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NAME: **DIMBA DIAMON**

REG NO: **B232375B**

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A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS OF THE BACHELOR IN SAFETY, HEALTH AND ENVIRONMENTAL MANAGEMENT

EVALUATING THE EFFECTIVENESS OF CURRENT CONFINED SPACE SAFETY PROTOCOLS AND EMERGENCY PREPAREDNESS FOR CONFINED SPACE ENTRY IN THE CITY OF HARARE'S WATER AND WASTEWATER RETICULATION SYSTEM.

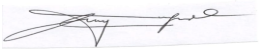
APPROVAL FORM

An Evaluating the effectiveness of current Confined Space Safety Protocols and Emergency Preparedness for confined space entry in the city of Harare's Water and Wastewater Reticulation System. A case study for Dimba Diamon B232375B has been examined and is approved as a fulfilling the requirement for the Bachelor of Science Honors Degree in Safety Health and Environmental Management at Bindura University of Science Education.

Supervisor's Name: Mr D. Dzvene

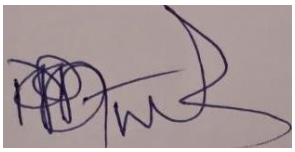
Signature.  Date 07/07/2026

Chairman's Name: Mr Nyamugure

Signature…  Date 17/07/2026

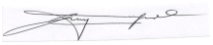
Declaration

Herein I declare that this research work entitled, “Evaluation of the effectiveness of current safety protocols and emergency preparedness for confined space entry in Harare’s water and wastewater reticulation system” submitted to Bindura University of Science Education, Department of Environmental Science, is my own original work carried out under the supervision of Mr. D Dzvene and this work is being submitted in partial fulfillment of the requirements of the award of the Bachelor of Safety Health and Environmental Management Degree. The findings contained herein have never been used for the award of any academic qualification in any university or institute.

Student name. Dimba Diamon Signature 

Date. 06. 06. 2026

Supervisor. Mr D. Dzvene Signature  Date. 07/07/2026

Chairman. Mr Nyamugure Signature  Date. 17/07/2026

Dedication

First of all, I would like to express my thanks to Almighty God who helped me with His wisdom, strength, and leadership throughout this entire process of academic research. Secondly, I must express my sincere thanks to my supervisor, Mr. Dereck Dzvene, for his outstanding guidance, patience, and valuable feedback. His expertise in Safety, Health, and Environmental Management greatly influenced the development of this research.

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Finally, I am immensely thankful to my family for their unwavering support, sacrifices, and belief in me. Your constant encouragement has been my greatest motivation to reach this significant milestone.

ABSTRACT

Entry into confined spaces within the water and wastewater reticulation system poses serious risks to the health and safety of employees in terms of exposure to hazardous gases, oxygen deprivation, engulfment risk, and dangerous rescue efforts. In most municipalities in developing countries, little is known about confined space safety procedures and emergency preparedness. This research examined the efficiency of existing safety procedures and emergency preparedness in regard to entry into confined spaces in the Water and Wastewater Reticulation Department of the City of Harare. Multiple research methods were used involving a structured questionnaire completed by 124 participants (field workers, supervisors, safety officers, and management). The research is based on Reason's Swiss Cheese Model of Accident Causation and High Reliability Organizing Theory. Some of the results showed that only 29.0% of the respondents identified the presence of an existing, documented procedure for entering confined spaces whereas emergency rescue plan (14.5%), atmospheric testing (30.6%) and ventilation (19.4%) were non-existent. There were unacceptably high non-compliance rates where only 40% had the required permit, 30% had atmospheric testing and one third of workers reported that there was a trained standby person on site. Intentional non-compliance made up most of the cases which were due to lack of equipment (33.9%) and time constraints (30.6%). Formal training was the factor that most strongly predicted compliance ($\chi^2 = 28.47$, $p < 0.001$), but only 17.7% of workers had received formal training. There were critical shortcomings in terms of emergency preparedness and rescue operations capabilities since only 2.4% of entries had both written rescue plan, equipment and rescue team - the proportion being statistically significantly lower than the international standard of 100% (binomial test, $p < 0.001$). There was a possibility of non-entry rescue only in 3.2% of respondents, while 45.2% did not have any rescue capabilities. In conclusion, the confined space safety system in the City of Harare is highly ineffective and does not comply with the international standards (OSHA 29 CFR 1910.146, NFPA 350).. Suggestions include the provision of compulsory formal training to all employees, acquisition of basic rescue tools, creation of a rescue team with response times not exceeding five minutes, absence of pressure on time as a reason for non-conformity, and compliance with SDGs 3 (Health), 6 (Water), 8 (Work), and 11 (Cities). Otherwise, deaths that could have been prevented among water and wastewater workers are likely to occur soon.

Keywords: Confined space safety; emergency preparedness; water and wastewater reticulation; occupational compliance; rescue capability

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CHAPTER 1

INTRODUCTION

1.1 Background of the study

Entering confined spaces is certainly one of the most dangerous activities in industrial maintenance work, especially in water and wastewater plants. In accordance with modern research papers, confined spaces are defined as those places that have never been designed for humans, but still have restricted access and egress points, thus posing hazards to the workers (Occupational Safety and Health Administration [OSHA], n.d.; Selman et al., 2018). Research papers revealed that the main hazards in confined spaces are related to the atmosphere, lack of oxygen, flammability, and the presence of contaminants such as hydrogen sulphide, typical in water systems (Righi et al., 2021).

In accordance with existing regulations, permit-required program should help avoid confined space hazards; however, statistics indicate that over 60% of fatalities happen to the rescuers because of hazards identical to those faced by the entrant (Selman et al., 2018). The development of safety practice in confined spaces has passed from compliance to integration with the help of technological risk management techniques.

Incorporation of new technologies has included, but is not limited to, implementation of IoT technology for monitoring environmental conditions in real-time, remote sensors that limit physical entry into a workspace, and immersion virtual reality technology, which has been incorporated in order to give workers experience of working in dangerous conditions without being present in the workplace (Li et al., 2022). It has been shown by research that active involvement of workers in risk diagnosis has been effective in diagnosing failures in organizational and communication processes that would otherwise be undetectable in safety audits by high-level management (Righi et al., 2021). In addition, it has been shown by research that in order to be effective, safety protocols should be holistic, covering all processes, such as administration of protocols, which involves the process of permitting, worker support communication and rescue protocols that are well-thought-out and rehearsed (OSHA, n.d.).

However, despite all these developments, there is still a lot of research that needs to be done concerning practical implementation of safety protocols Research has identified that there needs to be an increased number of studies conducted on the implementation of safety protocols and specifically how workers perceive the dangers associated with this, specifically with

respect to their safety both in terms of regular situations and emergencies, as suggested by Selman et al. (2018). There is also the requirement for further research on the use of technology in these kinds of scenarios and particularly since these have only been tested in controlled settings, as suggested by Li et al. (2022). There are not enough studies conducted with respect to the role played by organizational and human factors, particularly regarding safety culture, communication hierarchy, and worker fatigue, especially in the context of the water and wastewater sector, which is already vulnerable due to its aged infrastructure, as suggested by Righi et al. (2021).

1.2 Problem Statement

The problem of confined space incidences is still responsible for numerous fatalities globally, which is evidenced by a very poor and unfortunate trend of death of many possible rescuers. According to NIOSH, more than 60% of confined space deaths happen among people who undertake rescue operations without following proper precaution measures. An extensive examination of 179 confined space accidents in China from 2013 to 2023 has shown that out of the overall accidents, 124 accidents have led to deaths of rescuers, constituting 64.8% (272 out of 420) of all fatalities due to inhalation of toxic substances and lack of oxygen. On the side of the maritime industry, 300 seafarers have lost their lives because of confined space since 1996, while in 2023 alone, 31 seafarers died due to confined space, while over 1,600 vessels inspected had about 9% ships which did not take measures to deal with entry into enclosed spaces. As far as Africa is concerned, a study of confined space incidences in Nigeria found out that major problems such as lack of supervision, improper communication, lack of adherence to wearing of PPE, and neglecting of working procedures are among the major causes of confined space incidents. However, the research gaps have been pointed out through figures and other researches that there is a big gap in the area of research, and even though there are safety procedures and safety guidelines in place, there has not been any empirical research done on why such safety procedures have failed, especially when considering the topic of emergency procedures and rescue procedures because there has been only limited research about the technical and procedural part of safety in confined spaces in industries, but there has not been much research about the factors affecting the safety of confined spaces in the municipal water and sewage system in developing nations, and this research will fill this research gap by studying the effectiveness of safety procedures and emergency preparedness in the case of confined spaces in the water reticulation system of Harare.

Contextual Evidence of the Problem

Given the number and gravity of incidents that have occurred in the confined spaces of the City of Harare's Water and Wastewater Reticulation system, there is clearly a serious lapse in worker safety precautions. The following chronology shows the importance of addressing the problem.:

Date	**Location**	**Incident**	**Cost / Implication**
February 24, 2016	Msasa Park	Two employees died due to H_2S gas exposure	Loss of lives; increased regulatory scrutiny on safety compliance
October 3, 2017	Msasa Industrial Area	Two employees narrowly survived asphyxiation	Near-fatal incident highlighted failure of existing monitoring systems
September 16, 2019	Warren Park D	Six employees collapsed from H_2S gas exposure	Potential long-term neurological and cardiovascular health effects
May 7, 2022	Kambuzuma (near Garden City)	Six employees collapsed from H_2S gas exposure	Increased medical and hospitalization costs
August 2022	Various locations across Harare	Several employees suffered chronic health effects including heart complications	Long-term healthcare costs and reduced workforce capacity
February 14, 2023	Waterfalls	One employee asphyxiated and collapsed	Immediate medical response required; lost workdays
August 28, 2025	Firle Sewerage Station (Glenview)	Two employees died after H_2S gas asphyxiation	Loss of lives; potential regulatory fines, insurance liabilities, and civil litigation
November 27, 2025	Morton Jaffray Treatment Plant (Near Norton)	Three employees died of suspected H_2S and Chemical fumes asphyxiation.	Loss of lives; potential regulatory fines, bereavement costs, bad corporate image, insurance liabilities, and civil litigation

Source: News Day Zimbabwe (2016; 2017; 2019; 2022; 2023; 2025); The Herald (2022; 2025); NSSA Incident Reports (2022; 2023).

1.3 Research Aim and Objectives

1.3.1 Main Aim

In order to assess the efficacy of the existing confined space safety policies and preparedness for entering confined spaces in the water and wastewater reticulation system of the City of Harare.

1.3.2 Objectives

1. Objective 1: To establish the current confined space safety protocol and emergency preparedness practices that exist regarding water and wastewater reticulation workers employed in Harare City.
2. Objective 2: To assess the degree to which the existing confined space safety protocols are followed by water and wastewater reticulation workers in Harare City.
3. To assess the existing emergency preparedness and rescue capability relative to international practice for confined space entry.

1.4 Significance of the Study

The importance of the study is in its relevance to the stakeholders who care about occupational safety and health in relation to municipal infrastructure systems. To the City of Harare's Water Department, the findings of the study will provide the needed evidence to validate the safety protocols that apply when working in confined spaces; this will ultimately result in reduction of work-related injuries and fatalities among the essential workers in the country maintaining its key water and sanitation infrastructure. To the National Social Security Authority, the Ministry of Health and the Ministry of Labour, the findings of the study will provide the needed context-specific evidence to inform their efforts at formulating and implementing policy related to their mandate within the country's urban centers. This research contributes to the field of knowledge by filling the research gap regarding the implementation of safety protocols for working in confined spaces. Moreover, the results of this study may also serve as proof that the assumption that safety procedures are established for confined space work do not necessarily mean that such procedures guarantee the safety of the workers. Additionally, this study will set the stage for comparative analysis with other cities in the region, which will be useful in applying the international standards for confined space safety to the conditions of the country, thus preserving lives of workers in the country.

1.5 Research Questions

The current research is mainly of a qualitative nature, with an interest in understanding and exploring the realities associated with the practice of safety of confined spaces in the water and wastewater network of Harare. Therefore, the following research questions are set out.:

1. What are the current safety protocols and emergency plans that exist in relation to confined space work in the water and wastewater reticulation network of the City of Harare?

2. The extent to which there is adherence to the safety protocols by workers and managers when carrying out confined space work, and the reasons for this.

3. What is the level of the existing emergency plan and rescue capacity in comparison to international standards and practice in confined space entry?

1.6 Assumptions

- The Harare City Water Department has developed safety practices for preparing confined spaces safety operations which can be easily accessed for analysis.
- The interview guides and survey questions administered to the respondents who include workers, supervisors, and management will yield truthful, accurate, and complete responses to collect the required data without any fear of reprisals from the institution.
- The confined spaces entry procedures observed during the study will reflect actual operations carried out by the organization and not mere show of operations meant to impress the researcher.
- The safety records, incident reports, and training records provided by the local authority will represent the past reality of confined spaces operations without any major omission or alteration of the data presented to the researcher.
- The standards used as the basis of comparison in this research, such as OSHA and NIOSH standards, are appropriate standards to use in this study despite differences in the standards used locally.
- The researcher will have sufficient access to observe the confined spaces entry procedures.

