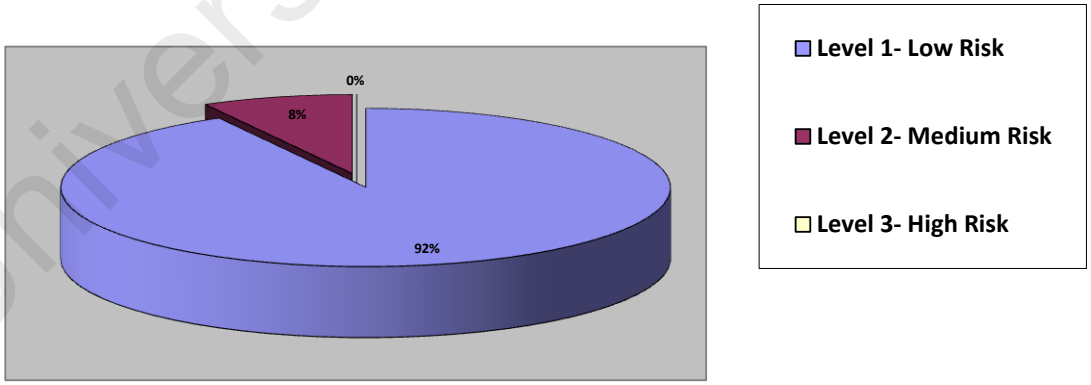

Figure 4.26: Percentage of three risk levels in Microbiological Laboratory 2- Bacteriology Laboratory.

The result of risk assessment is presented in percentage of the number of items as shown in Figure 4.26 above. The result is categorised into three levels with three degrees of hazards following the methodology of risk assessment. Based on this study for Microbiological Laboratory 2, 92% of hazards consider as low risk and the remaining 8% is at medium risk.

Based on the study and data collection from the selected laboratory, the main hazards were identified as chemical, physical, biological and electrical hazard. The result of hazard classification is presented in percentage of the number of items as shown in Figure 4.27 below.

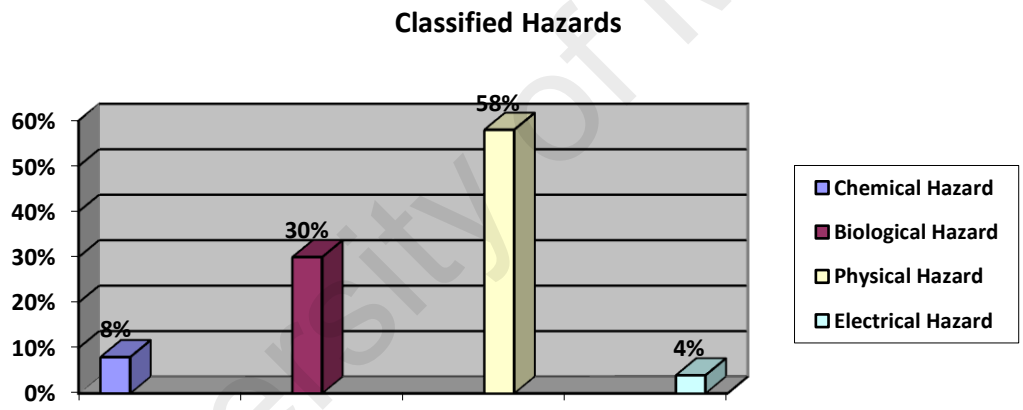

Figure 4.27: Percentage of four main classified hazards (Microbiological Laboratory 2-Bacteriology Laboratory)

The results of the bar chart, which is based on the findings, show that physical hazards at 58% is the main hazard that need to be considered in finding the best way to identify the main cause, prevent and control method. It follows by biological hazards at 30%, chemical hazards at 8% and electrical hazards at 4%.

