

Work Accident Risk Analysis in Water Treatment Plant Laboratory of PT XYZ using JSA and HIRARC Methods

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Article Information	ABSTRACT
Article History Received : September 15, 2025 Revised : October 10, 2025 Published : October 20, 2025	PT. XYZ produces fertilizers and chemicals for agro-industrial solutions. To maintain product quality, quality control is carried out in the water treatment laboratory. The increasing complexity of laboratory activities increases the risk of workplace accidents, such as inhaling reactive chemicals that can irritate the respiratory system and cause poisoning, or slipping while taking samples, which can cause injury. This study aims to analyze potential hazards and design control recommendations using the Job Safety Analysis (JSA) and Hazard Identification, Risk Assessment, and Risk Control (HIRARC) methods. Data were collected through interviews with employees and questionnaires assessing the likelihood and severity of hazards. The results of the study identified 12 potential hazards spread across 4 work activities. There were 2 very high-level hazards, 9 high-level hazards, and 1 moderate-level hazard. This study provides control recommendations to reduce risks, such as controls including the use of appropriate Personal Protective Equipment (PPE) etc., thereby supporting improved workplace safety at the PT. XYZ laboratory.
Keywords: <i>Workplace Accidents; Job Safety Analysis; HIRARC.</i>	

INTRODUCTION

Technological advancements in the industrial sector have improved productivity and convenience but also increased potential workplace accident risks. These accidents can harm workers physically and psychologically, disrupt operations, and reduce productivity. According to the Occupational Safety and Health Administration Guidelines, they may also cause significant financial losses. Therefore, Occupational Safety and Health (OSH) is essential in industrial production processes. Workplace accidents are incidents that occur during work activities, resulting in physical injuries that may be visible or invisible (Pratama & Apsari, 2024). Factors contributing to workplace accidents include technical aspects and the work environment as the main causes, as well as human factors. Mechanical and environmental conditions can also be categorized based on specific objectives (Wiryawan, 2024). However, the causes of workplace accidents are not limited to these factors alone (Afifudin, 2023).

PT. XYZ is a company engaged in the production of fertilizers and chemicals for agro-industrial solutions. To ensure product quality, quality control activities are conducted in the water treatment laboratory unit. As the complexity of laboratory activities increases, the risk of workplace accidents also rises. Between January and April 2025, notable incidents included 37 cases of gas bomb sample leaks, 24 cases of chemical inhalation affecting the respiratory system and posing a risk of acute poisoning, 8 slipping incidents during sampling that resulted in minor to moderate injuries, and 7 chemical splash incidents causing skin and eye irritation with the potential to lead to chemical burns. These conditions not only elevate the risk of serious injuries or fatalities but also negatively impact overall company productivity.

Previous studies have highlighted the importance of implementing OSH systems in laboratory environments. Laboratory settings inherently involve high hazard potential, and improper laboratory practices can endanger workers and lead to occupational injuries (Kyungsoo et al., 2023). Similarly, *Occupational Risk Assessment in Chemical Laboratories* emphasizes that the greatest risks stem from chemical exposure, worker negligence, and improper use of personal protective equipment (PPE). However, most of these studies remain general in scope and have not specifically identified potential hazards in water treatment laboratory activities within the fertilizer and chemical industry sector.

Based on these issues, the present study aims to analyze potential hazards in work activities and develop targeted improvement recommendations to control risks in the water treatment laboratory by applying the Job Safety Analysis (JSA) and Hazard Identification, Risk Assessment, and Risk Control (HIRARC) methods. The analysis utilizes JSA and HIRARC to provide a comprehensive risk mapping and clear prioritization of control measures. The findings are expected to offer a practical contribution to company management in strengthening OSH systems, reducing workplace accident rates, and fostering a safer and more productive laboratory work environment.

RESEARCH METHODS

The research was conducted from January 2025 to April 2025. The focus of the study was the laboratory area of the PT. XYZ water treatment plant. The research design employed was a descriptive study, aimed at systematically and accurately describing or illustrating the facts. During the research process, direct interviews were conducted with employees in the water treatment plant laboratory unit, and questionnaires were distributed to 10 respondents consisting of workers and related personnel in the Water Treatment Plant Laboratory with a minimum of one year of work experience. The data collection techniques included field observations, in-depth interviews, and questionnaire distribution. The questionnaire utilized two scales likelihood and severity to assess the level of risk associated with potential hazards in the workplace.