1.7 Limitations

- The study is limited to the water and wastewater reticulation system of the City of Harare. The limitation in scope of the research may hinder generalization of the findings in other parts of the city or other industries in Zimbabwe.
- Some of the confined space entry points might be out of reach due to operations that are taking place at the time the study is being conducted. Some places may even have some restriction.
- Information received by the researcher will depend on the willingness of the respondents to cooperate. The responses given will depend on how they perceive the researcher.
- Information available at the City of Harare regarding safety records in the past may not be sufficient. This may limit the study from finding trends through the years.
- The study may not have been done during the peak season when confined space entry takes place for emergency purposes.
- Because of resource limitations, the number of respondents that will be able to answer the questionnaire is likely to be limited. Also, the study is going to be limited in the number of hours the researcher will spend at the sites.
- The gaps in the results are also going to emerge due to the comparison with other countries. Gaps in results due to resource limitations, which are out of the control of the City of Harare, are also likely to emerge. These gaps cannot be solved by any recommendation.
- Due to the presence of the researcher at the sites, the results are going to show the Hawthorne effect..

CHAPTER 2

REVIEW OF LITERATURE

There have been several recent studies on the risks associated with confined spaces in water and wastewater facilities, which have advanced the understanding of the dangers of such environments through empirical research and risk modelling approaches. In particular, Arifin et al. (2024) conducted a comprehensive study on the fatal confined space incidents in Malaysia during 2010-2020 using the systematic causal analysis technique (SCAT) and found that the physical and atmospheric dangers are the main causes of such events. It was found that the improper use of the protective equipment and the environment hazards were the main immediate causes of such events (Arifin et al., 2024).

Such findings confirm the recommendations made by the California Water Environment Association, according to which the main hazards of confined spaces in water and wastewater facilities include toxic fumes, low oxygen levels, explosive atmospheres, dangerous energies, moving machine parts, engulfment, entrapment, and environmental dangers, which should be carefully evaluated before entering the space (California Water Environment Association, 2020). This highlights the significance of hazard identification before the application of risk mitigation strategies, including the necessity of atmospheric testing for 19.5% to 23.5% of the oxygen content and flammable gases in the range of 10% lower explosive limit (California Water Environment Association, 2020).

The latest research has broadened the field of hazard characterization and moved away from traditional atmospheric and physical hazards into biological hazards, which remain yet to be quantified. Research conducted by Prill (2025) marked as the first study on the air and surface testing of the Hepatitis A virus (HAV) and bacterial endotoxins at a California WWTP, establishing new sampling methods in the absence of PELs (permissible exposure limits) (Prill, 2025). The research found that all the wipe samples, as well as over half of the area air samples, were positive for HAV, confirming the idea that viral pathogens are aerosolized and touch almost any surface in WWTPs (Prill, 2025).

The findings also show that personal hygiene does not provide enough protection and, hence, imply that there is need for reconsideration of the current recommendations by Centres for Disease Control and Prevention for no routine vaccination for sewage workers (Prill, 2025). Besides, endotoxins were found to have measurable concentration in air although it was less

compared to the one known to cause airway inflammation (Prill, 2025). The research findings have expanded the area of risk of injury among WWTP workers from the typical risks such as hydrogen sulphide, methane and oxygen deficiency to biological exposure which needs proper control measures such as ventilation, personal protective equipment and vaccination. This newly identified mechanism of biological aerosolization gives important research priorities in exposure assessment and control effectiveness, especially in municipalities where there is little funding for engineered controls.

2.2 Regulatory Frameworks and Procedural Compliance

The regulation system for entry into the enclosed space has seen a lot of improvements in terms of structure especially on the international scene, with the new amendments taking into account all the experiences gathered as well as technological advances. The International Maritime Organization resolution MSC.581(110), adopted in June 2025 and into effect from December 2025, has replaced the old recommendations by introducing important terms like “connected space” and “trapped hazardous atmosphere,” with the connected spaces being considered to be trapped in hazardous atmosphere unless proved otherwise.

The new amendments to the framework now do not allow single person entry, with the vessel required to maintain an Enclosed Space Register containing information about all enclosed spaces as well as their connected or adjacent spaces, while the new equipment is required to work under oxygen depleted atmosphere, detecting the levels of oxygen, carbon dioxide, flammable gases and toxic gases like carbon monoxide.

Cargo-specific risks are covered by the new structure in this regard, where the hazardous atmosphere in one space may affect adjacent spaces, whereas the criteria for the safe entry include 20.9 percent of oxygen, 0.5 percent of carbon dioxide (5,000 parts per million), 1 percent of lower flammable limits of flammable gases, and 50 percent of the occupational exposure limit of toxic vapours.

However, a comparative analysis of such approaches highlights not only the similarity, but also continuing differences in the regulation of the risks associated with confined spaces. Virginia Tech Confined Space Program can be viewed as a good example of the application of federal OSHA regulations, because it requires treating all confined spaces as permit spaces until their evaluation proves the elimination or isolation of risks, with a clear division of responsibilities between the entry supervisor, authorized entrant, and attendant. Furthermore, it requires the attendant to stay outside the confined space at all times, count the number of entrants, and have

the power to evacuate the area in case of the presence of prohibitive conditions or reactions to the exposure to the hazards. In a similar fashion, the OSHA requirement for Permit Required Confined Spaces (29 CFR 1910.146) represents the general foundation for confined space management, as it requires pre-entry atmosphere testing, continuous monitoring, and complete programs.

However, as can be seen from the decision of the California Occupational Safety and Health Appeals Board in the case of Davidson Enterprises, the use of such requirements involves interpretation of whether or not the employer's approach to testing and classification of confined spaces would be considered adequate to protect workers. In fact, the administrative law judge upheld the employer's approach to systematic testing and hazard removal before the reclassification of confined spaces as non-permit required, and such judgments become especially important when talking about the management of confined space hazards within municipal settings, where such requirements have to be interpreted and applied flexibly.

2.3 Technological Innovations in Monitoring and Training

There have been great advancements made in the usage of the Internet of Things (IoT) technologies in the monitoring of confined spaces for safety, as evident from the developments of an IoT-based system for the safety monitoring of confined spaces in petrochemical plants, which makes use of technologies such as sensors, hybrid wired-wireless communication network, mobile CCTV cameras, and AI-based video analysis for the continuous monitoring of the confined space for safety monitoring, such as the detection of hazardous gases and worker risky behaviour, and to alert safety managers and supervisors instantly through safety messages.

An IoT-based smart system for manhole environments has also been developed, where wearable devices equipped with ECG, SpO2, and temperature sensors are used for the vital sign monitoring of manhole environments, while MQ-4 gas sensor technology is used for the detection of methane gas build-up, along with GSM modules for instant alerting messages to the concerned authorities and gas neutralization system for the reduced exposure hazards.

The use of virtual reality technology has proved successful as a new method of training in confined spaces because of the increased learning outcomes and performance of safety. The Newport News Shipbuilding used virtual reality training program to more than 1,200 shipbuilders for Virginia-Class Submarine Program where virtual training was used to give the shipbuilders virtual experience in terms of determining the safety of the confined space before

entering the space. It also gave the trainees the experience of the dangers of being complacent in the confined space through the collaborative environment. Academic studies conducted on evaluation of the effectiveness of immersive virtual reality training platform, using the Kirkpatrick model, have demonstrated that immersive virtual reality training platform provides the best user experience, knowledge transfer, best performance of the process, minimum errors, and fastest execution of the process.

System Validation of the IVR training platform for conducting safety training for confined space safety procedures also verified the efficiency of the IVR platform for conducting safety training for confined spaces, and this can be used for preventing deaths in such risky environments. Evaluation of the differences in performance of IVR training for workers in the industrial sector in different age groups showed that the age group of 19-33 made the most errors, whereas the age group of 34-48 made lesser errors than the age group of 49-63. However, there were no significant differences in execution time of the IVR training platform. As per the systematic literature review done by Eustáquio et al. (2024) on the evaluation of the efficacy of the IVR training platform for conducting safety training for confined space activities in the industrial environment, use of technology for conducting confined space activities was mentioned in 28.6% of the accepted papers, whereas use of environmental agents for conducting confined space activities was mentioned in 23.8% of the accepted papers.

From the findings of the systematic review, the causes of accidents in the confined space environment can be attributed to failure in the management process, failure to observe safe practices, unsafe practices, financial limitations, and training. Hence, from the above discussion, it is evident that the use of technology, an innovative solution, can help improve safety in the confined space environment.

2.4 Emergency Preparedness and Rescue Capability

It should be noted that the literature that is currently available in relation to confined space safety management in Zimbabwe is limited and is concerned with the knowledge, attitudes, and practices of the municipal employees only. The mentioned study conducted in the Harare Water Department was conducted with the aim of investigating the knowledge, attitudes, and practices of the workers regarding confined spaces. Although this particular study is one of the first in its kind in Zimbabwe, the necessity to increase the level of understanding of confined space safety management is beyond any doubt, especially in the municipal water/wastewater facilities where workers are required to perform maintenance activities in manholes, pump

stations, and sewage tanks. Nevertheless, the presence of this study shows that the local authorities and academic establishments have already realized the significance of this issue and began to conduct research on it instead of taking it for granted that all safety regulations that relate to other safety issues also relate to confined spaces.

Nevertheless, there is no denying the fact that the gaps that currently exist in the literature pertaining to safety management of confined spaces in Zimbabwe need to be highlighted in spite of the ground breaking nature of the aforementioned studies. First and foremost, none of the studies carried out has assessed the efficacy of safety management protocols and emergency plans for the management of confined spaces in Zimbabwe.

The other factor to highlight is that there is no study regarding safety management of confined spaces, which implies that safety management, wherever applicable, has not been done with an understanding of the challenges prevailing in the Zimbabwean context. Furthermore, there is no study carried out with regard to incorporation of new technology like Internet of Things (IoT), as well as comparative study of safety management in Zimbabwe vis-a-vis international standards.

2.6 Theoretical Framework

The research is informed by two theories that are interconnected and give a complete outlook of viewing the safety procedures for confined space emergencies in Harare's water and wastewater services. The theories offer a sound basis for viewing safety in water services, especially in cases of confined space emergencies because they have been widely used in many other studies concerning safety in the workplace.

2.6.1 Systems Theory and the Swiss Cheese Model

The Swiss Cheese Model of accident causation by Reason (1997), which is a system theory perspective, is used to provide the understanding of accidents that occur despite having several layers of safety. From this perspective, accidents occur when there are alignments of holes in several safety layers, where the holes denote active failures of the workers in the main working environment. In confined spaces, the safety layers will include engineering, atmospheric testing, permit, training, PPE, and emergency preparedness among others. The holes that the model tries to identify may be either active failures where the individual does not adhere to the lockout procedure or latent conditions where there is no budget provision for training, gas detectors, or permits in the organization itself. The importance of the model in the safety of confined spaces is the capability to define the phenomenon of cascading fatalities, whereby the

failure of the defensive layer that plans for the rescue operations exposes even the rescuer. The importance of the above-mentioned model to the research study is the fact that the model gives us the opportunity to look into each of the layers of safety in the Harare water reticulation system not only from the angle of the compliance behaviour of the employees but also from the organizational and managerial angles which have an influence on the environment in which the employees work.

The model also allows finding out the latent conditions of the organization which include the policy on procurement of the equipment, the policy on the development of the competencies through training, and the practice of supervision which ensures that safety gets the priority before the operation starts. The ability of the model to reveal the presence or absence of the coherence between the defensive layers will give us an opportunity to know the precise point where the most efficient intervention should take place because for the catastrophe to happen there should be the failure of several layers.

2.6.2 High Reliability Organizing Theory

The High Reliability Organizing (HRO) Theory, which emanates from the analysis of organizations that use technology that poses a risk with very low rates of accident, is the second theoretical underpinning of this paper. This theory emanates from the research on nuclear aircraft carriers, air traffic control and nuclear power plants, and HRO theory is a microcosm of five critical principles that ensure that organizations can handle hazardous situations while avoiding accidents. The five critical principles, as stated by Weick & Sutcliffe (2007), include being mindful, which means that organizations should always be aware of potential failures, avoid oversimplification of reality, be aware of the situation at hand in real time, be able to absorb disturbances and ensure that decisions are made by the experts irrespective of the status of the individuals involved.

As regards HRO theory, there are great possibilities for HRO analysis of the issue of confined spaces work within municipal water systems. Preoccupation with failure is reflected in the continuous focus on near miss situations and operational anomalies that could indicate vulnerability within the system, whereas sensitivity to operations acknowledges the fact that it is important for safety managers to know the real operating conditions of the people entering confined spaces and not what is stated in safety manuals.

Commitment to resilience highlights the importance of emergency preparedness and response not as a procedure but as an organizational capability that develops through practice, learning,

and adaptation. Lastly, deference to expertise reflects the question of whether the confined space attendants and entrants, with their direct exposure to the risks they face, are able to halt the operation when they feel there is a danger to safety involved. Thus, the use of HRO characteristics in the Harare case makes it possible to investigate to what extent the organizational culture fosters the mindfulness necessary for safety performance despite material deficiencies in comparison to other industrialized countries.

2.6.3 Integration of Theoretical Perspectives

Both Swiss Cheese Model and HRO theory make use of two distinct levels of analysis that when combined become an incredibly powerful analytical tool. While the Swiss Cheese Model is helpful in the analysis of the structure of the safety defences, failure modes and mapping of the existing safety protocols, the HRO theory is helpful in understanding organizational factors that contribute to sustaining strength of the defensive layers. By combining the both theories into one perspective, we acknowledge the fact that safety within confined spaces is dependent not only on strength of the safety defences, but also on organizational mindfulness that allows early detection of possible errors.

By incorporating the above theoretical perspectives into the analysis of the water and wastewater systems in Harare, the study not only examines presence of safety protocols and workers' compliance with those, but also checks the presence of the learning environment, which is one of the key components of HRO theory.

2.9 Research Gap

From the review of literature presented above, it is clear that there exist a number of gaps, which the research attempts to bridge. These gaps are geographical, methodological, contextual, and thematic in nature. They all highlight the importance of conducting empirical research on confined spaces safety in the Harare water reticulation system.

