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UAlberta
iGEM

ASHBLOOM

Preliminary Hazard Analysis (PHA)

@igem.ualberta

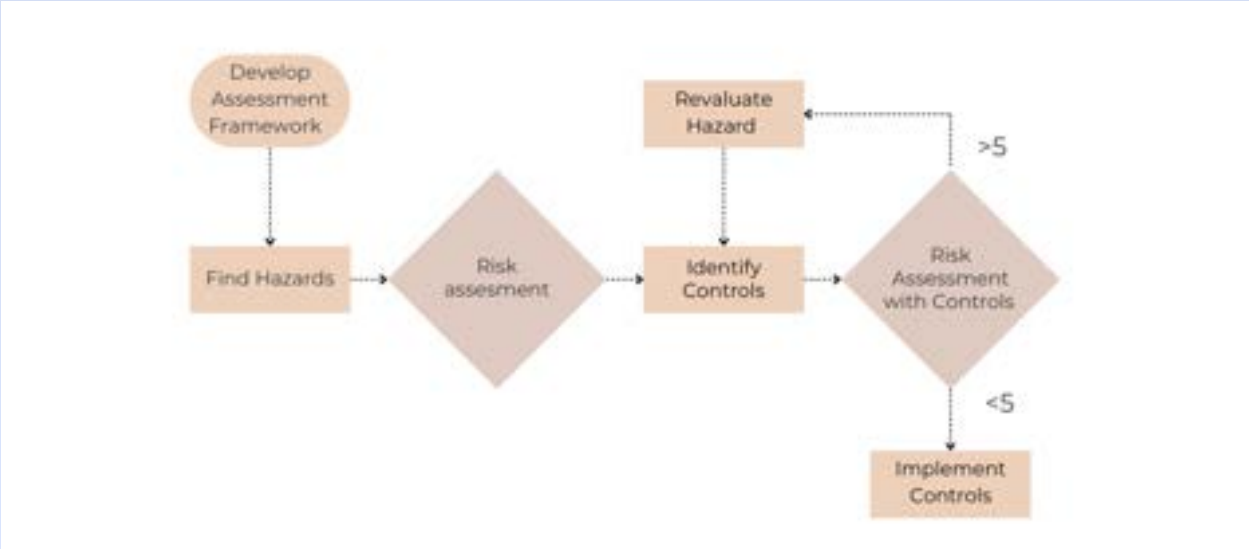
Introduction

Safety in the wet lab is essential, not only to ensure that personnel remain healthy and unharmed during experiments, but also to guarantee that the resulting product does not pose risks to people or the environment. Conducting a Preliminary Hazard Analysis (PHA) is a crucial first step in preventing accidents. This analysis helps identify and evaluate potential hazards in the lab, providing a foundational overview of risks that could affect health, safety, or the environment. By doing so, it enables the development of targeted mitigation strategies and helps prioritize which hazards require further detailed study. Ultimately, a PHA establishes the groundwork for an effective risk management system and strengthens overall preparedness.

A PHA is an early-stage risk assessment aimed at identifying all potential hazards and hazardous events that could occur during wet lab protocols and related activities. The two key components of risk assessment are *hazards* and *consequences*, which must be clearly defined and distinguished. A hazard refers to the potential for harm to occur, while consequences describe the actual effects of that harm. Identifying potential consequences allows for a more accurate and comprehensive evaluation of each hazard's severity and supports the development of effective risk controls.

Risk assessment, while highly customizable, is also a systematic process used to identify, evaluate, and implement controls for hazards that could negatively impact the process, product, or personnel. A variety of tools and models can be employed to address the wide range of scenarios requiring evaluation. PHA was selected for this assessment because it serves as a precursor to more advanced hazard assessment models. Additionally, given the minimal presence of hazardous materials, both chemical and biological, in the Biosafety Level 1 (BSL-1) laboratory used by the team, PHA was determined to be an appropriate framework for evaluating risk and ensuring safety. Expert consultation further confirmed that this approach would provide a solid foundation for our risk management efforts, offering both reliability and flexibility should more advanced assessments be required later on.

Preliminary Hazard Assessment Flowchart



Identification of the Risk Rate & Developing Assessment Framework

The risk rating score is a numerical representation of the criticality of each identified hazard. It serves as a tool to communicate the level of a risk and its urgency in a clear, standardized way.

