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Hazards Arising from Working in Confined Spaces Case Study: Khartoum North Industrial Area, Sudan

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Abstract: Multiple injuries and fatalities occur during confined space entry work more than any other type of work performed in all developed countries. This research aimed at evaluating employee's awareness of confined spaces basic concepts and work hazards, and to generally assess the entry program used to access these confined spaces. The data were collected from a random sample of factories and industries in Khartoum north industrial area. A questionnaire was the instrument used to collect the data. The data were analyzed using standard Statistical Package for the Social Sciences (SPSS). The results demonstrated lack of employee's awareness regarding the concept of confined spaces and hazards of working. It also shows failure of (80%) of workplaces to conduct confined space training, ensure supervision and provide procedures reinforcing the need for a comprehensive confined space safety program. It also demonstrated little evidence of a safe system of work in many of the cases. Over (82%) of the confined spaces were permitted to be entered without pre-entry hazards identification. In addition no atmospheric gases monitoring before or during entry (0%) since over (80%) of spaces expected to contain atmospheric hazards depending on confined space location, construction, condition, and work to be performed. also no effective nor adequate emergency rescue procedures were hold. The results showed that the most important reasons for confined spaces accidents and fatalities were lack of employees' perception of hazards from working in confined spaces, and scarcity of designing appropriate preventive measures and entry written programs by companies. Accordingly, the study will help in putting the companies comply with their own procedures and practices, and to maintain the safety of the employees.

Keywords: *Hazards; Confined space; Confined space entry system; Confined space safety program.*

1. INTRODUCTION

Many people are seriously injured or killed each year worldwide in confined spaces. This happens in wide range of industries from complex plant to simple storage vessels. Confined spaces are significantly more hazardous than normal workplaces. The hazards involved may not be unique to confined spaces, but are always exacerbated by the enclosed nature of the confined space. This explains why the resulting injuries are potentially fatal.

Work in confined spaces generally occurs during construction, inspection, maintenance, modification and rehabilitation. This work is non-routine, short in duration, non repetitive and predictable (often occurring during off-shift hours or when the unit was out of service). A seemingly insignificant error or oversight while working in confined space can result in a tragic accident. Furthermore, there is a propensity of multiple casualties due to the insidious nature of the hazards.

Injuries and fatalities involving confined spaces are frequent and often witness successive fatalities when would-be rescuers succumb to the same problem as initial victims. Approximately 60% of the fatalities involve would-be rescuers and more than 30% of fatalities occur in a space that has been tested against safety of entrance and found to be safe [1]

Confined space is defined by OSHA (Occupational Safety and Health Administration) as a space that is large enough and so configured that an employee can bodily enter and perform assigned work. It should has limited or restricted means for entry or exit for example, tanks, storage bins, hoppers, vaults, and pits, and is not designed for continuous employee occupancy [2]

Many confined spaces accidents occur because the worker does not realize the danger or potential dangers within or nearby the space. Workers may not take into account the new hazards and other conditions created during work in confined spaces. Thus, it is crucial to carefully identify all confined space hazards before entry [3].

Hazards of the confined spaces can be classified into Atmospheric and Non-Atmospheric hazards. Atmospheric hazards are hazards that involve problems with the air of the space. The hazardous atmosphere is any atmosphere that may incapacitate, injure, or impair an employee's self rescue or lead to acute illness or death to workers and rescuers who enter confined spaces, for example, Oxygen deficiency, Oxygen enrichment, Toxic atmospheres, and Irritant atmospheres [4].

There are many actual and potential non- atmospheric hazards within confined space, they must be eliminated before entry. Examples of these are Mechanical hazards, Electrical hazards, Environmental hazards, Engulfment, Biological Hazard. The related parts were the employer, the competent and the workers [4].

The Proprietors (employer) shall appoint a competent person to carry out risk assessment when work is to be undertaken in a confined space, and whenever there is any significant change in the conditions of the confined space or of the work therein. Also adopt all necessary safety measures and issue certificates in relation to work safety according to recommendations made in the risk assessment report, allowing only certified workers to work in the confined space. The competent (expert) person shall assess all possible hazards of working in confined spaces, make recommendations on the safety and health measures for workers working in confined spaces and submit reports to proprietors or contractors. The Certified (authenticated) workers shall observe instructions and attend training, comply with all safety working procedures formulated and make proper use of any safety equipment or emergency facilities and report any fault or defect in the equipment or facilities immediately.