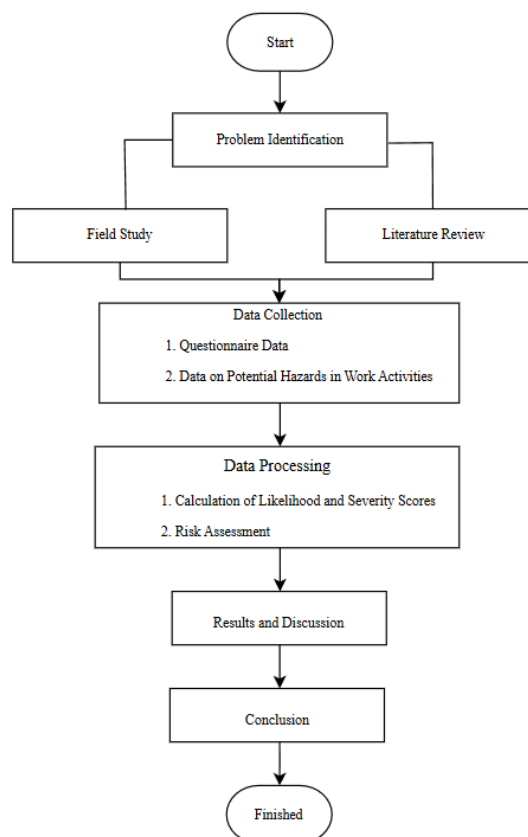


Figure 1. Flowchart

Figure 1 presents the flowchart that outlines the entire research process. The study begins with problem identification to define the main issue being addressed. This is followed by a field study to obtain direct data from the workplace and a literature review to build a strong theoretical foundation. The next step is data collection, which involves gathering questionnaire data and identifying potential hazards in work activities. The collected data is then processed by calculating likelihood and severity scores, followed by a risk assessment to determine the level of each identified hazard. The results and discussion stage explains and analyzes the findings in detail. Finally, the research concludes with a summary of key results and recommendations for appropriate risk control measures. The process ends with the finished stage, marking the completion of the research flow.

Job Safety Analysis (JSA)

Job Safety Analysis is one of the safety management methods that focuses on hazard control and identification related to a series of work activities (Saputra et al., 2021). Job Safety Analysis aims to detect potential hazards in each stage of work activities, enabling workers to understand and recognize potential risks in the workplace before accidents occur (Putri Sakinah, 2022). The implementation of Job Safety Analysis consists of three stages: selecting specific jobs or activities and breaking them down into work steps, identifying all possible workplace accidents that could occur at each work step, and controlling all risks to minimize actions in accordance with preventive procedures (Widjaya & Mahbubah, 2022).

Hazard Identification Risk Assessment and Risk Control (HIRARC)

Hazard Identification Risk Assessment and Risk Control (HIRARC) is a method for assessing occupational safety and health risks and serves as a basic reference for mitigating identified work risks, aiming to determine the potential hazards that may occur in the work (Triswandana & Armaeni, 2020). HIRARC is divided into three stages: hazard identification, risk assessment, and risk control (Prasetyo et al., 2023). After observing and identifying hazards in work activities at the water treatment plant laboratory, a risk assessment was conducted. The risk assessment was obtained from a combination of the probability of a hazard occurring (Likelihood) and the severity of the consequences if the hazard occurs (Severity) (Azzahra et al., 2022). The product of likelihood and severity yields the risk level. To determine the likelihood and impact in the calculation of the risk level, the severity/likelihood index (SI/LI) is applied, which can be calculated using the following formula (Al-Hammad & Assaf, 1996).

$$SI/LI = \frac{\sum(a_i \times x_i)}{5\sum x} \times 100\%$$

a_i = Likelihood/severity scale value

x_i = Number of respondents who gave score a_i

Table 1. Likelihood Scale (AS/NZS 4360:2004)

Level	Description	Information	Likelihood Index (%)
5	Almost	Incidents occur very frequently	81-100
4	Likely	Incidents occur frequently	61-80
3	Possible	Incidents occur under certain conditions	41-60
2	Unlikely	Incidents are very rare	21-40
1	Rare	Incidents are almost impossible	0-20