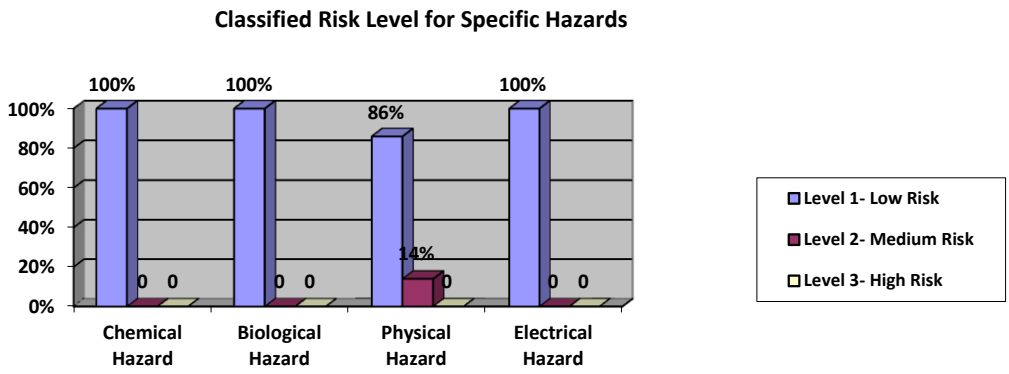

Figure 4.28: Classified three risk level results for four main hazards (Microbiological Laboratory 2- Bacteriology Laboratory).

According to Figure 4.28, the results for the classified risk level for each specific hazard indicates 100% lower risk, with no medium and high risk of a total of 8% of chemical hazards. Biological hazards show 100% lower risk, with no medium and high risk of a total of 30%. Physical hazards indicate 86% low risk, 14% medium risk and 0% of high risk from a total of 58%. The electrical hazards indicate 100% of low risk out of a total of 4% from classified risk. In general, the above data presents all hazards and their risk level classification in Microbiology Laboratory 2- Bacteriology Laboratory IBRC SIRIM Bhd.

4.5 General Discussion

Based from the HIRARC done to all 4 laboratories, most of the results show on the lower risk level for four main hazards. None of the results indicate any high risk level. The low level of risk was observed as manageable, if the risk can be resolved quickly. However, control actions should be established and be properly documented.

Regarding the safety study in the study area, The General Manager shall ensure that HIRARC has been carried out periodically for all facilities, equipment, research and new process/project involving all staff, contractors, sub-contractors, visitors and trainees. The Safety Coordinator is responsible for coordinating, preparing and updating the HIRARC Document in collaboration with other representatives, while the Safety Committee shall discuss the HIRARC and report to the Chairman of the Safety Committee any significant risk in the quarterly Safety Committee meeting; besides that, all employees must be in close communication with their supervisor for effective HIRARC implementation.

Below are the summary of the result in terms of awareness, implementation and practice of occupational safety and health in the four laboratories involved based on questionnaire given to random IBRC employee. Based on result, majority of the employees which is more than 70% of the employee aware, implement and practice the occupational safety guideline that have been adopt in IBRC culture. This shows that, IBRC, SIRIM Berhad focus on providing safety workplace to their staffs. The summary results as in **Table 4.13** below.

Table 4.13: Percentage of awareness, implementation and practice of occupational safety and health in IBRC, SIRIM Berhad.

	No of question out of 36	Percentage
Awareness	14	>70%
Implementation	10	>70%
Practice	12	>70%

Generally to ensure that the safety programme is running well in the laboratory system, it is important to have a well-established maintenance and supervision programme.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In conclusion, the selected laboratories in IBRC at SIRIM Bhd Shah Alam in a way have committed towards quality in safety and health, which is reflected in their certifications. Where it has implemented the OSH practices in the selected laboratories. With these accreditations, the management hopes to keep laboratories capable of providing a safe working environment.

Reviews on the effectiveness of WIs and SOPs proved that each laboratory has their own WI according to the research, experimentation and/or laboratory activity involved. MSDS were provided by the employer and employees aware of the existence of MSDS but not utilised frequently, as much as they refer to WIs in their daily routine.

The level of safety awareness, implementation and practices of OSH and ERP practices among the employer and employees in the study area can be considered to be in a good state. The employer provides information, knowledge and also materials to ensure the safety of the employees. It covers from the general work environment, information and posting on OSH, PPE, ventilation, training and ERP. From the facilities provided by the employer, employees have the responsibility to implement and practice the occupational safety and health in the workplace.

In general, the OSH practices and ERP have been practiced well in the study area. Still, there were some small areas that need to be looked at, where it might lead to bigger problems.