Currently, it is required that the employer has to carry out a risk assessment for work in the confined space in addition to the entry permit, before the worker enters that space for the first time. For a particular confined space employers shall conduct a risk assessment for each hazard identified, including the chance of encountering such hazards by any person, the extent of impact, and the effectiveness of the existing measures for controlling risks [5].

There are two types of confined spaces depending on existence of atmospheric hazards, permit required confined space and non permit required confined space. For a confined space has been identified as having any potential hazards there needs to a written program developed, that outlines and instructs on the proper procedures for working around these spaces. This permit must be posted near the space entry for entrants to verify that pre-entry procedures have been done [6].

Many organizations related to workers safety at work had put regulations and standards that cover work in confined spaces. Two of these were: The safety, health and welfare at work confined spaces regulations 2001, regulation No.5, and the Occupational Safety and Health Standards, standard No 1910.146.

Controlling confined spaces means to control hazards from working in confined spaces. Controlling hazard is to eliminate or reduce each of the hazards to an acceptable level to reduce confined spaces risk; the control process was ordered by engineering Controls, and practice control, and personnel protective equipments (PPE) control [7].

The literature shows few comprehensive studies on confined spaces and its related accidents, with little information on the etiologies of confined space accidents. Ferry [8] states that: "identification is the starting point for a system of control". This indicates the importance of research investigating the entry programs used to access these spaces.

This paper is set to:

- Evaluate employee's awareness about hazards resulting from working in confined spaces.
- Evaluate the confined space's entry system program within Khartoum north industrial area.
- Analyze the results by which employers can establish effective confined space entry program

2. MATERIALS AND METHODS

This article explains the sample selection and the instrument used in collecting the data, and provides an explanation of the statistical procedures used to analyze the data.

Descriptive research method was used. It is designed to provide a picture of a situation as it naturally happens. It may be used to justify current practice and make judgment to develop theories. [9] Samples and data collection took place Khartoum North industrial area, Khartoum North (Bahri). Ten industries were randomly chosen from the area. Factories selected contain different types of confined spaces.

Questionnaire was the instrument used in the process of data collection (survey instrument). Questions were designed to fit all different industries and work places. The language used in the questionnaire, is Arabic (mother tongue), because most of the subject speak Arabic only.

Data analysis means denotes to organise, provide structure and elicit meaning out of the collected data. SPSS statistical software program is used in analysis, which stands for Statistical Package for the Social Sciences [10].

3. RESULTS AND DISCUSSION

Results will be presented in tables and charts. The results address the research objectives as in the following two parts (A and B).

3.1 Part (A)

The first results reflect the first part of the questionnaire which assess the employee's awareness of the concept of the confined spaces and its hazards in factory.

All of the employees in the sample above entered the confined spaces as entrant (to perform a specific job). Data in Fig. 1and

Table 1. Employees confined spaces definition

Valid	Frequency	Percentage	Cumulative Percentage
Yeas	7	43.8	43.8
No	9	56.3	100
Total	16	100	

Table1 suggests that over 56% of the employees are unaware of the concept of "confined space".

Fig. 2 shows that about 18% of the employees had attended training before working in the confined spaces for the first time.

Regarding the result presented in Table 1 and Fig. 1, 56% of the total employees didn't know the concept of confined spaces although they had entered and performed works in it. The main reasons behind this are:

- Non identification of confined spaces in their industry.
- Absence of orientation and training.
- Reliance on temporary workers in some cases.

Fig. 2 also indicates that 81% of the employees have never undergone training because of the following:

- Unawareness of employers of the importance of training.
- Unawareness of employees of the dangers of not having proper training in confined spaces.
- Funding training programs is not a priority for the employers.
- Non-commitment of the employers to the acts that prohibit working in confined spaces without training.

Providing training to the employees has been one of the important responsibilities of the employer, Not- enough training or no training to the employees will increase accident probability.

3.1 Part (B)

These results address questions in the second part of the questionnaire; types of confined spaces, the work performed in the confined spaces and the hazards found at the confined spaces. The results also show that the mechanism used to control the confined spaces. The employees were asked about the difficulties they had faced during entry to the confined spaces, the control measures they had took, the accidents they had and the available rescue operations.

Fig. 3 shows that the employees had entered different types of confined spaces. Apparently, as represented in the figure, the majority of the employees had entered tanks and silos. Others entered kettles, pumps, boilers and sewers.