Table 2. Severity Scale (AS/NZS 4360:2004)

Level	Description	Information	Severity Index (%)
1	Insignificant	Incidents that do not impact workers	0-20
2	Minor	Incidents that have a minor impact on workers	21-40
3	Moderate	Incidents that cause moderate injuries and minor material losses	41-60
4	Major	Incidents that cause serious injuries and moderate losses	61-80
5	Catastrophic	Incident causes fatal injuries and major losses	81-100

Once the likelihood and severity scales of each activity's risk are known, the level of risk can be determined and categorized as low, medium, high, or extreme. This can be determined using the Risk Assessment Matrix Level (Purbarani, 2024). This matrix is used to identify risks that require a quick response, based on the combination of the likelihood of occurrence and the magnitude of the impact caused (Aisyah & Dahlia, 2022). The result of this combination produces a risk level that indicates the magnitude of a risk and how to manage it.

Table 3. Risk Assessment Matrix Level

Likelihood of Hazard	Severity of Hazard				
	Insignificant 1	Minor 2	Moderate 3	Major 4	Catastrophic 5
5 (Almost)	High	High	<i>Extremely</i>	<i>Extremely</i>	<i>Extremely</i>
4 (Likely)	Medium	High	High	<i>Extremely</i>	<i>Extremely</i>
3 (Possible)	Low	Medium	High	<i>Extremely</i>	<i>Extremely</i>
2 (Unlikely)	Low	Low	Medium	<i>High</i>	<i>Extremely</i>
1 (Rare)	Low	Low	Medium	<i>High</i>	<i>High</i>

Description:

Low : Acceptable risk, minimal control measures required.

Medium : Acceptable risk with supervision, additional controls required.

High : Significant risk requiring immediate management and control.

Extremely : Very high risk requiring immediate attention and stricter controls, possibly even temporary suspension of work.

Integration of Job Safety Analysis (JSA) and Hazard Identification, Risk Assessment, and Risk Control (HIRARC)

The Job Safety Analysis (JSA) and Hazard Identification, Risk Assessment, and Risk Control (HIRARC) methods are integrated to obtain a more comprehensive risk analysis result. Through JSA, hazards are identified by selecting the job to be analyzed, breaking it down into work steps, assessing the potential hazards at each step, and determining appropriate control measures. The results of this identification are then further analyzed using HIRARC. At this stage, risk assessment is conducted by identifying hazards in each work step, evaluating the effectiveness of existing controls, and assessing the probability (*likelihood*) and the severity of potential consequences. The combination of these two methods enables a more systematic determination of risk levels (Sertyaning Ari et al., 2024).

RESULTS AND DISCUSSION

Identification of Potential Hazards with Job Safety Analysis (JSA)

The first step in this stage is to observe and identify hazards in work activities at the water treatment plant laboratory. There are four work processes in the water treatment plant laboratory. At the start of the shift, the sample technician collects samples from designated areas in the plant. The samples collected include Mixedbed, Reverse Osmosis, Demin, Condensate Turbine Amurea, Condensate Tank, Cation Exchanger, and UF Outlet Water. Then analyze pH, conductivity, Fe, FMA, TH, NH₄, turbidity, and SiO₂ in the water treatment plant laboratory. After that, clean up the analysis residue and wash the analysis equipment with clean water. The analysis results are then recorded in the laboratory logbook and computer. The following is a summary of the questionnaire results based on likelihood. This summary provides an overview of the likelihood of an event or condition according to the respondents' perceptions.