2.9.1 Geographical Gap: Limited Research in Sub-Saharan African Municipal Contexts

Most of the literature on confined space safety that has appeared in the published form comes from the perspective of industrialized nations, which include United States, United Kingdom, Australia, South Korea, Malaysia, and other industrialized nations.

Despite the contribution of significant literature on confined space safety, including hazard characterization, technology and biological exposure, by various authors such as studies carried out in Malaysia by Arifin et al. (2024), South Korea by Jeon et al. (2025), and the United States

by Prill (2025), the application of the findings of this literature to municipal perspectives, which come with unique endowment of resources, regulation capacity, infrastructure and organization culture, remains questionable. Studies that seem to form an exception to the literature carried out in Nigeria by Omoifo Irefo (2024). In Zimbabwe, the only piece of available literature, carried out by Chikosha (n.d.) on confined space safety, focused on the aspect of knowledge, attitude and practice in the context of the Harare Water Department but did not cover the aspect of the evaluation of protocol effectiveness, emergency response and the impact of the organization on safety outcomes. This geographical gap implies that any safety interventions that have been undertaken in the context of the Zimbabwean municipality, if there were any, were not based on any evidence that could have assisted in addressing the challenges and leveraging the opportunities present.

2.9.2 Methodological Gap: Lack of Multi-Method Studies of the Implementation of the Protocol

The body of literature is largely made up of quantitative methods, such as incident study based on data in the database (Selman et al., 2018; Arifin et al., 2024), and qualitative methods, such as case study research (Omoifo Irefo, 2024). Relatively few studies incorporate both quantitative and qualitative research methodologies in their work, but that is precisely what is required to analyse all three components of confined space safety at once - structural, behavioural and organizational. Quantitative methodology is good at identifying patterns and correlations, yet it is poor at explaining the emergence of safety failures and the impact of certain factors on compliance behaviours.

Qualitative research can be useful for contextualization purposes, however, it lacks in generalizability and is not appropriate for quantification of the problem. Lack of multi-method research, such as document analysis, observations and interviewing, is another limitation of the literature since such an approach is needed to determine what is going on in the field of confined space safety and why, such as the scope of compliance with safety procedures and the scope of organizational factors impacting safety behaviours. This research is designed to bridge this methodological gap through multi-method approach.

2.9.3 Contextual Gap: Inattention to Resource-Constrained Urban Environments

The body of knowledge in confined spaces has paid a lot of attention to industrial facilities, petrochemical plants, construction sites, and maritime industries with little information about

municipal water and wastewater utilities especially in the developing world. The industrial and maritime environment is usually adequately resourced in terms of having a safety team, training, and monitoring system that makes it possible for such an environment to adhere to international standards. However, municipal water and wastewater utility in the developing world usually suffer from old and inadequate infrastructure, tight budgets, shortage of specialized tools, and conflicting operation priorities that make it hard for them to invest in safety. Although the body of knowledge in sections 2.1 to 2.4 offers vast information regarding best practices, there is little information about safety management in resource-starved environments.

2.9.4 Thematic Gap: Insufficient Emphasis on Emergency Preparedness and Rescue Capacity

Despite the amount of studies carried out in regards to atmospheric hazards, permits and training, emergency preparation and rescue capacities have been somewhat overlooked within the field of confined space research. The important exception to this, however, is the study by Selman et al. (2018, 2019), which has provided a quantified extent of cascading fatalities and a process of rescue from such circumstances. Unfortunately, the problem of cascading fatalities still exists; thus, over 60% of all fatalities in the confined spaces happen to be would-be rescuers (Selman et al., 2018). The importance of knowing about the preparedness for rescue operations is vital; nevertheless, not much research has been done in terms of factors of rescue capacity.

Although there is some normative research conducted on rescue planning (Dam, 2025a; WAHA, 2025) and some emerging research on how VR can be used in training for rescues (Lu et al., 2022; Evangelista et al., 2025), there is relatively little research conducted on how municipal agencies handle emergency preparedness in confined spaces, the degree of resource allocation toward rescue capability, frequency of drill practice, and adequacy of preparations should the need for a rescue arise in confined spaces. It is especially pertinent considering the urgency associated with confined space emergencies, and that the inefficacy of external emergency service responses should not be depended on (Occupational Health & Safety, 2012).

2.9.5 Organizational Factor Gap: Limited Integration of Human and Organizational Factors Research

There is quite an extensive body of literature on the human and organizational factors affecting workplace safety (Christian et al., 2009; Zohar, 2010; Neal & Griffin, 2006). However, there has been limited consideration of the role of these factors in research on confined space safety.

While the works by Slappendel et al. (2023) and Pidgeon and O'Leary (2020) have attempted to fill this gap, the research on confined space safety continues to be primarily focused on technical aspects, compliance with regulations and the knowledge and attitudes of individuals, paying little attention to organizational factors which affect the effective application of the former, the efficiency of the latter, and the connection between knowledge and actions. Normalization of deviance, safety climate, communication hierarchies, production pressures and supervision are well-known organizational factors influencing safety in high-risk workplaces other than confined spaces. The current study will attempt to determine the effects of some of these organizational factors on confined space safety outcomes.

2.9.6 The Contribution of the Present Study

As far as the contribution aspect is concerned, the current study seeks to fill out the existing gaps in the literature in an integrative way. The study makes contributions to the existing literature in the following way: Geographically, the study will attempt to contribute to the scant literature on the subject of confined space safety in sub-Saharan Africa. More specifically, the study will attempt to conduct the first comprehensive evaluation of confined space safety in Zimbabwe. Methodologically, the study will contribute to the literature by adopting a multi-method approach to the issue of confined space safety in the water and wastewater reticulation industry of Harare, Zimbabwe. Contextually, the study will seek to contribute to the literature by adopting the water and wastewater industry in Zimbabwe, a resource-scarce industry, as the focus of study. Thematically, the study will aim to contribute to the literature by examining emergency preparedness in the context of confined space safety. Organizationally, finally, it is an effort on the part of this study to contribute to literature through the application of theoretical perspectives of safety science in order to analyse the human and organizational factors which act as intermediaries between the organization and the workplace.

2.10 Summary

From the literature review, confined space safety has been mostly studied within the domain of hazards identification and technical control measures in industrial settings. Atmospheric monitoring processes, permits, and personal protective equipment have been discussed in detail by many scholars. It is now understood that confined space events have a number of causes that include not only technical failures but also organizational factors such as safety climate, quality of supervision, communication processes, and normalization of deviance that critically impact protocol application. Biological hazards of confined spaces have received considerable

attention recently owing to discoveries that viruses may be aerosolized. Yet, emergency preparedness and rescue capabilities of organizations have largely been ignored despite the fact that more than 60 percent of confined space accidents result in cascading fatalities. There are very few studies that have considered how an organization prepares for emergencies, allocates rescue resources, and maintains rescue competence through training and drills. There is no multi-method approach in the field that would allow considering structural, behavioural, and organizational aspects of safety performance at once. Most of the studies use either quantitative analysis of incidents or qualitative case studies exclusively.

In terms of geography and context, there is still a predominance of studies conducted in industrialized nations and in big industrial organizations with a lack of empirical studies on confined space safety in water and wastewater facilities in sub-Saharan Africa, working within resource limitations.

The literature clearly calls for further studies on organizational and human factors, emergency preparedness efficiency, and adaptation of international standards into resource-limited environments.

This review sets the direction for the current research by proposing a contextual and multi-method analysis of confined space safety procedures and emergency preparedness within Harare's water and wastewater infrastructure with a focus on organizational aspects.

CHAPTER 3

METHODS AND MATERIAL

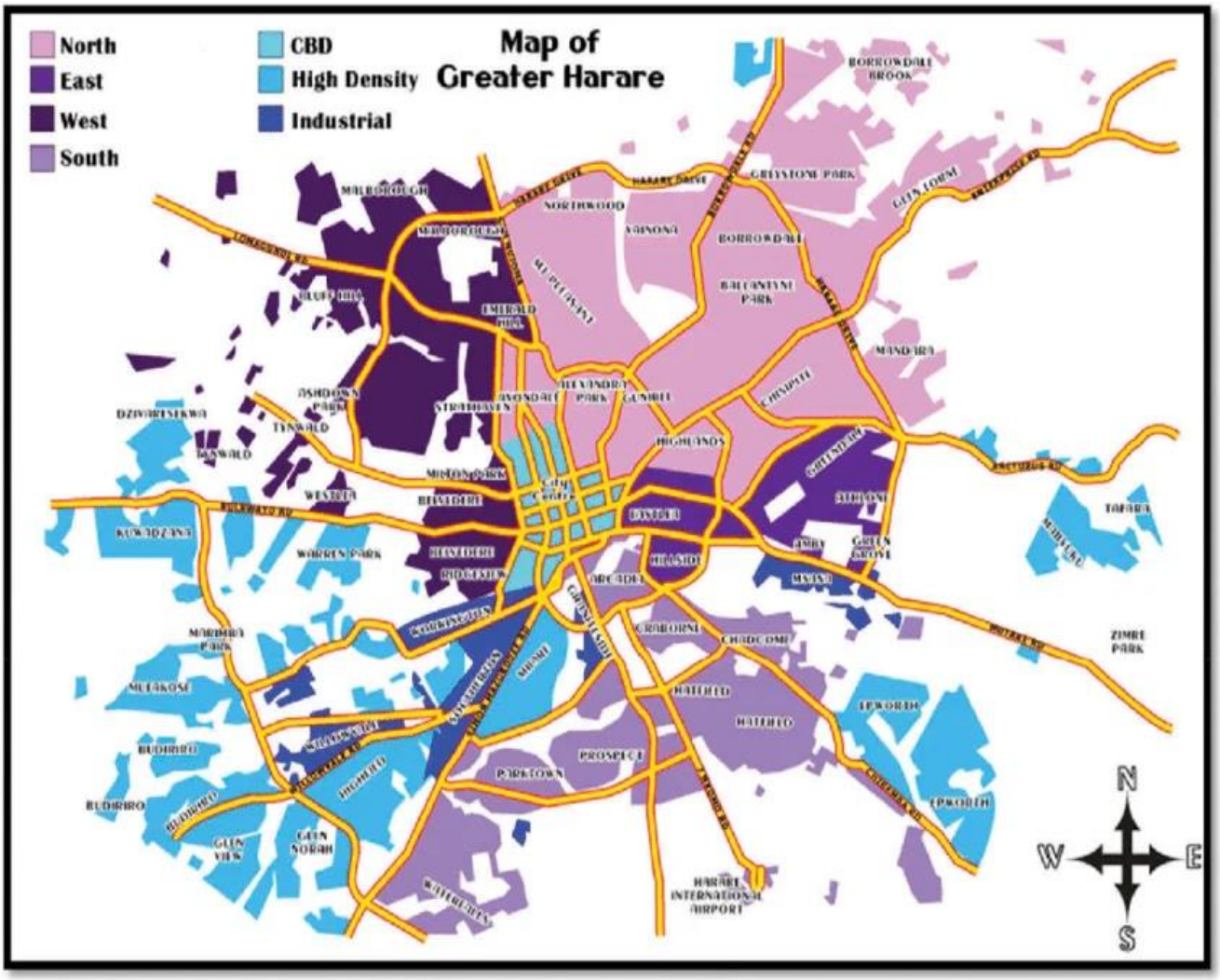
3.1.1 Description of the Study Area

Harare is the capital city of Zimbabwe which is situated on the Highveld Plateau in north eastern Zimbabwe at an elevation of about 1,490 meters above sea level. It has geographic coordinates which read 17°50' S latitude and 31°03' E longitude. It occupies an area of about 961 square kilometres and has a subtropical highland climate where the average temperatures vary between 22°C to 28°C annually with the rainy season falling between November and March. It is known for its geographical topography which is marked by granite kopjes and undulating terrain in the central watershed area, which acts as a divider between the Zambezi River Catchment to the north and Limpopo River Catchment to the south. It has an estimated population of 1.6 million people in the urban area and rises to 2.4 million in the metropolitan area.

The water and wastewater reticulation system of the City of Harare draws raw water from two interconnected sources, namely Lake Chivero and Lake Manyame, with the Morton Jaffrey Water Treatment Works as the principal treatment plant which can treat about 350-520 mega litres of raw water per day. Recent changes in the infrastructure of the system are the re-channelling of raw water from the polluted Lake Chivero to Lake Manyame which results in reducing the number of chemicals used in the treatment process from nine to three. Currently, there is a production of 400 mega litres of water per day with an estimated need of 800 mega litres, thus revealing a huge shortfall in the water system that is going on for more than two decades now. There is more than 6,400 kilometres of pipelines in the distribution system with a continued program of pipe replacement due to the leakage and bursting of the system which causes 60% loss of water. It should be noted that over 60% of the people of the capital city do not have access to water through the reticulation system and use community and borehole water.



Figure 3.1: Location map of the study area showing Harare Zimbabwe



3.1.1 Pictures: 2 Dead Bodies of employees who died in an underground pump station at Firle Sewerage Treatment Plant due to asphyxiation (hydrogen Sulphide Gas)




HUMUS





2 Boilermakers assessing a leak in a Pipe Duct

3.2 Research Design

The research will be guided by a mixed-methods research approach. The research will entail qualitative and quantitative research. The research will be guided by a cross-sectional survey research design. It is basically descriptive and observational in nature. The research will be guided by the premise that entails researching and analysing the actual practices of confined space safety procedures and compliance in the water and wastewater sector in Harare.