Fig. 4 shows that about 87% of the employees reported that the work they performed usually must be with prior permission.

Fig 5 shows that 56.3% of the employees confirmed that they had written entry permission.

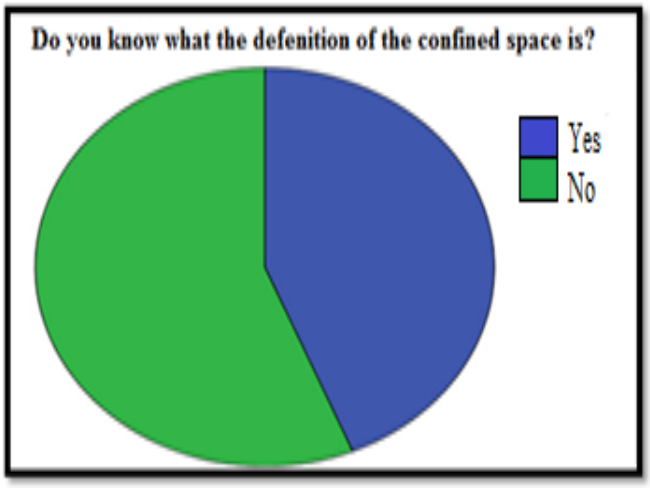

Fig. 1. Employees confined spaces definition

Fig. 2. Employees Training

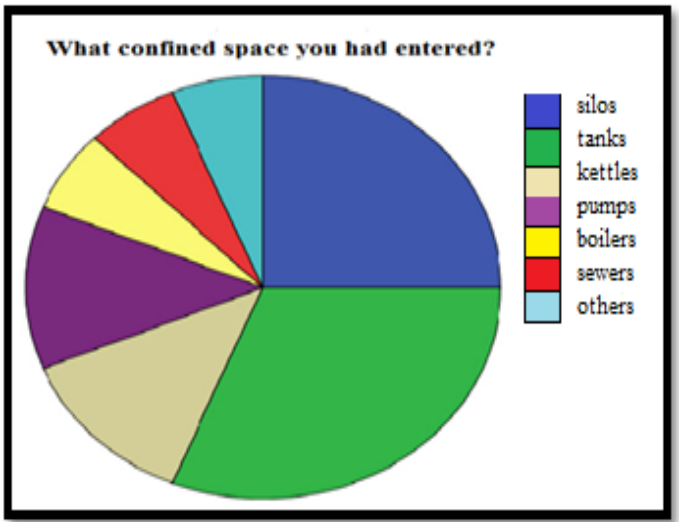

Fig. 3. Types of the confined spaces that employees had entered

Generally, most of the tasks carried in the permitted spaces are cleaning, welding and maintenance. In this study as shown in Fig. 6 (62.5%) of the employees entered the confined space for cleaning, (25%) welding and (12.5%) maintenance.

Fig. 7 shows that 82% of the employees reported that they did not experience pre-entry hazard identification; especially there wasn't any measurement for atmospheric hazard during entry (0%) as shown in Fig. 8.

Fig. 9 shows 31.3% of the employees had entered the confined spaces using locks (for electricity and the switch of the unit), 37.5% had entered with locks/ tags and PPE. The rest were varying within natural ventilation and forced ventilation with 6% and 25%, respectively.

Fig. 10 and Table 2 show that 37.5% of the employees had faced difficulties while entering and/or performing work in the confined spaces.

Table 3 shows that 43% of the employees had accidents while working in the confined spaces.

The data in Table 3 and Fig. 11 show that seven of the employees had accidents while working in confined spaces. Five of them confirmed that they had been rescued.

Roughly half of the employees obtained an entry permit, though the permits didn't meet the standards required. It was short of many important items, such as regular atmosphere tests, rescue arrangements, etc. Employees must be aware that they shouldn't enter any confined space unless it is safe.

As mentioned in the results presented in Fig. 6, the employees who enter the permitted confined space for welding and cleaning purposes are exposed to more hazards compared to others to the space hazards depending on the type of the space they weld in or clean, and the equipment used. With no atmospheric monitoring during the cleaning process the space may become dangerous, critical and deadly in seconds.

with no atmospheric monitoring during welding process which contains serious toxic and irritant gases worker might suffer from inhaling and exposure to the toxic fumes released during the welding process when not wearing the suitable PPE. Some of the employees involved in this study used to weld with safe way. They exchange within short period (15 min) as team work, and the others weren't wearing the welding PPE.