This score is based on two combined variables: the likelihood of the event occurring and the significance of the consequences should the event occur. These variables are multiplied to generate an overall score, which is then assigned a corresponding colour to indicate the hazard's criticality. While probability and severity are standardized variables, the specific factors that influence the numerical outcome can be adjusted to fit particular scenarios.

As representatives of the University of Alberta, the UAlberta iGEM team aligned the consequence variables with the values outlined in the University of Alberta Risk Management Program (1). This program promotes risk awareness and provides an Enterprise Risk Management (ERM) framework and policy that serves as the basis for the consequence factors. The ERM policy defines the university's approach to risk management, while the framework guides practical implementation, offering tools to integrate risk management into daily activities effectively.

In wet lab safety, one of the main priorities is protecting the health and safety of those performing experiments, making consequences a key factor in risk evaluation. Given that the UAlberta iGEM chose Climate Crisis as our village, environmental impacts were also considered when assessing consequences. Additionally, because the team works with genetically modified organisms, precautions are necessary to prevent unintended release into the environment. Finally, financial consequences are an important consideration as well, as the UAlberta iGEM team is fully responsible for securing its own funding. Thus, significant financial losses could jeopardize research and the ability to compete, making financial risk a critical component of the consequence variable.

Table 1. Variables used to evaluate risks and assess consequences to prioritize response actions. Adapted and modified from the University of Alberta Faculty of Science template for our purposes.

RR	Likelihood: Operational Considerations	RR	Consequence: General Rating	Health and Safety	Environment	Financial
5	Almost Certain - This has happened, happens frequently, or will most certainly happen without proper controls	5	High	One or more fatalities	Very Serious and potentially irreversible effect on the environment	Any financial loss greater than $4000
4	Likely - This has happened, happens regularly, or is likely to occur without proper controls	4	Major	Permanently disabling injuries to one or more individuals	Major Long term damage to environment, reportable to regulatory authorities	Loss of Around $2000
3	Moderate - This has happened, happens infrequently, or it could occur without proper controls	3	Moderate	Serious injuries to one or more individuals or minor injuries to three or more	Serious medium term environmental effect	Loss of Around $800

2	Unlikely - This may or may not have happened, happens very infrequently, or is unlikely to occur even without proper controls.	**2**	Minor	Minor injuries to one or two individuals	Short term effects to the environment	Loss of Around $400

Development of Preliminary Hazard Analysis

The PHA was conducted both before control measures were introduced and after they were implemented. Evaluating risk at both stages allowed the team to confirm that all necessary precautions were addressed and to determine whether any remaining hazards required additional mitigation. This comparison also highlighted the importance and effectiveness of each control measure for the team members responsible for operationalizing the PHA.

For each identified hazard (Table 2), the corresponding consequences were listed to create a more thorough and organized risk assessment. Each laboratory protocol was assigned its own section, along with its specific hazards and controls, to make the information easy to reference. Table 2 also serves as an overview of the safety component included in each Standard Operating Procedure (SOP).

To strengthen their safety practices, the UAlberta iGEM team organized a workshop on risk assessment, led by Lucca Filippo, a Master of Engineering Management student from the Lynch School of Engineering Safety and Risk Management at the University of Alberta. During the session, team members learned about safe handling of regulated biological materials and took part in a virtual tour of the university’s biosafety resources. They also engaged with the University's biosafety officer and representatives from the Public Health Agency of Canada, gaining insight into risk management practices at institutional and federal levels.

The workshop introduced a structured approach to assessing laboratory risks and familiarized participants with key safety terminology. Team members were shown how to evaluate hazards from several perspectives, namely health, environmental, and financial, and were taught how to use risk matrices to quantify and prioritize risks.

These exercises promoted a more systematic and analytical approach to hazard assessment.

As part of the workshop, the team gave Lucca a guided tour of their lab, during which he helped identify real hazards within their own workspace. This activity marked the team's first exposure to Preliminary Hazard Analysis. With Lucca's mentorship, they completed a practice PHA, which laid the foundation for their official analysis. A follow-up meeting provided additional guidance, during which Lucca recommended conducting a comprehensive PHA and shared his thesis, which helped the team refine their methodology and project structure. This process gave the team a solid foundation for performing a formal and well-documented Preliminary Hazard Analysis.

Table 2. UAlberta iGEM Laboratory Hazard Risk Assessment and Control.
Evaluation of laboratory protocols to identify hazards and evaluate risk. Each hazard is listed with the risk rating before and after the controls to evaluate the effectiveness of the current controls and to see if any more controls need to be implemented.