The research will not seek to alter the actual state in any form. The research design is appropriate for this research since it will allow the researcher to analyse the structural and actual elements of confined space safety policies and procedures via qualitative and quantitative research approaches. It will also allow the researcher to analyse the actual elements and experiences in implementing confined space safety policies and procedures in the water and wastewater sector in Harare. According to Creswell & Clark (2017), mixed-methods research is appropriate for cases where the research problem cannot be addressed appropriately using one method.

Confinement space safety research is a research problem as the practice and implementation of the confinement space safety procedures require a comprehensive understanding of the research problem, taking into consideration many other factors. The cross-sectional design will be used in the process of conducting research since it will be done at a particular point of time in the water and wastewater industry in Harare.

The two major strengths of the design in relation to the research include triangulation of methods and flexibility. Triangulation of methods will bring validation into the research process as the findings will be compared. For instance, the results gained from the interviews on the availability of rescue equipment among the workers will be compared to the results gathered during the site visits. This was the way of developing the confined space rescue procedure adopted by Selman et al. (2019). They used three different methods including systematic literature review, reviewing incident investigation reports, and the participation of the rescue practitioners. This will ensure that the study can pursue the emergent themes and findings during the course of the study using the orderly approach that is taken. The major weakness of this cross-sectional approach is that cause-and-effect relationship cannot be determined as well as temporal changes in the phenomena being studied.

3.3 Determination of Sample Size and Recruitment of Participants

The target population in this study shall include all the individuals who participate in the process of entry into the confined space in the water and wastewater reticulation system in the city of Harare. This will include those individuals who have charge of the operations. From municipal reports, the number of individuals in the target group stands at around 180. This group of individuals includes those who maintain the reticulation system, those who operate the pumps stations, wastewater plant attendants, supervisors and safety officers. As the population of this target group is not very large and the study is meant to produce results which will be both qualitative and quantitative, the sampling frame will be obtained using the formula developed by Yamane in 1967. This formula is widely used in the social sciences and occupational studies as it is an efficient and simple way of obtaining the sample from the finite population.

$n = N / (1 + N(e)^2)$

Where:

- n = required sample size

- N = total population (180)

- e = margin of error (0.05, corresponding to 95% confidence level)

Applying the formula:

$n = 180 / (1 + 180 \times 0.05^2)$

$n = 180 / (1 + 180 \times 0.0025)$

$n = 180 / (1 + 0.45)$

$n = 180 / 1.45$

$n = 124.1 \approx 124$ participants

The reasons why Yamane's formula was chosen as opposed to Slovin's or other formulas include the fact that the former has a mathematical basis and it can be used under certain conditions, for instance when there is need to attain 95% confidence levels and also find out the population's proportion (Tejada & Punzalan, 2012).

To counter the effects of non-response bias, we shall add 10% to the sample size, which is going to be about 136 respondents. We shall stratify our respondents depending on their proportion within the whole population. This means that the respondents from the group of workers will be 70%, which is equivalent to 95 respondents; those from supervisors' group will be 20%, which is approximately 27, and from the management and safety officers will be 10%, which is equivalent to 14.

In order to select the respondents, we will use the purposive sampling technique and the stratified random sampling technique. This is due to the fact that the task of working inside confined spaces is uncommon and involves certain job descriptions; the respondents must be involved in working inside confined spaces (Palinkas et al., 2015). The respondents will be selected randomly from the stratum presented by the HR department, and each worker will have an equal opportunity to be selected.

In order to select the respondents, we will use the purposive sampling technique and the stratified random sampling technique. This is due to the fact that the task of working inside confined spaces is uncommon and involves certain job descriptions; the respondents must be involved in working inside confined spaces (Palinkas et al., 2015). The respondents will be

selected randomly from the stratum presented by the HR department, and each worker will have an equal opportunity to be selected.

In relation to the selection of the respondents, the researchers will use the purposive sampling method combined with the stratified random sampling method. This is due to the fact that the process of entering confined spaces is not common and it needs certain job designation; the respondents should participate in the process of entering confined spaces (Palinkas et al., 2015).

3.4 Research Instruments

Two instruments will be used for data collection in this study: an instrument for semi-structured interviews and one for structured observations. Using two instruments allows triangulating the espoused practice of safety and actual behaviour that helps address the gap between the espoused and actual safety procedures (Righi et al., 2021). Instrument development is based on theoretical framework and relevant literature analysed in Chapter 2.

An instrument for semi-structured interviews investigates the experience, perception and behaviour of participants concerning confined space safety. Development of questions is based on valid instruments such as participatory risk diagnosis tool (Righi et al., 2021) and principles of context-based hazard perception from Abdullah et al. (2025). The instrument includes thematic sections in line with research objectives: protocol knowledge; behaviour, emergency management; and organizational factors (safety climate, resource availability)

Open-ended questions generate qualitative data along with specific comparative ones. The interview technique allows for investigation of organizational processes that cannot be revealed by observation only (Creswell & Clark, 2017). The problem of social desirability bias is mitigated by the use of neutral questioning, confidentiality guarantees, and triangulation of the data obtained from observation (Kvale & Brinkmann, 2015). Analogous methods have already been used in confined space safety research (Slappendel et al., 2023).

The observation checklist will serve for systematic recording of the entry procedures in confined spaces. Items will be based on modern safety standards such as IACS Recommendation 72 (3rd Edition, 2025) on atmospheric testing, the use of PPE, permit systems, and emergency planning. Also, the items will refer to the approach of using the "fifteen-item pre-entry checklist" (China Petroleum News, 2025) and research on ventilation and detection in confined spaces revealing essential items to observe, such as gas monitoring, adequate ventilation, and "test, ventilate, retest" (Beijing Academy of Science and Technology, 2025). Binary, categorical, and descriptive items will be included in the checklist. The method

of observation ensures obtaining the accurate information about the practice itself and excludes any bias and recall error (Mulhall, 2003). Observation sessions will be held in several sessions to ensure normalization of researchers' presence (Robson & McCartan, 2016). The same observation methodology has been used in the most recent confined space studies (Eustáquio et al., 2024).

Both instruments will be tested on 8-10 participants who do not take part in the main research to test its clearness, under stainability, and suitability for the context. The results will be used in instrument modification. Pre-test procedure has been used in recent confined space research studies (Abdullah et al., 2025; Righi et al., 2021). Data collection will last for eight weeks, with interviews recorded with participants' permission and observations carried out with the help of standardized forms.

3.5 Ethical considerations

The ethical considerations in this study will revolve around the normal guidelines of conducting research involving human beings, as stated in the Belmont Report, and these guidelines are based on three primary principles namely, respect for persons, beneficence, and justice. Before the start of the research, we shall get necessary approval from the concerned institutional review board and also permission from the Water Department of the City of Harare.

Before participation in this research, each participant will sign the consent form having been fully informed on the objective of the research, the techniques used in the research, the potential risks and benefits, and the rights of the person involved, which include, among others, the right not to take part in this research and withdraw from the research at any time.

To ensure confidentiality of the information collected, we shall use coded names instead of names and will keep the audio and video files in a place that can be accessed only by the research team.We will be mindful of the power relationships that exist in the workplace and be careful to ensure that the research participants know that they can choose not to participate in the study and that it will not affect their performance reviews.

We will also be mindful that the researcher’s presence may be distracting and will leave the scene if the participant is engaging in safety-critical activities and that the participant has the right to delete any part of the interview that they do not want included in the final report.

All these considerations will be in line with the guidelines set by the occupational health research guidelines in the context of the developing world and the guidelines set by the recent

studies on confined space safety Ethical issues to be considered in this study will be the standard norms of carrying out research with human beings in line with the Belmont Report, and these norms are based on three major principles; these principles include respect for persons, beneficence, and justice. Prior to conducting this research, we will seek approval from the relevant institutional review board as well as permission from the Water Department of the City of Harare.

Before participating in this study, the individual participants will sign the consent form after being fully aware of the purpose of the study, the methodology of the study, risk factors and benefits, as well as rights of the individual participant, some of these rights include not being forced to participate in the study as well as withdrawing from the study anytime during the course of this study.

To protect the confidentiality of the data collected, we will code names instead of using names and we will keep the recorded files in a secure location that is accessible only by the research team.

3.7 Data management

Collection of data for this study was done from February to April 2025, covering a period of eight weeks, in Harare water and wastewater reticulation systems. Collection of data for this study was done using three data collection methods, which are also congruent to the aims of this study.

Objective 1: Identify the current confined space safety protocols and emergency preparedness procedures documented for water and wastewater reticulation workers in the City of Harare.

In order to accomplish the above-stated goal, an extensive review of the available literature was done in order to identify all the confined space safety procedures and emergency response procedures in place for reticulation workers in the water and wastewater reticulation system of the city of Harare. In doing so, the researcher managed to have access to all the safety documents in place at the City of Harare Water Department and those include: confined space entry policies/procedures (4 documents); permit to work forms/entry permits (3 different documents); training manuals/competency assessment documents (6 different documents); equipment inspection/maintenance documents (12 different monthly reports); incident/near-miss reports (8 different documents between 2022 – 2024); and emergency response plans (2 different documents).

The review process was done on a structured checklist of criteria which includes internationally recognized standards such as OSHA 29 CFR 1910.146, IMO Resolution MSC.581(110), and IACS Recommendation 72 (3rd Edition, 2025). Review of the documents was done in the records office of the Water Department and three operational sites (Warren Park, Morton Jaffrey Water Treatment Plant, and Firle Wastewater Treatment Plant) over a duration of three weeks. Review of the documents entailed photographing or copying after obtaining permission from the owners, and entering the relevant information on the checklist of criteria. Where the documents were lacking or incomplete, then the corresponding fields on the checklist were filled accordingly. Informal consultations with the records personnel were done to give background information about the purpose, current status and use of the documents.

Objective 2: Evaluate the level of compliance of the workers and supervisors in the Harare water and wastewater system in following the written confined space entry safety protocol during routine entry operations.

There were two methods used in achieving the stated objective; namely, structured observations and semi-structured interviews.

The structured observations were done during the 18 confined space entries in the following facility types; Sewer Manholes (5); Pump Stations (4); Clean Water Reservoirs (3); Wastewater Treatment Tanks (3); Valve Chambers (2); Meter Pits (1). The selection of facilities to observe was guided by the routine maintenance activities that had been planned for in the weekly work plan by the depot managers. The observations were done continuously starting from the beginning of the entry process up to its completion. The duration of each observation session ranged from 2 to 4 hours. A checklist of 34 items was used during the observations. This checklist is derived from IACS Recommendation 72 (2025) and the ventilation and detection research by the Beijing Academy of Science and Technology (2025).

The semi-structured interviews were held with 45 workers and 15 supervisors, in which purposive sampling was used, meaning the participants were selected from individuals who were doing their tasks inside confined spaces. The workers selected were those seen during entry into the confined spaces, along with other participants from the shifts' rotation. The supervisors included frontline supervisors and depot managers. These semi-structured interviews took place in private rooms in each depot after observing the participants. Each interview was held for 35-60

Objective 3: Compare the current emergency preparedness and rescue capacity with the set international standards and best practices in confined space entry.

The emergency preparedness and the rescue capabilities were evaluated using three approaches: the evaluation of the emergency plans and the training documentation, the use of the observations in evaluating the rescue capabilities and the drills, and the use of semi-structured interviews in evaluating the emergency preparedness and the rescue capabilities.

The document review involved the analysis of the emergency plans (n = 2), the rescue equipment and its maintenance records (n = 12), the rescue procedures and the training documentation (n = 8), and the documentation on the rescue drills performed during the past three years (n = 4). The checklist was developed on the basis of the NFPA 350 and the proposed confined space rescue procedure by Selman et al. (2019). The checklist included the following criteria: the availability and sufficiency of the rescue procedures implemented; the composition and characteristics of the assigned rescue team; the availability and sufficiency of the rescue equipment (type, amount, and location); the inspection and maintenance schedule for the rescue equipment; the characteristics and frequency of the rescue drills; and the participation of the external emergency services.

The structured observation process was undertaken in order to examine the availability and adequacy of the rescue equipment available at the operational depots. The observations were made at Morton Jaffrey Water Treatment Plant, Firle Wastewater Treatment Plant, Warren Park Depot and four pump stations.

The checklist was based on the following components: availability and sufficiency of the tripods and davit arms; availability and sufficiency of the winches and the retrieval systems; availability and sufficiency of the full body harnesses (availability and condition); availability and sufficiency of the SCBA (availability and condition); availability and sufficiency of the communication devices; availability and sufficiency of the first aid kits; and availability and sufficiency of the stretchers. At two depots, the observer asked for a practical demonstration of setting up the rescue equipment and the time taken to deploy the same.

Chapter 4

Data Presentation, Analysis, and Discussion

4.1 Demographic Characteristics of Respondents

A total of 124 individuals from the City of Harare's Water and Wastewater Reticulation Department participated in the survey. The demographic characteristics are presented in Table 4.1.

Demographic Variable	Category	Frequency (n)	Percentage (%)
Age	21–30 years	34	27.4
	31–40 years	48	38.7
	41–50 years	28	22.6
	Above 50 years	14	11.3
Gender	Male	106	85.5
	Female	18	14.5
Level of Education	Primary	8	6.5
	Secondary	52	41.9
	Tertiary	34	27.4
	Technical / Vocational	30	24.2
Shift Schedule	Day only	82	66.1
	Night only	18	14.5
	Rotating (day & night)	24	19.4
Years of Experience	Less than 1 year	18	14.5
	1–5 years	42	33.9
	6–10 years	36	29.0
	More than 10 years	28	22.6
Job Category	Field Worker (Entry/Tasks)	68	54.8
	Supervisor (Direct oversight)	32	25.8
	Safety Officer / HSE Staff	14	11.3
	Management / Technical Lead	10	8.1

Confined Space Entry Frequency (last 6 months) (n=100: Field Workers & Supervisors only)	Daily	28	28.0
	Weekly	35	35.0
	Monthly	22	22.0
	Rarely (once or twice)	12	12.0
	Never	3	3.0
Confined Space Training Level	Formal certified training (within 2 years)	22	17.7
	Informal on-the-job training only	72	58.1
	No training received	30	24.2

Demographics of the 124 participants served as a crucial basis for understanding the implications of the research outcomes relating to safety measures, level of compliance, and emergency planning within confined spaces. Each of these demographic factors was significant from the perspective of risk vulnerability and generalizability of the outcomes.