Table 4. Summary of Questionnaire Results Based on Likelihood

Work Activity	Risk	Likelihood				
		1	2	3	4	5
Sampling (<i>Mixed, Reverse Osmosis, Demin, Condensate Turbin Amurea, Condensate Tank, Cation Exchanger, UF Outlet Water.</i>)	Spillage of hot solution during sample collection	0	1	5	3	1
	Hearing impairment during sample collection	0	1	2	3	4
	Inhalation of toxic gases during sample collection	0	1	4	3	2
	Falling during sample collection due to high and slippery locations	0	0	4	2	4
Analysis (pH, Conductivity, Fe, FMA, TH, NH ₄ , Turbidity, SiO ₂)	Chemical splashes during analysis	0	1	2	4	3
	Chemical inhalation during analysis	0	0	0	4	6
	Contact with hot glass during analysis	0	1	2	5	2
	Risk of being cut by broken glass when cleaning broken equipment	0	1	4	2	3
Cleaning up residual waste from analysis	Inhalation of chemicals that react when cleaning waste residue Analysis	1	0	2	3	4
	Spillage of chemicals when cleaning waste residue Analysis	0	0	1	7	2
	Sitting in the same position for a long time in front of a computer or laptop	0	3	3	3	1
Working in front of a computer	Staring at a computer or laptop screen for a long time	0	4	3	3	0

The following is a summary of the results of the questionnaire distributed to respondents based on severity to assess the impact or consequences that may arise if a risk or event actually occurs. This summary provides an overview of the magnitude of the impact on individuals, organizations, the environment, or the system as a whole.

Table 5. Summary of Questionnaire Results Based on Severity

Work Activity	Risk	Severity				
		1	2	3	4	5
Sampling (<i>Mixed, Reverse Osmosis, Demin, Condensate Turbin Amurea, Condensate Tank, Cation Exchanger, UF Outlet Water.</i>)	Blisters on the hands due to contact with hot liquids	2	4	4	0	0
	Hearing impairment due to noisy environments	2	3	4	1	0
	Dizziness, shortness of breath, and coughing due to inhalation of toxic gases during sampling	2	4	2	1	1
	Broken bones and sprains due to falls from high or slippery places	0	3	4	3	0
	Skin irritation, itching, and burns while conducting analysis	1	4	4	1	0
Analysis (pH, Conductivity, Fe, FMA, TH, NH ₄ , Turbidity, SiO ₂)	Coughing and shortness of breath due to inhalation of chemicals while conducting analysis	2	1	6	0	1
	Blistering of the skin due to contact with hot glass while conducting analysis	1	6	3	0	0
	Injured by broken glass while cleaning damaged equipment	0	6	3	1	0
Cleaning up residual waste from analysis	Irritation of the nose and throat due to inhalation of chemicals that reacted while cleaning waste residue Analysis	2	2	4	1	1
	Dermatitis and burns due to exposure to corrosive chemicals	2	3	3	2	0

	while cleaning waste residue				
	Analysis				
	Back and neck pain due to sitting in the same position for long periods of time in front of a computer or laptop	6	4	0	0
Working in front of a computer	Vision problems due to staring at a computer or laptop screen for long periods of time	7	3	0	0

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

The calculation of the Likelihood Index measures the probability of a hazard or risk occurring (Faradillah et al., 2024). The following is an example of the calculation of the likelihood index for sampling activities (Mixbed, Reverse Osmosis, Demin, Amurea Turbine Condensate, Condensate Tank, Cation Exchanger, UF Outlet Water).

1. Spillage of hot solution during sample collection

$$LI = \frac{\sum_{i=0}^5 a_i \times X_i}{5N}$$

$$LI = \frac{(1 \times 0) + (2 \times 1) + (3 \times 5) + (4 \times 3) + (5 \times 1)}{5 \times 10} \times 100\%$$

$$LI = \frac{0 + 2 + 15 + 12 + 5}{50} \times 100\%$$

$$LI = 68\%$$

The Severity Index calculation measures the impact of the risk if an incident occurs (Saruni et al., 2025). The following is an example of the likelihood index calculation for sampling activities (Mixbed, Reverse Osmosis, Demin, Amurea Turbine Condensate, Condensate Tank, Cation Exchanger, UF Outlet Water).

1. Blisters on the hands due to contact with hot liquids

$$SI = \frac{\sum_{i=0}^5 a_i \times n_i}{5N}$$

$$SI = \frac{(1 \times 2) + (2 \times 4) + (3 \times 4) + (4 \times 0) + (5 \times 0)}{5 \times 10} \times 100\%$$

$$SI = \frac{2 + 8 + 12 + 0 + 0}{50} \times 100\%$$

$$SI = 44\%$$

After obtaining the results from the Likelihood Index and Severity Index calculations, the next step is to conduct risk control and risk assessment. Risk assessment is used to determine the level of risk in terms of the likelihood of occurrence and the severity that may be caused (Urrohman & Riandadari, 2019). The method for determining the risk value is by using a risk assessment matrix, by multiplying the likelihood value and the severity value (Smarandana et al., 2021). Risk assessment aims to understand the level of risk from several identified hazards (Abryandoko, 2018). The risk assessment table will explain the types of workplace accidents that commonly occur, along with the results of the risk assessment analysis based on the combination of severity and likelihood values.