According to the study, the HIRARC were carried out for activities involved in the system of the selected laboratories to identify hazards, assess the risk level and find the best approach to control or reduce the impact of hazards. HIRARC shall be carried out in accordance to Guidelines for Hazard Identification, Risk Assessment and Risk Control (HIRARC) 2008. The HIRARC must be done prior to modifying or introducing new ways of working, work chemicals/materials or even new processes involve in the laboratory activities. The HIRARC should be reviewed and updated annually during document review session to ensure the effectiveness of the system.

The general risk assessment which was conducted in the study areas showed the laboratory is in safe condition where for Chemical Laboratory 1, 91% of hazards were considered as low risk and the remaining 9% is at medium risk; in Chemical Laboratory 2, 90% of hazards were considered as low risk and the remaining 10% is at medium risk; in Microbiological Laboratory 1, 90% of hazards were considered as low risk and the remaining 10% is at medium risk, and based on these study for Microbiological Laboratory 2, 92% of hazards were considered as low risk and the remaining 8% is at medium risk. Therefore, the outcomes of the risk assessment are recorded for action, to devise, maintain or improve controls.

Meanwhile, safety policies have a role in this study to prevent and control the hazard by applying training, education programmes and maintaining all classified documents related

to safety and health. Training and education programmes are essential to involve all employees rather than selecting employees as representatives.

5.2 Recommendations

This study has shown how the HIRARC model can be implemented in the laboratory system to ensure the whole system is in low risk and safe condition.

The OSH concept in the selected laboratories can be simplified as:
Work affects the OSH of employees in the laboratories, where it includes systems which contain hazards, which must be under control to minimise risk. This can be achieved by understanding the concept of OSH, which includes **monitoring** and **review** that will result in improvement in the OSH of employees in the laboratories.

The monitoring process can be considered as quality control where it includes observation and document analysis. These two elements combined will determine whether all employees are working with the safe work procedures outlined and if the work procedure is still relevant at the current stage. When there are safety procedures not being followed, the reason of that need to be found out. Some causes include:

- Several aspects of the safety procedure are not appropriate
- A new hazard has been identified in the system which needs to be checked.
- Employees have not been fully informed of the proper procedure.

The reviewing process can be considered as quality improvement where safety document, records of observations/inspection and safety audit form will be used as a component of the process. The review process will look at issues such as:

- Hazards and risks have been identified
- Changes in procedure
- Requirements of skills and knowledge

Review periods need to be set when establishing the implementation plan. Review periods can be either quarterly, bi-yearly or yearly. On the other hand, review changes can be made as a continuous improvement. Results from the review are designed from the information gathered during the monitoring/evaluation phase. This may involve reviewing the collected data as well as feedback. All changes made and their reasons for being made need to be documented. This information may be useful for future hazard control measures or/and the development of the new implementation plan. Monitoring strategies provide data to inform process improvement.

Monitoring and reviewing ensures that the best level of laboratories' OSH is maintained. The monitoring and review procedure must be taken out in discussion between employer and employees. Discussions between employees' regarding responsibility for creating the hazard control implementation plan and monitoring should be designed, open and responsive. More participation from employees will actually help them to understand their roles and responsibility in OSH system. This will permit everyone to experience an opportunity to clarify the monitoring process, voice any concerns with the selection of

monitoring strategies allow the individuals responsible for showing the plan to hold the monitoring standards. This discussion should be done on a regular basis.

The following recommendations are given which can help to improve safety and health in the laboratory system:

1. Workplace inspections can be a good way to check and control the system by applying monitoring control. If the HIRARC is applied well, identified hazards are under control and mitigated enough; as a result, it helps in running the laboratory system efficiently with lower risk.
2. Workplace OSH activities should focus on preventing new cases of illness and injury.
3. Updating and improving the safety programme is the other effective way to keep the laboratory system as a safe workplace. These programmes include training and educating of all employees.
4. Participation from all groups in building safety consciousness in order to create and maintain a safe working environment is important.
5. The employer has primary responsibility for workplace OSH while employees have responsibility for their safety, through how they act/work in their workplaces.
6. Workplace OSH activities must be based on reasonability and practicability, given particular conditions.

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