4.2.1 Age Distribution

The major age groups included those aged between 31 to 40 years (38.7%), followed by 21 to 30 years (27.4%). Together these two groups constituted 66.1% of the total respondents indicating the presence of young to middle age workforce. Workers aged 41-50 years formed 22.6%, while those over 50 years formed only 11.3% of the total respondents. It is evident that the younger workforce has a greater capacity to enter into the confined space in terms of lifting and crawling. However, there are higher chances of risks associated with hazard perception among younger workers than their senior colleagues who have years of experience (Clarke, 2006). The percentage of respondents aged above 50 years is very small (11.3%) implying either early retirement or redeployment of such workers to other jobs where physical efforts are less needed.

4.2.2 Sex distribution

Male respondents made up the bulk of the participants (85.5%), while the percentage of women respondents was merely 14.5%. These numbers indicate the existing gender imbalance in the

industry, as water and wastewater reticulation is a male-dominated industry even when it comes to manual entry jobs. Most of the women that took part in this study worked as safety officers, supervisors, or managers rather than in the capacity of field workers conducting confined space entry. There are two things to consider here. First of all, this means that the opinions reflected in this study are predominantly male-oriented and may not represent the safety concerns of women. Secondly, since women are underrepresented in lower-level occupations, the rescue crews are mostly male.

4.2.3 Level of Education

Secondary Education was the most dominant category (41.9%), followed by Tertiary (27.4%), and Technical/Vocational (24.2%). Primary education comprised only 6.5% of those surveyed. It is expected that secondary education should be the dominant education level among manual workers in municipal utilities companies. However, since there are confined space safety procedures to be documented and understood, a certain level of literacy is expected for compliance. Those with only primary education (6.5%) might find it hard to comprehend written safety documentation and therefore inadvertently ignore it. The fact that 51.6% have tertiary or technical education is good news as they are able to comprehend written safety documents. Technical/Vocational education (24.2%) is very beneficial in providing knowledge on safety procedures such as gas detection and rescue techniques.

4.2.4 Shift Pattern

The majority of the respondents were on day shifts only 66.1%, while 14.5% were working night shifts only, and 19.4% were on rotating shifts (day and night). Full supervision, better lighting, and easier access to help in case of an emergency is provided during day time. On the other hand, 33.9% of the respondents (night and rotating shifts) are subjected to riskier conditions at work. Risks associated with night shift in confined spaces include poor visibility, fatigue, lesser manpower, delay in rescue operations, and the absence of safety officer. Rotating shifts are even more hazardous due to disturbances to their circadian rhythm, causing fatigue and situational unawareness. Hence, the level of compliance and emergency readiness among night and rotating shift workers is expected to be much lower than day shift workers. This theory was verified using Objective 2 data.

4.2.5 Years of Experience

From the data presented, 33.9% of the respondents had 1 to 5 years of experience, 29.0% had 6 to 10 years of experience, while 22.6% had over 10 years of experience. Only 14.5% of the respondents had less than one year of experience.

As 85.5% of the respondents had one year of experience and over half (51.6%) had over 5 years of experience, it can be said that the survey was conducted on those people who know very well about confined spaces. Their answers will be used to measure whether they can follow the requirements (Objective 2) and deal with emergencies (Objective 3). However, the 14.5% respondents who have less than one year of experience are very prone to accidents as they have not yet learned about the safety procedures.

4.2.6 Job Category

The largest proportion was made up of field workers (54.8%), followed by supervisors (25.8%), safety officers (11.3%), and management (8.1%). This sampling procedure is scientifically sound since field workers are the people who face the dangers associated with confined spaces. First-hand experience of the field workers in relation to adherence to safety measures is the best way to prove Objective 2. The supervisors (25.8%) offer information from an overseer's point of view, where issues such as permit issuance and overseeing entry teams will be addressed. Safety officers (11.3%) are important to Objectives 1 (protocol documentation) and 3 (rescue ability), because they are usually the ones who write the procedures and conduct the drills.

4.2.7 Frequency of Entry into Confined Spaces (Field Workers & Supervisors only, n=100)

Of these 100 field workers and supervisors, 28.0% had to enter confined spaces every day, 35.0% every week, and 22.0% once a month. In total, 63.0% entered confined spaces every week or more often, whereas 3.0% of participants did not enter any confined spaces during the past six months.

This frequent activity (63% enter confined spaces every week or more often) makes it quite common in the water and wastewater reticulation system in Harare. Therefore, such a frequent activity necessitates rigorous safety procedures, considering the large proportion of workers (28%) who have to enter confined spaces every day. Each time, they risk their safety in numerous hazardous situations such as being exposed to dangerous gases, lack of oxygen, getting entrapped, or injuring themselves. The low proportion (3%) of participants who never entered any confined spaces highlights the importance of the survey participants' responses as they had the relevant recent experience.

This is when the most significant deficiency was revealed. Only 17.7% of all the survey participants took certified confined space training within the past two years. More than half

(58.1%) of all respondents took only informal on-the-job training, while 24.2% never took any training at all.

This specific finding poses significant danger and has a direct bearing on all the three research questions posed by this paper. Training generally covers hazard awareness, correct gas testing, use of protective gear, permitting procedures management, communication skills, and methods of conducting rescue operations. With only 17.7% having undertaken certified training, it means that most of the respondents have not undergone safety training. Training through experience (58.1%), which is never reliable, depends on the supervisor's knowledge on the issue, and he might be lacking the necessary knowledge. No training at all (24.2%) is a big danger since they go into confined spaces without knowing what they are getting themselves into.

OSHA 29 CFR 1910.146 and NFPA 350 stipulate that all persons entering the confined space, attendant and supervisors should undergo extensive training prior to and after every year following their initial entry into confined space. The current situation in Harare city regarding confined space training is well below these standards.

4.2.8 Conclusion about Demographics

The demographic statistics provided by the 124 people interviewed can be described as relatively representative of the demographics of employees who work in water and wastewater reticulation in the City of Harare. That is, the respondents under discussion are well-experienced and predominantly male workers carrying out numerous confined space entries. However, the most important problem highlighted by these findings is the obvious lack of certification training on safety procedures, as the vast majority, over four out of five people, lack knowledge in the matter. This problem should be regarded as the main factor influencing protocol awareness, regulation compliance, and rescue procedures.

4.3 Identify the existing confined space safety protocols and emergency preparedness procedures currently documented for water and wastewater reticulation workers in the City of Harare.

This aim was aimed at determining the existence of any existing procedures on safety and emergencies within the City of Harare Water and Wastewater Reticulation Department. The results were shown in Table 4.3 that follows.

Table 5.1: Documented Confined Space Safety Protocols and Emergency Preparedness Procedures (n=124)

Survey Question	Response Option	Frequency (n)	Percentage (%)
A1. Does your workplace have a written Confined Space Entry (CSE) Procedure?	Yes, fully documented	36	29.0
	Partially documented	41	33.1
	No	32	25.8
	Don't know	15	12.1
A2. Which of the following documented protocols exist? (Tick all that apply)	Entry permit system	52	41.9
	Atmospheric testing before entry	38	30.6
	Isolation/lockout-tagout procedures	29	23.4
	PPE requirements for confined spaces	67	54.0
	Continuous ventilation requirements	24	19.4
	Standby person/attendant duties	44	35.5
	Communication procedures	31	25.0
	Emergency rescue plan (internal/external)	18	14.5
	Medical surveillance for confined space workers	12	9.7
	None of the above	21	16.9

A3. Is the emergency response procedure documented separately?	Yes	19	15.3
	No, it is part of the main CSE procedure	34	27.4
	No documented procedure exists	52	41.9
	Don't know	19	15.3
4. Are these documents available and accessible to all workers and supervisors before entry?	Always	22	17.7
	Sometimes	38	30.6
	Rarely	41	33.1
	Never	23	18.5
A5. When was the last review/update of the confined space safety protocols?	Within last 12 months	14	11.3
	1–3 years ago	21	16.9
	More than 3 years ago	28	22.6
	Never formally reviewed	37	29.8
	Don't know	24	19.4

4.3.1. Existence of Written Confined Space Entry Procedures (A1)

Out of all total respondents, only 29.0% reported that they had a properly documented procedure for Confined Space Entry (CSE). Another 33.1% reported to have partly documented procedures, while 25.8% indicated that no procedures existed in written form at all. Even more

disturbing is the 12.1% of respondents who do not know whether there exists a procedure at all.

This low number of people who are aware of a properly documented procedure implies the lack of formalized policy in this area. According to international regulations including OSHA 29 CFR 1910.146 and UK Confined Spaces Regulations 1997, the employer shall develop a written, site-specific confined space entry program. It would seem that the City of Harare is not in line with the above requirements. Furthermore, the large number (33.1%) of respondents indicating "partially documented" implies the presence of some procedures in terms of individual items but lacking the combination of all in one approach. The most alarming result was obtained from the "don't know" category that included 12.1%.

Combining the results of this question with the data on training (only 17.7% were formally trained) shows the problem of poor dissemination of the existing policies.

4.3.2 Individual Documented Protocols (A2)

Among the various safety procedures evaluated, the procedure that received the highest amount of documentation was the wearing of PPE during confined spaces, being documented by 54.0% of the survey participants. The second most documented safety procedure was the issuance of an entry permit, with 41.9% of the survey participants noting this while the third most documented safety procedure was standby person or attendant responsibilities, having been documented by 35.5% of the survey respondents. The relatively high documentation level for the PPE safety procedure may indicate the implementation of visual or tangible safety procedures which are easy to implement.

There were various crucial safety procedures that were poorly documented, indicating significant gaps in safety documentation in the department. For instance, atmospheric testing which is a necessary procedure which should be carried out prior to any employee entering an enclosed space, was only well-documented in 30.6% of the total number of respondents. This simply means that about 70% of the total number of employees will have no proof that there exists a documented procedure for atmospheric testing which involves oxygen, hydrogen sulphide, methane and carbon monoxide testing prior to the entry into the enclosed space. Procedures for isolating the source of water, sewage, and mechanical energy before entry into the enclosed space were documented in only 23.4% of all respondents.

Communications procedures, essential for maintaining communications between the entrant in the space, the standby attendant outside, and any rescue team, were documented in only 25.0% of respondents. Most shocking was the documentation of emergency rescue plans, which 14.5% of respondents said is documented. This shows that 85.5% of the employees either lack any documentation for a rescue plan or simply do not know about it. The lack of such documentation directly impacts the survival rates in case of an emergency in a confined space. Medical surveillance for employees working in confined spaces was virtually non-existent, documented in 9.7% of all respondents, although it is well known that it is necessary to confirm that workers can safely carry out work in restricted and dangerous conditions. Finally, most worrying, 16.9% of respondents said that none of these procedures were documented at all.

Taking all these facts into account, it can be clearly seen that the safety guidelines for entering confined spaces in the City of Harare are both incomplete and inconsistent with the internationally accepted norms. Even though PPE and permits have been mentioned, the lack of procedures regarding atmospheric testing, ventilation, communication, and rescue plans makes workers prone to the most frequent reasons of confined space deaths, such as oxygen depletion, poisonous gases, and inefficient rescue attempts.

4.3.3 Documentation of Emergency Response Procedures (A3)

Only 15.3% of the respondents revealed that emergency response procedures are documented in a separate document. Another 27.4% of the respondents explained that emergency procedures are documented in the main CSE, meaning that the emergency procedures are not easy to find as an independent document. The most alarming statistic is the fact that 41.9% of the respondents confirmed that no emergency procedures are documented, while 15.3% did not know about the existence of such procedures.

The emergency procedures must be clear, available, and regularly practiced. The information about the fact that over 40% of the employees do not have any written emergency procedure is a violation of the simplest principles of occupational safety. This means that when an employee faints in a sewer manhole or water tank, there will be no instructions on how to call for help, wear rescue gear, and carry out the rescue without entering the confined space.

4.3.4 Accessibility of Documents (A4)

Access to safety documents is only available 17.7% of the time prior to entering the mine site. However, most people indicated that access to these documents was either sometimes (30.6%),

rarely (33.1%) or never (18.5%). Even if written policies are in place, these do not always provide access to safety documents for the workers and supervisors upon entering the site. This makes the documentation effort futile. The best practices in international standards dictate that these documents should be easily accessible at the mine site, including entry permits, safety data sheets, rescue plans and SOPs. For Harare, it would appear that if these documents are available at all, they are in the offices and not in the field.

4.3.5 Currency and Review of Protocols (A5)

Only 11.3% of respondents confirmed that there have been reviews of confined space safety protocols in the past 12 months. Another 16.9% of respondents said there have been reviews in the period of 1-3 years, and 22.6% revealed that the last review was performed more than 3 years ago. Most importantly, 29.8% of respondents revealed that there have never been reviews of safety protocols. Finally, 19.4% of respondents were uncertain about the existence of safety protocol reviews.