Monitoring the atmosphere in the confined spaces is one of the powerful tools of precautions by which the space can be maintained safe, e.g. measuring the toxic gases and maintaining Permissible Explosion Limit (PEL) in conditions not to be Immediately Dangerous to life and Health (IDLH). The main hazard that may exist in the confined spaces of the study (cleaning of storages, cleaning of underground sewage, cleaning of condensers, cleaning of silos, welding of tanks and welding of pipes) is atmospheric hazard (oxygen deficiency, toxic gases, combustible dust, and flammable gases).

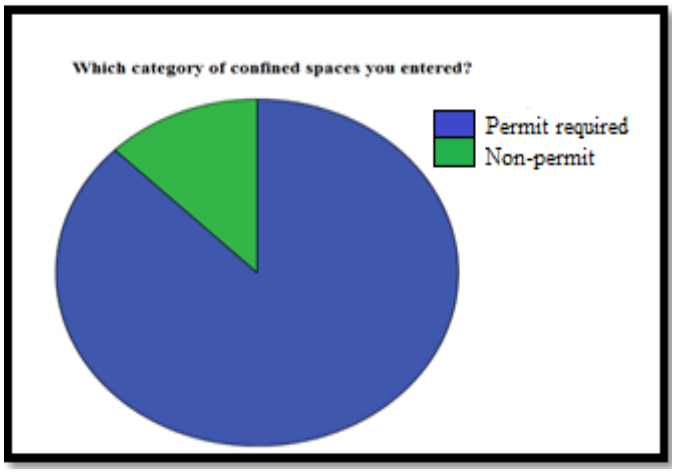

Fig. 4. Categories of confined spaces that employees had entered

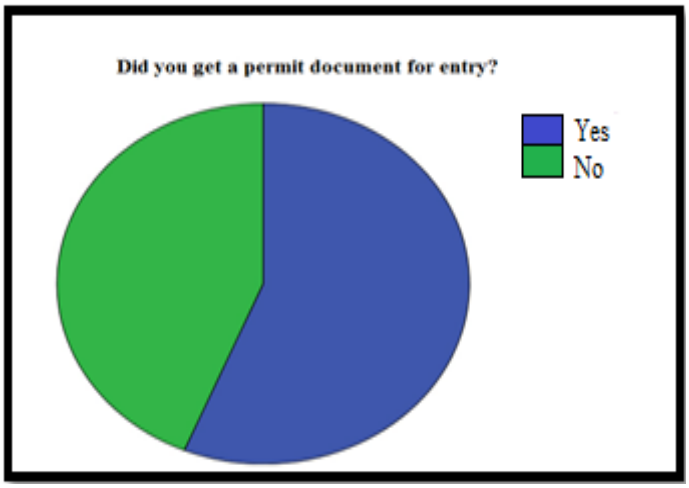

Fig. 5. The authorized employees' entry using an entry permit

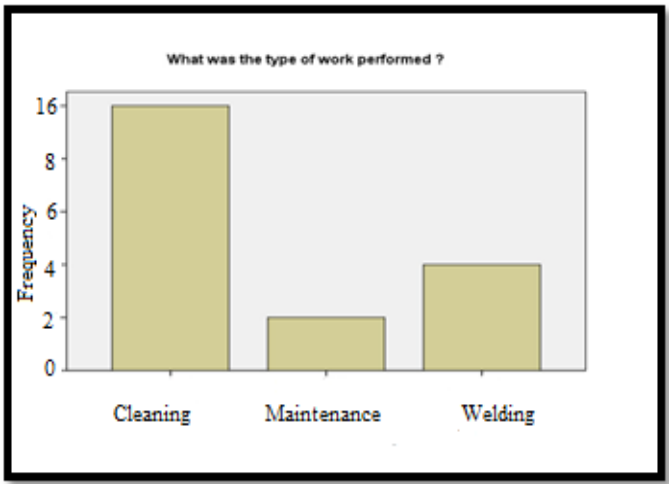

Fig. 6. Types of work had been performed in the confined spaces

OSHA and NIOSH data during the period 1980-1993 indicates atmospheric conditions were the leading cause of death associated with confined space entry. The data indicate that oxygen deficiency, hydrogen sulphide, methane, and inert gases were found to have led to specific atmospheric hazardous conditions. Engulfment was found to be the second in terms of occurrence. Mechanical asphyxiation from loose materials such as grain, agricultural products, sand, cement, and gravel were dominant. Evidence suggests that the cause of death associated with confined space entry hasn't changed appreciably during recent years.