Table 6. Risk Assessment of Identified Hazards

No	Risk	Likelihood Index (LI)	Likelihood Scale	Impact	Severity Index (SI)	Severity Scale	Risk Level
1.	Spillage of hot solution during sample collection	68%	4	Blisters on the hands due to contact with hot liquids	44%	3	High
2.	Hearing impairment during sample collection	80%	4	Hearing impairment due to noisy environments	48%	3	High
3.	Inhalation of toxic gases during sample collection	72%	4	Dizziness, shortness of breath, and coughing due to inhalation of toxic gases during sampling	50%	3	High
4.	Falling during sample collection due to high and slippery locations	80%	4	Broken bones and sprains due to falls from high or slippery places	60%	3	High
5.	Chemical splashes during analysis	78%	4	Skin irritation, itching, and burns while conducting analysis	50%	3	High
6.	Chemical inhalation during analysis	92%	5	Coughing and shortness of breath due to inhalation of chemicals while conducting analysis	54%	3	<i>Extremely</i>
7.	Contact with hot glass during analysis	76%	4	Blistering of the skin due to contact with hot glass while conducting analysis	42%	3	High
8.	Risk of being cut by broken glass when cleaning broken equipment	74%	4	Injured by broken glass while cleaning damaged equipment	50%	3	High
9.	Inhalation of chemicals that react when cleaning waste residue Analysis	78%	4	Irritation of the nose and throat due to inhalation of chemicals that reacted while cleaning waste residue Analysis	54%	3	High
10.	Spillage of chemicals when cleaning waste residue Analysis	82%	5	Dermatitis and burns due to exposure to corrosive chemicals while cleaning waste residue Analysis	50%	3	<i>Extremely</i>
11.	Sitting in the same position for a long time in front of a computer or laptop	64%	4	Back and neck pain due to sitting in the same position for long periods of time in front of a computer or laptop	28%	2	High
12.	Staring at a computer or laptop screen for a long time	58%	3	Vision problems due to staring at a computer or laptop screen for long periods of time	26%	2	Medium

The risk assessment table shows that 12 potential hazards were identified from 4 work activities. The classification is as follows: 1 potential hazard is classified as medium risk, 9 potential hazards are classified as high risk, and 2 potential hazards are classified as extremely high risk. The following line chart illustrates the proportion of risk levels from the identified potential hazards.

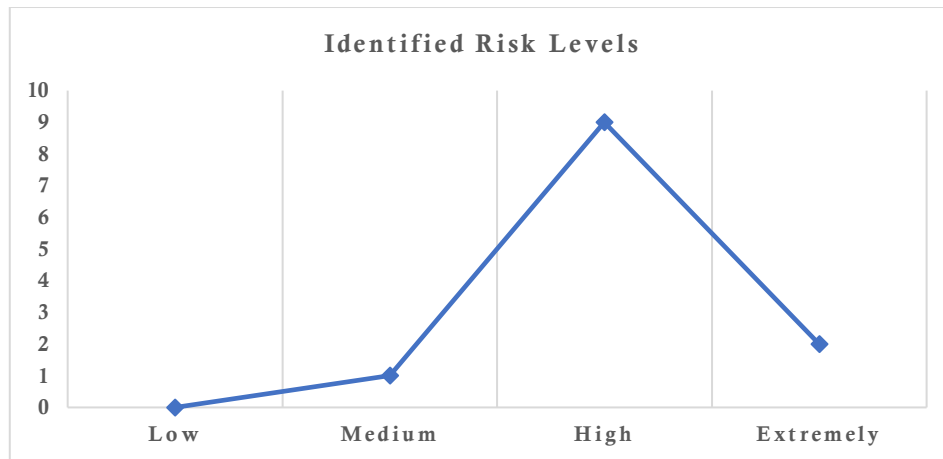


Figure 2. Identified risk level

The line chart illustrates the proportion of each risk category. Most hazards fall into the high category (nine), followed by extremely (two), medium (one), and low (zero). This visualization clearly highlights the dominant risk level, providing valuable information for prioritizing appropriate risk control measures.