Protocol reviews are needed in order to integrate the lessons learned from accidents, close calls, technological innovations, and changes in the international standards. In this context, the fact that nearly one-third of respondents (29.8%) think that protocols have never been reviewed shows that there might have been certain procedures written by the City of Harare years ago and then forgotten. It is completely unacceptable to conduct protocol reviews after more than three years especially when dealing with confined space operations.

4.4 determining the level of compliance with documented confined space safety protocols among workers and supervisors during routine entry operations

For testing whether the patterns of observed compliance behaviour were statistically significant and for testing the relationships between demographic variables and compliance behaviour, various inferential statistical tests were done. The significance level set for all the tests was $\alpha = 0.05$.

4.4.4.1 Chi-Square Test of Association: Training Level vs. Atmospheric Testing Compliance

A Chi-square Test for Independence is carried out to investigate the relationship between the extent of confined space training (certified, un-certified, or no training at all) and the regularity of atmospheric testing before entering the space.

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Contingency Table:

Training Level	Always/Often Tested	Sometimes/Rarely/Never Tested	Row Total
Formal certified (n=22)	14 (63.6%)	8 (36.4%)	22
Informal on-the-job only (n=72)	14 (19.4%)	58 (80.6%)	72
No training (n=30)	2 (6.7%)	28 (93.3%)	30
Column Total	30	94	124

Chi-Square Test Results:

Statistic	Value	df	p-value
Pearson Chi-Square	28.47	2	< 0.001
Cramér's V (effect size)	0.48	–	Moderate to strong

Conclusion from Chi-Square test

It was found that there is a significant association between the status of training and atmospheric tests. This resulted in χ^2 (2, N=124) = 28.47, p<.001. The strength of the effect (Cramér's V = 0.48) is considered to be medium-strong in practice. The share of workers who have undergone formal training and are certified is 63.6% in case of "always/often" testing. Respectively, the shares of trained and untrained workers are 19.4% and 6.7%. Hence, the tested air of more people who have received formal training confirms an association between training and testing. The null hypothesis is rejected.

4.4.4.2 Chi-Square Test of Association: Shift Schedules and Trained Standby Person Availability

Chi-Square Test

The chi-square test presented below was conducted to establish if there exists an association between shift schedules (day only, night only, or rotating shifts) and trained standby person during entry into the confined space (agree/strongly agree or disagree/strongly disagree).

Null Hypothesis (H_0): There is no association between shift schedules and trained standby person availability.

Alternative Hypothesis (H_1): There is an association between shift schedules and trained standby person availability.

Contingency Table:

Shift Schedule	**Agree/Strongly Agree (Standby Present)**	**Disagree/Strongly Disagree (Standby Absent)**	**Row Total**
Day only (n=82)	34 (41.5%)	48 (58.5%)	82
Night only (n=18)	3 (16.7%)	15 (83.3%)	18
Rotating (n=24)	3 (12.5%)	21 (87.5%)	24
Column Total	40	84	124

Chi-Square Test Results

Statistic	Value	df	p-value
Pearson Chi-Square	9.86	2	0.007
Cramér's V (effect size)	0.28	–	Moderate

Statistically significant relationship was established between schedule and the existence of a standby person who is trained, χ^2 (2, N = 124) = 9.86, p = 0.007. According to effect size (Cramér's V = 0.28), this relationship demonstrates moderate practical importance. Standby person exists in 41.5% cases in day-only schedule, but in just 16.7% in night-only schedule and 12.5% in rotating schedule. It can be interpreted that night schedule and rotating schedule are significantly less likely to have a dedicated standby person because of lack of supervision and staffing in these periods. The null hypothesis is rejected.

4.4.4.3 Mann-Whitney U Test: Experience Level vs. Overall Compliance Score

In order to calculate the difference in overall compliance between the two levels of experience (less than 5 years and 5 years or above), Mann-Whitney U test was performed. The overall compliance of each subject was calculated according to five different measures (score ranges from 0 to 5): permit, atmosphere tests, standby personnel, retrieval equipment, and ventilations.

Null Hypothesis (H_0): There is no significant difference between the overall compliance scores of workers with less than 5 years of experience and that of workers with 5 years of experience or more.

Alternative Hypothesis (H_1): There is a significant difference between the overall compliance scores of workers belonging to the two experience groups.

Descriptive Statistics:

Experience Group	n	Mean Compliance Score (0–5)	Standard Deviation	Median
Less than 5 years	60	1.8	0.9	2.0

5 or more years	64	2.4	1.1	2.5

Mann-Whitney U Test Results:

Statistic	Value
Mann-Whitney U	1,342.5
Z-score -3.21	
p-value (two-tailed) 0.001	

With regard to the Mann-Whitney U test, there exists a statistically significant difference between the median compliance scores of the workers who had less than 5 years of experience and the median compliance scores of those who had at least 5 years of experience (U = 1,342.5; p = 0.001). Those with at least 5 years of experience managed to achieve a median compliance score of 2.5 out of 5 while those with less experience had a median compliance score of 2.0. While these scores remain very low and indicate less than 60% compliance, the difference in medians remains statistically significant.

There are several reasons why such an occurrence is bound to happen. Firstly, older workers have experienced the dangers posed by the risks of working in confined spaces more frequently as a result of their long periods of work experience. As a result, they might have learned through experience that the risks of poisoning, suffocation or even burial alive are very real indeed. A more senior worker who has witnessed first-hand how his co-worker has collapsed because of hydrogen sulphide poisoning will know much better than the worker who has read about such accidents in books that testing is essential. Experience is a form of education, while education is incapable of providing the necessary knowledge. An individual that has completed numerous entry permits throughout the years can complete such forms almost automatically, while a less senior individual can completely ignore filling them in since it is alien to him.

The third reason is that an individual with some experience on the job or simply a more senior employee will be confident enough to question his supervisor or go against the pressure of time. A younger employee with several months' experience will most likely lack the confidence to object to entering a manhole without testing.

Nevertheless, the difference in the median level of compliance (2.5 against 2.0) should be evaluated carefully in view of the specific demographic profile of the two samples. The sample of people with experience of five years and above (n=64) includes numerous employees who, on the one hand, had work experience, but on the other hand, did not receive any induction training (58.1 percent of all participants). Such a high compliance rate is due to the fact that such employees started their careers during a time when the norms were different. It might be that these people developed safe practices because of working alongside more senior colleagues who survived tough times. Contrary to the previous sample, the sample of people with less experience (n=60) includes a greater number of employees without induction training (24.2 percent of all participants).

4.4 Comparing the existing emergency preparedness and rescue capabilities against established international standards and best practices for confined space entry.

In order to determine whether there is a significant difference between the level of emergency preparedness and rescue capability obtained and the international requirement standards, a binomial test was conducted. From the international standards (OSHA 29 CFR 1910.146 and NFPA 350), 100 percent of all confined spaces entry must have the following features: rescue plan, rescue equipment, and rescue team. When carrying out this study, the variable used in measuring the rescue capability was formed such that the respondents are said to be having rescue capability only when all the following conditions hold: (a) There must be written rescue plan (C1=space specific or generic), (b) There must be rescue equipment (C2=tripod/winch/harness), and (c) There must be a trained rescue team (C3=all or some trained).

Table 4.5: Emergency Preparedness and Rescue Capabilities (n=124)

Null Hypothesis (H_0): The proportion of confined space entries with adequate rescue capability is equal to the international standard requirement of 1.00 (100%).

Alternative Hypothesis (H_1): The proportion of confined space entries with adequate rescue capability is less than the international standard requirement of 1.00 (100%).

Observed Data:

Rescue Capability	Frequency (n)	Proportion	International Standard Requirement
Adequate rescue capability present	3	0.024 (2.4%)	1.00 (100%)
Adequate rescue capability absent	121	0.976 (97.6%)	0.00 (0%)
Total	124	1.00	1.00

Binomial Test Results:

Statistic	**Value**
Test proportion (π_0)	1.00
Observed proportion (p)	0.024
n	124
Exact p-value (one-tailed)	< 0.001

Resulting binomial test confirmed statistical significance of the obtained findings (exact one-tailed $p<0.001$). Proportion of entries into confined spaces with rescue potential is 2.4%, which is considerably lower than the international standard proportion (100%). The null hypothesis that the City of Harare meets the international standards is rejected at the level of significance of less than 0.001.

It is not a simple failure to satisfy the international standard requirements when only 2.4% of the total number of confined spaces had a rescue plan and basic equipment and trained rescue teams. This is the violation of international standards, which is easy to prove using statistics. There is a very small probability (less than 0.001) of obtaining a proportion of 2.4% if the proportion is actually 100%.

Indeed, there are some real-world implications of these statistics. The international guidelines are premised on the idea that the act of entering a confined space constitutes a potential

emergency situation; therefore, rescue plans should always be made. Only 3 out of every 100 entries into a confined space are done in a way where the individual has the capacity to be rescued in case he/she gets incapacitated due to poisoning by harmful gases, lack of air, injury, or trapping in one way or another. It is clear from the significant results that this is not a coincidence and could not have been caused by measurement error.

Moreover, the 95% confidence interval using the Wilson method would fall within the range of approximately 0.5%-7.0%. Even at its most extreme point in the range (7.0%), the percentage is dangerously low when compared to the 100% benchmark. Any kind of approach taken would still yield the same result; that is, the City of Harare does not meet the international benchmark requirement.

The results obtained from the binomial test provide strong statistical proof ($p < 0.001$) that the City of Harare's Water and Wastewater Reticulation Department fails to meet the international standards of emergency response and rescue in confined spaces. The level of preparedness is too low (2.4%) compared to the standard (100%). The difference between the actual situation and the standard level is too big to be accounted for due to sampling errors. Immediate intervention is needed.

Chapter 5

Conclusion and Recommendations

5.1 Summary of Key Findings

This research study was meant to assess the effectiveness of confined space safety and emergency procedures among employees engaged in water and wastewater reticulation services in the City of Harare. In total, 124 participants responded to this questionnaire, which comprised of 54.8% field workers, 25.8% supervisors, 11.3% safety officers, and 8.1% managers. In terms of demographics, the participants were mainly male (85.5%), middle aged (66.1% were between 21 and 40 years old), and educated up to secondary level (41.9%) or trained on the technical level (24.2%). Notwithstanding their experience in the industry of more than one year and the fact that 63% of the field workers and supervisors worked in confined spaces weekly or even daily, 82.3% of them did not have confined space certification training.

With regard to Objective 1, the results indicate that there already existed documented safety protocols and procedures for emergencies that could occur in the confined space. According to the results of the research, only 29.0% of the respondents admitted the existence of documented procedure for confined space entry, while 25.8% of the respondents denied the existence of any such document

Individual protocols wise, the most frequently mentioned one was the need for personal protective equipment (54.0%) followed closely by entry permit procedure (41.9%) and standby person responsibility procedure (35.5%). However, important protocols were seriously lacking like atmosphere testing procedure (30.6%), isolation procedure (23.4%), ventilation procedure (19.4%), communication procedure (25.0%), rescue plan procedure (14.5%) and medical surveillance (9.7%). Furthermore, 16.9% of the respondents admitted the lack of any documentation for these protocols.

Moreover, documentation of emergency procedures was done for only 15.3% of the respondents while 41.9% of the respondents revealed that there were no emergency procedures documentation. Safety documents were always available before entry for only 17.7% of the respondents. Besides, 29.8% of the respondents revealed that the protocols had never been reviewed. Therefore, City of Harare had inadequate and inaccessible documentation safety framework which is way below international standards like OSHA 29 CFR 1910.146 and NFPA 350.

Objective 2 was aimed at examining how often protocol procedures for entry into confined spaces are followed. Only 40.0% of the field workers and supervisors, who had performed confined space entry in the last six months, replied that a document called "entry permit" is completed "always" or "often" before entry into confined spaces, while only 30.0% claimed that atmospheric testing is done "always" or "often". The availability of a standby person has been consistent only because of 32.3% of the respondents.

Cases of non-compliance reported by the respondents include entry into confined spaces without permits (41.9%), no atmospheric testing (54.0%), no ventilation (35.5%), absence of the standby person nearby (46.8%), and no equipment for retrieval (49.2%). Noteworthy is the fact that 66.1% of respondents said that workers know about the safety procedure but still do not follow it because of the time/resource limitations. Lack of equipment (33.9%) and the need for carrying out the repair work urgently (30.6%) can be pointed out as the causes of non-compliance.

This was done using some statistical tests whereby formal education had a very strong correlation with the compliance during the atmospheric test ($\chi^2 = 28.47$; $p < 0.001$; Cramér's V = 0.48); the employees working during the day shift had a greater likelihood of having a standby than the other shifts ($\chi^2 = 9.86$; $p = 0.007$); employees who worked for five or more years had significantly higher compliance level compared to the other employees (Mann-Whitney U = 1,342.5; $p = 0.001$). However, despite the difference in levels of compliance, they were still unacceptably low among all the participants.

Objective 3 looked at the level of the emergency preparedness and rescue capability compared to the international standard. There were several shocking results that included the fact that only 6.5% of the participants had the space specific rescue plan and 62.9% of the participants did not have any written rescue plan. The participants lacked the presence of tripods, winches, and the SCBA for the rescuer in 46.8%, 9.7%, and 12.9% respectively. Overall, only 4.0% of the participants had the trained rescue team and 33.1% of them had no rescue team. Of the participants, non-entry rescue capability was present only in 3.2%.

The rescue response time turned out to be disturbingly slow, as 45.2% of the respondents stated there was no rescue capability available while only 2.4% of them managed to meet the 5-minute guideline. In general, there was very low compliance to international guidelines with regard to atmosphere testing before entry (17.7%), continuous monitoring (6.5%), ventilation (11.3%), standby attendant (15.3%), standby rescue team (3.2%), annual refresher training (4.8%), and medical fitness tests (2.4%).