Task/Step/ Activity	Hazard	Consequences	Pre-Control Risk Rating			Existing Controls or Controls Needed	Post-Control Risk Rating		
			L	C	Total		L	C	Total
Operation of Micropipettor	**Repetitive Movement**	**Repetitive movement stress**	**4**	**2**	**8**	*Take frequent breaks, organize work area*	**2**	**2**	**4**
	Bacteria Causing Disease in Humans, Plants or Animals	**Infection in Human, plant or animal**	**4**	**3**	**12**	*Wear appropriate PPE (lab coat/gown, Safety glasses), practice aseptic technique, report any exposures*	**2**	**2**	**4**
Culturing Bacteria - *P.putida*	**Bacteria Causing Disease in Humans, Plants or Animals**	**Infection in Human, plant or animal**	**4**	**3**	**12**	*Wear appropriate PPE (lab coat/gown, Safety glasses), practice aseptic technique, report any exposures*	**2**	**2**	**4**
	Working with a Bunsen	**Burns, equipment catches fire**	**4**	**4**	**16**	*Refer to SOP for proper operation of burner, keep area*	**2**	**2**	**4**

	Burner					*around burner clear of flammable materials.*			
	Working with blades	**Cut due to improper use**	**4**	**3**	**12**	*Appropriate PPE (lab coat/gown, face shield and glasses, insulated gloves).*	**2**	**2**	**4**
Assay for Quantification of Rhamnolipid	**Heating tubes**	**Burns, broken glass**	**4**	**4**	**16**	*Refer to SOP for proper operation of Heat Reaction. Appropriate PPE (lab coat/gown, safety glasses, insulated gloves).*	**2**	**2**	**4**
	Working with Sulfuric acid	**Acid burn, Corrosion due to acid exposure**	**4**	**4**	**16**	*Wear appropriate PPE (lab coat/gown, Safety glasses, disposable gloves), refer to SOP for proper use,Refer to SOP for proper disposal instructions.*	**2**	**2**	**4**
	Work with glass	**Cuts due to broken glass**	**4**	**3**	**12**	*Wear appropriate PPE (lab coat/gown, face shield, disposable gloves), Use proper disposal containers*	**2**	**2**	**4**
	Toxic Materials (orcinol)	**Equipment or person catching fire, Burn, Toxic with inhalation**	**4**	**3**	**12**	*Store in proper safety cabinets, Wear appropriate PPE(Lab coat, Safety goggles, Face shield, Nitrile Gloves, Close Toed Shoes)*	**2**	**2**	**4**
	Flammable Dust	**Equipment or person catching fire**	**3**	**4**	**12**	*Keep away from open flame, Store in proper safety cabinet*	**1**	**3**	**3**

DNA Extraction	**Bacteria Causing Disease in Humans, Plants or Animals**	**Infection in Humans, Plants or animals**	**4**	**3**	**12**	*Wear appropriate PPE (lab coat/gown, Safety glasses), practice aseptic technique, report any exposures, clean all surfaces after use*	**2**	**2**	**4**
	Working with Acid	**Burns, Corrodes equipment, Irritant, Toxic**	**4**	**4**	**16**	*Wear appropriate PPE (lab coat/gown, face shield, disposable gloves), refer to SOP for proper use of portable UV light source, report any exposures*	**2**	**2**	**4**
	Toxic Materials	**Carcenagen, Irritant, Toxic**	**4**	**4**	**16**	*Wear appropriate PPE (lab coat/gown, Safety glasses, disposable gloves, Face shield), refer to SOP for proper use, wipe up spills immediately,*	**2**	**2**	**48o l**
	Pressurized tubes	**Explosion**	**3**	**4**	**8**	*Wear appropriate PPE(Lab coat, gloves, safety glasses, closed toed shoes), Refer to the SOP for proper use(open in fume hood, let vials cool)*	**2**	**3**	**6**
deBont Media Protocol	**Dry powder Inhalation**	**Respiratory Track Irritation**	**4**	**2**	**8**	*Refer to SOP for deBont Media*	**2**	**2**	**4**
	Using autoclave	**Burn due to touching equipment**	**4**	**3**	**12**	*Autoclave training, Proper PPE (Lab coat, gloves)*	**2**	**2**	**4**
Colony PCR	**Irritant Materials**	**Irritates skin and eyes, Allergic reaction**	**4**	**2**	**8**	*Wear appropriate PPE(Lab coat, closed toed shoes, safety goggles,)*	**2**	**1**	**2**