Following the hazard identification and risk assessment stages, the next step is risk control. In this study, risk control is implemented by starting with the highest risk and proceeding to the lowest risk. This risk control mechanism aims to reduce the impact of risk variables to prevent workplace accidents (Alfiyah et al., 2023). This method aims to handle and prevent risks in the best way possible, while considering all the options available that fit the company's situation (Hamdani & Andesta, 2024). Here are some recommendations for improvements using the Hierarchy of Control based on OHSAS 18001.

Table 7. Improvement Recommendation

Work Steps	Potential Hazards	Impact	Safety Procedure Recommendations
Sampling (<i>Mixed, Reverse Osmosis, Demin, Condensate Turbin Amurea, Condensate Tank, Cation Exchanger, UF Outlet Water.</i>)	1. Spilling hot liquids	1. Blistered hands	1. Use of Personal Protective Equipment (safety helmet, safety shoes, heat-resistant gloves, ear plugs, gas/dust masks, goggles)
	2. Hearing impairment	2. Hearing impairment	2. Use of Personal Protective Equipment (safety helmet, safety shoes, heat-resistant gloves, ear plugs, gas/dust masks, goggles)
	3. Inhaling toxic gases	3. Dizziness, shortness of breath, and coughing	3. Use of Personal Protective Equipment (safety helmet, safety shoes, heat-resistant gloves, ear plugs, gas/dust masks, goggles)
	4. Falling while taking samples from high places	4. Broken bones, sprains, and death	4. Use of Personal Protective Equipment (safety helmet, safety shoes, heat-resistant gloves, ear plugs, gas/dust masks, goggles, body harness)
Analysis (pH, Conductivity, Fe, FMA, TH, NH ₄ , Turbidity, SiO ₂)	1. Chemical splashes	1. Skin irritation, pruritus, and burns	1. Use of Personal Protective Equipment (lab coats, goggles, gas/dust masks, polymer gloves)
	2. Chemical inhalation	2. Coughing and shortness of breath	2. Use of Personal Protective Equipment (lab coats, goggles, gas/dust masks, polymer gloves)
	3. Contact with hot glass	3. Blistering skin	3. Use of Personal Protective Equipment (lab coats, goggles, gas/dust masks, polymer gloves)

Cleaning up residual waste from analysis	1. Risk of being cut by broken glass when cleaning up broken tools.	1. Wound on the hand	1. Use of Personal Protective Equipment (lab coats, goggles, gas/dust masks, polymer gloves, absorbent cloths)
	2. Inhalation of reactive chemicals.	2. Nose irritation	2. Use of Personal Protective Equipment (lab coats, goggles, gas/dust masks, polymer gloves, absorbent cloths)
	3. Spillage of chemicals.	3. Dermatitis, burns caused by corrosive chemicals	3. Use of Personal Protective Equipment (lab coats, goggles, gas/dust masks, polymer gloves, absorbent cloths)
Working in front of a computer	1. Sitting in the same position for a long time	1. Back and neck pain	1. Stretch every 2 hours for 15 minutes
	2. Staring at a computer or laptop screen for a long time	2. Vision problems	2. Performing the 20-20-20 Technique

CONCLUSION

From the risk assessment results, it is known that there are two potential hazards with an extremely level, namely inhalation and exposure to chemicals during analysis. There are nine potential hazards with a high risk level and one potential hazard with a medium risk level. Based on the identification of potential hazards in all work activities at the water treatment plant laboratory, it was found that each activity carries varying levels of risk, ranging from minor physical injuries to potentially fatal outcomes such as death. To minimize the impact of these potential hazards, the use of appropriate Personal Protective Equipment (PPE) is highly recommended. PPE such as safety helmets, safety shoes, gloves, gas/dust masks, goggles, lab coats, and body harnesses should be used and tailored to the specific activities being performed. This study provides a clear basis for companies to strengthen their occupational health and safety management systems through more targeted hazard control and more effective occupational safety planning.

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