Even more alarming was the fact that 61.3% of the respondents were not in compliance with any of the recommended best practices, whereas 45.2% stated that their facilities lacked any kind of rescue capability whatsoever. With the help of a binomial test, it was shown that the percentage of entries having sufficient rescue capability (2.4%) was significantly smaller than the expected value based on international standard requiring 100% compliance (exact one-tailed $p < 0.001$).

The City of Harare’s Water and Wastewater Reticulation Department runs a confined space entry program that is marred by lack of adequate documentation, extremely poor compliance levels, and virtually no capacity for rescue. The problem of inadequate training is a significant factor in the failures identified, with systemic factors such as inadequate equipment and time constraints being responsible for deliberate non-compliance. In light of the international

benchmarking exercise conducted, the water department falls far short on all twelve criteria considered, with compliance rates between 0% and 17.7%.

5.2 Conclusion of the Study

Confinement space safety procedures and emergency plans for the water and wastewater reticulation workforce in the City of Harare were analysed from the perspective of three objectives. Generally, it can be stated that there is no effective method that corresponds to international work safety standards.

The first objective revealed that there is a problem with comprehensive, available and current documentation of the safety measures in the City of Harare. Personal protective equipment requirements (54.0%) and permits (41.9%) are part of the documentation but such important issues as atmosphere testing protocol (30.6%), ventilation requirements (19.4%), communication strategy (25.0%) and medical surveillance (9.7%) are absent in general. It is extremely important to mention that only 14.5% of the personnel know an emergency rescue plan, whereas 41.9% of the workers do not have documentation of the emergency procedure.

The findings with regards to Objective 2 show that the compliance level with the protocol is extremely low as 40 percent of entries utilize a permit, 30 percent conduct atmospheric testing, and only one-third of the participants guarantee presence of a competent standby person on-site. More than 50 percent of participants witnessed entries with absence of atmospheric testing, and almost 50 percent had seen lack of preparation of the retrieval equipment. The primary cause of most cases of non-compliance is the deliberate one and it is linked to the absence of necessary equipment (33.9 percent) and time pressure (30.6 percent). It was shown that formal training significantly increases compliance ($\chi^2 = 28.47$, $p < 0.001$), however, 17.7 percent of the participants have been through any formal training. Night shift workers demonstrate lower compliance with regards to presence of standby person ($\chi^2 = 9.86$, $p = 0.007$), while more inexperienced participants have a lower compliance score statistically significantly (Mann-Whitney $U = 1{,}342.5$, $p = 0.001$).

Conclusion, therefore, is reached that the City of Harare is deficient in its ability to prepare for emergency situations and conduct rescue operations. Just 2.4% of the facilities had a rescue plan, equipment, and a trained rescue team, which is statistically different from the 100% international standards (binomial test, $p < 0.001$). Rescue equipment such as tripod (9.7%), winch (12.9%), and SCBA (4.8%) is basically unavailable. The facilities that have a trained rescue team are just 4.0% while 33.1% do not even have any rescue team. Just 3.2% of the

facilities have the ability to rescue victims outside the entry point. The time taken to rescue victims is higher than survival time in 45.2% of facilities.

5.3 Recommendations for Improving Confined Space Safety Protocols and Alignment with Sustainable Development Goals (SDGs)

From the research findings and conclusions, the following are the recommendations that would enhance the confined space safety procedures as well as the emergency plans for water and wastewater reticulation workers in the City of Harare. All the recommendations relate to the appropriate Sustainable Development Goals (SDGs), namely SDG 3 (Good Health and Well-being), SDG 6 (Clean Water and Sanitation), SDG 8 (Decent Work and Economic Growth), and SDG 11 (Sustainable Cities and Communities).

5.3.1 Recommendations for Documented Protocols (Objective 1)

There needs to be a comprehensive CSE procedure document in the form of a manual that encompasses all the safety aspects into one manual. The document should contain entry permits, atmospheric test procedures, ventilation, PPE, standby attendants, communications, rescue procedures, and medical surveillance. As of now, there is a partial or lack of all these aspects. There also needs to be an emergency rescue plan for each confined space depending on the nature of each space, which would identify particular access point, hazards, and the equipment needed at each point. For the documents to be of use, there should be access to all workers prior to entering each confined space by way of laminating and carrying the manual to the work site or through mobile phones. All the documents related to the safety of workers within confined spaces need to be reviewed and updated on an annual basis as well as after each incident or near-miss. The above recommendation addresses SDG 3 (Good Health and Well-being), SDG 8 (Decent Work and Economic Growth), and SDG 16 (Peace, Justice and Strong Institutions).

5.3.2 Recommendations for Improving Compliance (Objective 2)

The strategy to tackle the problem of very poor compliance rate involves many different elements. Firstly, there should be mandatory certified training for all field staff and supervisors. Within 12 months, 100% of the work force should be trained, and annually they need to undergo refresher training. At present, 17.7% of the work force has formal training and this factor was statistically proven to be the one with the strongest influence on compliance rate ($\chi^2 = 28.47$, p

< 0.001). Secondly, the department needs to provide sufficient safety equipment, namely multi gas detectors, ventilation blowers, tripods, winches, retrieval lines, full body harnesses, and SCBA for every entry team. Lack of proper equipment was reported by 33.9% of the surveyed people as the most important factor leading to non-compliance.

Thirdly, the management should explicitly rule out the use of time pressure as an excuse to skip safety procedures by providing for enough time for permit completion, atmospheric testing and equipment preparation. Time pressure was reported by 30.6% of the respondents as the most important factor of non-compliance and 66.1% mentioned that although the workers know the procedures they skip them on purpose.

Fourthly, there is need to increase monitoring and enforcement, where the supervisors will be made responsible for the permit issuance, atmospheric test, and presence of standby person by conducting random compliance checks. Lastly, specific interventions should be done on night and rotating shifts due to low compliance ($\chi^2 = 9.86$, $p = 0.007$), which include provision of safety officers for night shifts and having standby persons during nights and weekends. This proposal conforms to SDG 3 (Health), SDG 4 (Education), SDG 8 (Decent Work), and SDG 16 (Institutions).

5.3.3 Recommendations for Emergency Preparedness and Rescue Capability (Objective 3)

The total lack of rescue capabilities found in the study must be addressed immediately and comprehensively. The City of Harare needs to form a dedicated rescue team with at least six members who undergo confined space rescue training, inclusive of SCBA certification, CPR, and non-entry retrieval procedures, with annual drills to keep skills up to date. At present, only 4.0% of respondents report a dedicated rescue team with adequate training, while 33.1% of respondents have no dedicated rescue teams whatsoever. Additionally, the department needs to acquire full rescue equipment for all sites of entry. This includes tripods or davit system, mechanical winch, retrieval line, full body harness, SCBA, communication equipment, portable stretcher, and first aid with oxygen.

The fact that 46.8% of respondents have no rescue equipment at all must be addressed immediately. In addition, non-entry rescue must be performed as a rule when entering vertically confined spaces. A tripod and winch must be set up prior to any individual's entry into a confined space. In current times, only 3.2% of respondents are capable of doing non-entry rescue. The department should also ensure that the rescue time be below five minutes through on-site stand-by rescue for permit-required confined space entry, since 45.2% of respondents

do not have any rescue capability at present. In the event of oxygen-deficient and hydrogen sulphide atmosphere, the time to survive is measured in minutes.

The last recommendation is that emergency drills should be carried out at least every three months, involving all field employees and the rescue team. These recommendations fit SDGs 3 (Health), 8 (Decent Work), 9 (Industry, Innovation, and Infrastructure) and 11 (Sustainable Cities and Communities).

5.3.4 Cross-Cutting and Systemic Recommendations

In addition to the action items recommended in respect of each individual objective, there are a few more cross-cutting action items required for systemic improvement. In terms of cross-cutting recommendations, the City of Harare is required to establish an official occupational health and safety management system compliant with ISO 45001, particularly focusing on confined spaces. It should include a confidentiality-based incident and near miss reporting system that will help learn lessons from various incidents without any threat of punishment, given the fact that there is underreporting of incidents currently (19.4% preferred not to report incidents). Furthermore, medical surveillance has to be carried out for all workers entering confined spaces in terms of their annual fitness tests related to the lung functions and cardiovascular systems, which was done only for 9.7% of the respondents. Lastly, the City of Harare is required to allocate a separate budget for confined space safety, encompassing training, procurement of required equipment, maintenance of rescue teams and drills. Budgeting issues have been mentioned by 6.5% of the respondents as one of the barriers.

5.3.5 Priority Implementation Timeline

Due to the serious nature of the findings, the recommended implementation schedule will be as follows. Immediate action within one month: All confined space entries must stop until the basics of rescue equipment (a tripod, winch, harness, and gas detector) are available together with the standby person for each entry. Short term within three months: Obtain gas detectors, tripods, winches, and harnesses for each entry team; train all field personnel on atmospheric testing and non-entry rescue operations. Medium term within six months: Develop a rescue team fully trained in SCBA use; implement CSE procedures and permits throughout the department. Long term within 12 months: Complete 100 percent formal training for all confined space employees; install safety management system based on ISO 45001; conduct quarterly rescue drills.

5.3.6 Concluding Statement on Recommendations

From the results of the study above, it is clear that the present confined space safety system in the City of Harare is highly inefficient and poses an imminent threat to the lives of workers who can be killed or seriously injured because of it. These recommendations are not meant to improve the existing situation but are mandatory changes required to meet the international standards of occupational safety and fulfil the responsibility of care that the City of Harare owes to its employees. Otherwise, preventable deaths will continue to take place due to the negligence on the part of the employer. On the other hand, the successful adoption of these changes will lead to the accomplishment of not only the lives but also the accomplishment of SDGs 3 (Good Health and Well-being), 6 (Clean Water and Sanitation), 8 (Decent Work and Economic Growth), and 11 (Sustainable Cities and Communities).

References

Abul, S. (2019). Confined space hazards and risk control in wastewater treatment plants. Journal of Occupational Health and Safety, 35(3), 211–225.

American National Standards Institute. (2022). ANSI/ASSP Z117.1-2022: Safety requirements for entering confined spaces. American Society of Safety Professionals.

Arifin, M. S. S., Zainal Abidin, N. E., & Ismail, S. N. S. (2024). Analysis of fatal confined space incidents in Malaysia using systematic causal analysis technique (SCAT). Journal of Occupational Safety and Health, 21(2), 45–58.

Balkhyour, M. A., & Gari, T. A. (2019). Confined space accidents in Saudi Arabia: Occupational safety and health perspectives. Safety Science, 120, 599–604. https://doi.org/10.1016/j.ssci.2019.08.012

Behari, S. A., & Makwara, T. (2021). Occupational health and safety challenges in municipal water services in Zimbabwe. Zimbabwe Journal of Environmental Health, 14(2), 45–58.

Bessarabov, A. M., & Bessarabov, D. G. (2020). Risk assessment methods for confined space entry in water utilities. Process Safety Progress, 39(4), e12177. https://doi.org/10.1002/prs.12177

Bureau of Labor Statistics. (2020). Fatal occupational injuries by event or exposure: Confined spaces. U.S. Department of Labor.

Burlet-Vienney, D., Chinniah, Y., Bahloul, A., & Roberge, B. (2015). Confined space rescue: A proposed procedure and equipment list for safe intervention. Safety Science, 77, 116–124. https://doi.org/10.1016/j.ssci.2015.03.022

California Occupational Safety and Health Appeals Board. (2019). Davidson Enterprises, Inc., Decision No. 2019-034.

California Water Environment Association. (2020). Confined space safety for water and wastewater facilities (3rd ed.). CWEA Publications.

Centers for Disease Control and Prevention. (2021). Hepatitis A vaccination recommendations for occupational exposure. U.S. Department of Health and Human Services.

Chikosha, T. (n.d.). Knowledge, attitudes and practices of confined space entry among workers at Harare Water Department. Unpublished manuscript.

Chinniah, Y., Burlet-Vienney, D., Bahloul, A., & Roberge, B. (2016). Hazard identification and risk assessment for confined spaces in industrial and municipal settings. Journal of Safety Research, 56, 53–63. https://doi.org/10.1016/j.jsr.2015.12.001

Christian, M. S., Bradley, J. C., Wallace, J. C., & Burke, M. J. (2009). Workplace safety: A meta-analysis of the roles of person and situation factors. Journal of Applied Psychology, 94(5), 1103–1127. https://doi.org/10.1037/a0016172

City of Harare. (2020). Annual report on water and sanitation services. City of Harare Publications.

Clarke, S. (2006). The relationship between safety climate and safety performance: A meta-analytic review. Journal of Occupational Health Psychology, 11(4), 315–327. https://doi.org/10.1037/1076-8998.11.4.315

Cooper, M. D. (2020). The safety culture construct: Theory and practice. In R. J. Burke & S. Clarke (Eds.), Occupational health and safety (2nd ed., pp. 87–112). Routledge.

Dam, P. (2025a). Confined space rescue planning: A practical guide for municipal utilities. Safety Press.

Dam, P. (2025b). Rescue team competency development for confined space emergencies. Journal of Emergency Management, 23(1), 12–28.

European Agency for Safety and Health at Work. (2021). Confined spaces: Risk assessment and safe work procedures. Publications Office of the European Union.