	Bacteria Causing Disease in Humans, Plants or Animals	**Infection in Huaman, Plant or Animal**	**4**	**3**	**12**	*Wear appropriate PPE (lab coat/gown, Safety glasses), practice aseptic technique, report any exposures*	**2**	**2**	**4**
Miniprep	**Bacteria Causing Disease in Humans, Plants or Animals**	**Infection in Huaman, Plant or Animal**	**4**	**3**	**12**	*Wear appropriate PPE (lab coat/gown, Safety glasses), practice aseptic technique, report any exposures*	**2**	**2**	**4**
	Highly Reactive Materials	**Explosion**	**3**	**4**	**12**	*Store properly, Refer to SOP for Mini prep*	**2**	**4**	**8**
	Working with acid	**Burns or corrodes equipment due to exposure to acid**	**3**	**3**	**9**	*Refer to SOP for Mini Prep, Wear proper PPE(Lab coat, Safety glasses, closed toed shoes)*	**2**	**2**	**4**
	Flammable	**Equipment catches on fire, Burns due to ignition of solvent**	**3**	**3**	**9**	*Refer to SOP for Mini Prep, Store properly*	**2**	**3**	**6**
Electroporation	**Working with high voltage machine**	**Electric Shock or Burn due to touching wire**	**4**	**4**	**16**	*Proper training, keep well maintained condition, wear appropriate PPE, Refer to SOP for electroporation and how to prevent arcing*	**2**	**4**	**8**
Gibson Assembly	**Bacteria causing Disease in Humans, Plants or Animals**	**Infection in Huaman, Plant or Animal**	**4**	**3**	**12**	*Wear appropriate PPE (lab coat/gown, Safety glasses), practice aseptic technique, report any exposures*	**2**	**2**	**4**
	Working with Irritant	**Irritates skin and eyes, Allergic reaction**	**4**	**2**	**8**	*Wear appropriate PPE(Lab coat, Safety glasses, closed toed*	**2**	**1**	**2**

						shoes)			
Electrophoresis	**Working with heated agarose**	**Burns due to a spill or touching hot glass**	**4**	**4**	**16**	*Wear appropriate PPE(Lab coat, safety glasses, closed toed shoes, heat protecting gloves)*	**2**	**1**	**2**
	UV radiation	**Cancer or Burn due to UV exposure**	**3**	**4**	**12**	*Refer to SOP on Electrophoresis*	**2**	**1**	**2**
	Working with high voltage machine	**Electrical Shock due to exposed wire**	**4**	**3**	**12**	*Proper training, Refer to SOP of electrophoresis*	**2**	**2**	**4**
	Mutagen	**Cancer due to Exposure to Mutagen**	**4**	**4**	**16**	*Wear appropriate PPE (Lab coat, safety googles, nitrile gloves, closed toed shoes)*	**2**	**3**	**6**

Conclusion

The findings of the Preliminary Hazard Analysis (PHA) indicated that the existing control measures in the laboratory were sufficient and effective. The assessment reinforced the importance of adhering to these established protocols, demonstrating that consistent compliance significantly reduces risks and promotes a safer work environment. Sharing the results with the entire team increased awareness of both the controls in place and the potential consequences of non-compliance, encouraging greater accountability and safer lab practices overall.

Although the PHA did not lead to the addition of new controls, it provided an important opportunity to scrutinize existing ones. Additionally, this review process allowed the team to identify that the laboratory's eyewash station was not functioning properly at the time of the safety workshop, prompting a report to the University of Alberta's Health, Safety and Environment (HSE) team. Taking corrective action not only improved laboratory safety but also gave the team valuable experience in navigating the HSE reporting process, which will be beneficial for any future safety concerns.

This process also reinforced the importance of maintaining key safety practices, such as ensuring that all wet lab members obtain official autoclave training before beginning experimental work. Moreover it solidified the requirement for team members to complete a series of safety courses prior to entering the wet lab, further strengthening the culture of safety established through the PHA.

References:

(1) University of Alberta. (2023). Enterprise Risk Management Framework. https://www.ualberta.ca/en/alfresco/uappol/administrationoperations/risk-management/framework/enterprise-risk-management-framework.pdf