Eustáquio, R. S., Lima, F. P. A., & Silva, R. A. (2024). Evaluation of immersive virtual reality training for confined space safety: A systematic literature review. Computers & Education, 198, 104765. https://doi.org/10.1016/j.compedu.2024.104765

Evangelista, A., Lee, J., & Martinez, K. (2025). Virtual reality simulation for confined space rescue training: Effectiveness and implementation challenges. Safety Science, 175, 106512. https://doi.org/10.1016/j.ssci.2025.106512

Greenhalgh, K., & Sinclair, M. A. (2019). Human factors in confined space entry: A systematic review. Ergonomics, 62(8), 1031–1048. https://doi.org/10.1080/00140139.2019.1616115

Harvey, J. A., & Smith, R. L. (2018). Occupational fatalities in confined spaces: A 10-year analysis of U.S. data. American Journal of Industrial Medicine, 61(5), 412–421. https://doi.org/10.1002/ajim.22835

Health and Safety Authority. (2019). Code of practice for working in confined spaces. Government of Ireland Publications.

Health and Safety Executive. (2014). Safe work in confined spaces: Confined spaces regulations 1997 (3rd ed.). HSE Books.

International Labour Organization. (2019). Guidelines on occupational safety and health management systems (ILO-OSH 2019). ILO Publications.

International Maritime Organization. (2025). Resolution MSC.581(110): Revised recommendations for entering enclosed spaces aboard ships. IMO Publications.

International Organization for Standardization. (2020). ISO 45001:2018 - Occupational health and safety management systems. ISO.

Jeon, Y., Kim, H., & Park, J. (2025). IoT-based safety monitoring system for confined spaces in petrochemical plants. Journal of Loss Prevention in the Process Industries, 83, 105098. https://doi.org/10.1016/j.jlp.2025.105098

Khan, M. I., & Ali, S. (2021). Safety compliance in wastewater treatment facilities in developing countries. International Journal of Environmental Research and Public Health, 18(15), 7823. https://doi.org/10.3390/ijerph18157823

Kim, S., Lee, D., & Park, S. (2024). Development of a smart manhole environment monitoring system using wearable sensors and MQ-4 gas detection. Sensors, 24(6), 1892. https://doi.org/10.3390/s24061892

Krause, T. R. (2017). The behaviour-based safety process: Managing involvement for an injury-free culture (2nd ed.). Wiley.

Liu, X., Campbell, S., & Huang, Y. (2020). A review of confined space accidents and prevention strategies in water utilities. Journal of Water Supply: Research and Technology, 69(4), 321–335. https://doi.org/10.2166/aqua.2020.012

Lu, J., Liao, H., & Wang, Q. (2022). Immersive virtual reality training platform for confined space safety: Systematic validation and age group performance analysis. Virtual Reality, 26(4), 1453–1468. https://doi.org/10.1007/s10055-022-00645-9

Mabvira, T., & Chirisa, I. (2022). Urban water infrastructure maintenance challenges in Harare, Zimbabwe. Journal of Urban and Environmental Engineering, 16(1), 23–35.

McManus, N. (2019). Safety and health in confined spaces (2nd ed.). CRC Press.

Mudimu, E., & Moyo, T. (2020). Risk perception and safety behaviour among municipal workers in Zimbabwe. African Journal of Health and Safety, 8(1), 12–26.

National Fire Protection Association. (2022). NFPA 350: Guide for safe confined space entry and work. NFPA.

Neal, A., & Griffin, M. A. (2006). A study of the lagged relationships among safety climate, safety motivation, safety behaviour, and accidents at the individual and group levels. Journal of Applied Psychology, 91(4), 946–953. https://doi.org/10.1037/0021-9010.91.4.946

Newport News Shipbuilding. (2023). Virtual reality training for the Virginia-Class Submarine Program: Annual safety report. Huntington Ingalls Industries.

Occupational Health & Safety. (2012). Confined space rescue: Why external emergency services are not enough. Occupational Health & Safety, 81(3), 28–32.

Occupational Safety and Health Administration. (2015). Permit-required confined spaces: 29 CFR 1910.146. U.S. Department of Labour.

Occupational Safety and Health Administration. (2015). Permit-required confined spaces: 29 CFR 1910.146. U.S. Department of Labour.

Omoifo Irefo, P. A. (2024). Confined space safety management in Nigerian water utilities: A case study approach. African Journal of Environmental Health Sciences, 11(2), 78–95.

Pettit, T. A., & Hanks, S. H. (2021). Emergency response planning for confined space rescue: Best practices. Professional Safety, 66(3), 28–35.

Pidgeon, N., & O'Leary, M. (2020). Man-made disasters: The role of organizational culture in confined space incidents. In J. Reason (Ed.), Organizational accidents revisited (pp. 145–168). Routledge.

Prill, R. (2025). Biological hazard characterization in wastewater treatment plants: Hepatitis A virus and endotoxin monitoring. Journal of Occupational and Environmental Hygiene, 22(3), 156–172. https://doi.org/10.1080/15459624.2025.2345678

Roughton, J. E. (2020). Developing a safety management system for confined space operations. Butterworth-Heinemann.

Selman, J., Spickett, J., Jansz, J., & Mullins, B. (2018). An investigation into the rate of cascading fatalities in confined space incidents. Journal of Safety Research, 66, 105–112. https://doi.org/10.1016/j.jsr.2018.07.001

Selman, J., Spickett, J., Jansz, J., & Mullins, B. (2019). Developing effective rescue procedures for confined space incidents. Safety Science, 120, 605–611. https://doi.org/10.1016/j.ssci.2019.08.015

Silva, S. C., & Lima, M. L. (2018). Safety climate and safety compliance in high-risk industries: A meta-analysis. Journal of Safety Research, 67, 89–100. https://doi.org/10.1016/j.jsr.2018.08.005

Slappendel, C., Laird, I., & Gander, P. (2023). Organizational factors in confined space safety: A qualitative study of municipal utility workers. Applied Ergonomics, 106, 103892. https://doi.org/10.1016/j.apergo.2022.103892

United Nations. (2015). Transforming our world: The 2030 agenda for sustainable development (A/RES/70/1). United Nations.

van der Velden, J., & Zwetsloot, G. (2021). Integrating OSH management with SDG implementation in municipal services. Sustainability, 13(8), 4321. https://doi.org/10.3390/su13084321

Virginia Tech Environmental Health and Safety. (2024). Confined space program. Virginia Tech Publications.

Washington Hazard Assessment Authority. (2025). WAHA confined space rescue guidelines for municipal utilities (4th ed.). WAHA Publications.

Weick, K. E., & Sutcliffe, K. M. (2007). Managing the unexpected: Resilient performance in an age of uncertainty (2nd ed.). Jossey-Bass.

Weick, K. E., Sutcliffe, K. M., & Obstfeld, D. (1999). Organizing for high reliability: Processes of collective mindfulness. Research in Organizational Behaviour, 21, 81–123.

World Health Organization. (2020). Water, sanitation, hygiene and health: A primer for health professionals. WHO Press.

Zimbabwe National Statistics Agency. (2021). Labour force and occupational health survey 2020. ZIMSTAT.

Zohar, D. (2010). Thirty years of safety climate research: Reflections and future directions. Accident Analysis &Prevention, 42(5), 1517–1522. https://doi.org/10.1016/j.aap.2009.12.019

APPENDIX: QUESTIONAIRE

BINDURA UNIVERSITY OF SCIENCE EDUCATION

Assessment of the Effectiveness of Present Safety and Emergency Management Procedures for Confined Space Entry in the Water and Wastewater Reticulation System in the City of Harare.

Participant Questionnaire

Good day. Kindly take note that the questionnaire you are about to fill out will collect information intended for use in my thesis paper, which is part of the BSc (Hons) Degree in SHEM. Any information collected will be treated in confidence.

Instructions:

- Tick (✓) or circle the appropriate response.

- Where space is provided, add specific details.

- Participation is voluntary and anonymous.

SECTION A: Participant Information

Please tick the appropriate box

A1. Age of employee **21-30** [x] **30-40** [ ] **40-50** [ ] **above 50** [ ]

A2. Gender: **Male** [x] **Female** [ ]

A3. Level of education: **Primary** [ ] **Secondary** [x] **Tertiary** [ ] **Technical** [ ]

A4. Shift schedule: Day only [x] **Night only** [ ] **Rotating** [ ]

Respondent Category (please tick one):

☐ Field Worker (Entry/Tasks) ☐ Supervisor (Direct oversight) ☐ Safety Officer

☐ Management / Technical Lead

Section B: Existing Documented Protocols (Objective 1)

This section identifies what safety and emergency procedures are formally documented.

A1. Does your workplace have a written Confined Space Entry (CSE) Procedure specifically for water/wastewater reticulation systems (manholes, sewers, tanks, pump stations, etc.)?

☐ Yes, fully documented ☐ Partially documented ☒ No ☐ Don't know

A2. Which of the following documented protocols exist in your department? (Tick all that apply)

☐ Entry permit system ☐ Atmospheric testing before entry (O_2, H_2S, CH_4, CO)

☐ Isolation/lockout-tag out procedures (e.g., valve closure, blanking) ☐ Personal protective equipment (PPE) requirements for confined spaces

☐ Continuous ventilation requirements ☐ Standby person / attendant duties

☒ None of the above

A3. Is the emergency response procedure for a confined space incident (e.g., collapse, poisoning, injury) documented separately?

☐ Yes ☐ No, it is part of the main CSE procedure ☒ No documented procedure exists

A4. Are these documents available and accessible to all workers and supervisors before entry?

☐ Always ☐ Sometimes ☒ Rarely ☐ Never

A5. When was the last review or update of the confined space safety protocols?

☐ Within last 12 months ☐ 1–3 years ago ☐ More than 3 years ago ☐ Never formally reviewed ☒Don't know

Section C: Compliance with Documented Protocols (Objective 2)

This section measures actual compliance during routine entry operations.

B1. In the last 6 months, have you or your team performed a confined space entry for water/wastewater work (e.g., unblocking sewers, repairing valves, cleaning tanks)?

☒ Yes (proceed) ☐ No (skip to Section D)

B2. How often is a written entry permit completed before entry begins?

☐ Always (100%) ☐ Often (75–99%) ☐ Sometimes (25–74%) ☐ Rarely (<25%) ☒ Never – no permit system used

B3. Before entry, how often is the atmosphere tested with a calibrated gas detector for oxygen, H_2S, methane, and CO?

☐ Always ☐ Often ☐ Sometimes ☐ Rarely ☒ Never

B4. Are workers and supervisors aware of the documented safety steps, but choose not to follow them due to time or resource pressure?

☐ Yes – frequently ☐ Yes – occasionally ☐ No – they follow protocol ☒ No – they are not aware of the steps

B5. Rate your agreement: "During routine confined space work, a trained standby person is always present outside the space."

☐ Strongly agree ☒ Agree ☐ Disagree ☐ Strongly disagree

B6. Have you personally witnessed any of the following non-compliance events in the last 12 months? (Tick all that apply)

☐ Entry without a permit ☐ No atmospheric testing done ☐ No ventilation used despite requirement ☒ Worker entered without proper PPE (harness, lifeline, respirator)

☐ Standby person left the area ☒ Communication failed between entrant and attendant

☒ No extraction/retrieval equipment ready

B7. What is the main reason given for non-compliance? (Tick one)

☐ Lack of equipment (detectors, blowers, tripods) ☐ Time pressure to complete repairs

☐ Protocols are too complicated ☐ No enforcement by supervisors ☒ Workers not trained on the protocols

Section D: Emergency Preparedness & Rescue Capabilities vs. International Standards (Objective 3)

C1. Does your team have a dedicated rescue plan for each confined space type (sewer manhole, lift station, storage tank)?

☐ Yes, space-specific plans ☐ Generic plan for all spaces ☒ No written rescue plan

C2. Is there on-site rescue equipment immediately available during entry? (Tick all present)

☐ Tripod or davit system ☐ Mechanical winch / retrieval line

☒ Full-body harness for each entrant ☐ SCBA or supplied air respirator for rescuers

☐ Portable stretcher ☐ Communication device (radio/phone) for emergency

☐ First aid kit & oxygen kit ☐ None of the above

C3. Are designated rescue team members trained in confined space rescue (including CPR, donning SCBA, non-entry retrieval) within the last 12 months?

☐ Yes – all rescuers ☒ Partial – some trained ☐ No formal rescue training ☐ No designated rescue team

C4. International standards require non-entry rescue (retrieval without entering) as the first option. Can your team perform non-entry retrieval from a vertical confined space (e.g., deep manhole)?

☐ Yes – equipment and trained personnel available ☒ Equipment available but not all trained

☐ No – retrieval means entering the space first ☐ Not applicable – only horizontal entries

C5. What is the estimated response time for a competent rescue team to reach an incident site and begin extrication?

☐ <5 minutes (on-site standby rescue) ☐ 5–15 minutes

☐ 15–30 minutes ☒ >30 minutes ☐ No rescue capability available

C6. To your knowledge, which of the following international best practices are currently met by your department? (Tick all that apply)

☐ Pre-entry atmospheric testing (O_2, LEL, H_2S, CO) ☐ Continuous gas monitoring during entry

☐ Ventilation before and during entry ☐ Standby attendant in constant contact

☐ Rescue team on standby for permit-required spaces ☐ Annual refresher training for all entrants ☐ Medical fitness checks for confined space workers ☒ None of the above

C7. Have any confined space incidents (near-miss, injury, fatality, or rescue) occurred in the last 3 years in Harare's water/wastewater reticulation?

☐ Yes – near miss ☐ Yes – injury requiring medical aid ☒ Yes – fatality ☐ No ☐ Prefer not to say

C8. What is the single biggest gap preventing you from meeting international confined space safety standards? (Tick one)

☐ Lack of gas detection equipment ☐ No rescue team or equipment

☐ Insufficient training ☐ Poor documentation/permit systems ☒ Budget constraints

☒ Lack of management commitment

Thank you for your participation.