For maintenance, employees enter to repair or change parts and/or spare parts. In the study the maintenance was an electric maintenance during which the employees are exposed to the hazard of live wires. According to the OSHA standards, the first step before starting any work in the confined space, electricity must be switched off and proper lockout/tag out must be used.

Before starting any of the above processes the supervisor shall ensure that employees wear the required personal protective equipment (employees must follow all written plans and procedures developed by the employer). Workers should not enter the confined spaces or hazardous atmospheres when there are no written plans or procedures for working in the areas.

The data represented in Fig. 7 suggest that only 18% of the employees said that there was identification which helped and guided their supervisor in choosing the suitable PPE. Some employees said that combustion probability was the pre-entry hazard identified before entering the space (type boiler); they hold an extinguisher for emergency. The rest entered without identifying the hazard that might face them. It was justified from many supervisors by that the confined space entry program is to be initiated. The employees must not enter any confined space without an entry program that insure the space safety and arrange for the entry as whole. Working without pre-entry hazard identification causes serious accidents and fatalities.

There are no detector devices of atmospheric contaminant to test any confined space found in the entire sample factories visited. Testing enables employers both to devise and implement adequate control measures for the protection of authorized entrants and to determine if acceptable entry conditions are present immediately prior to, and during, entry. There wasn't any measurement for atmospheric hazard during entry as shown in the result represented in figure-8. Generally the reason behind this is less safety priority or deficiency in the fund provided for safety.

Safety measures used to protect employees wasn't adequate. In much of the cases the PPE consist of safety shoes, gloves and aprons. Special PPE must be used to suit each type of space and its expected conditions. In few cases, only tags were used to control the energy. As mark pendent on the switch, there was no use of locks in all cases. The level of safety is higher when using lock with tag. In OSHA standard

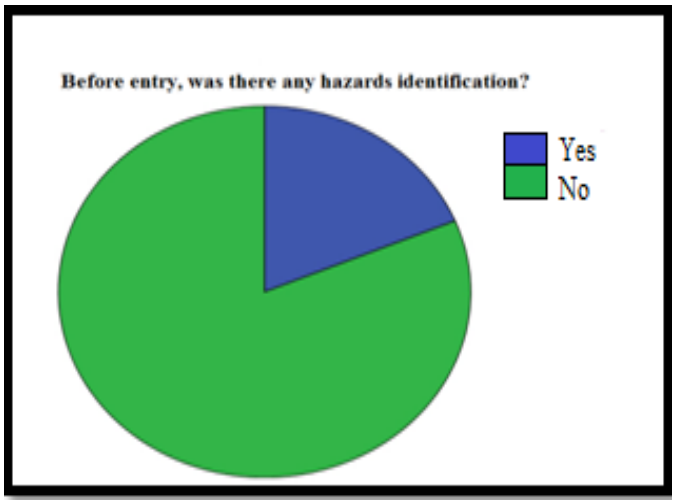

Fig. 7. Pre-entry hazard identification

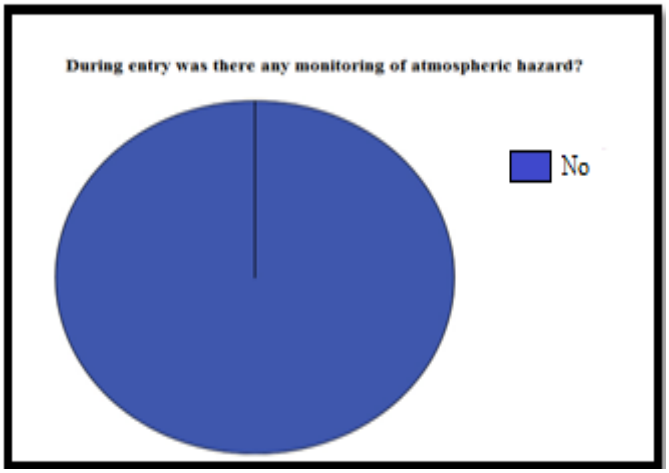

Fig. 8. Atmospheric measurement availability

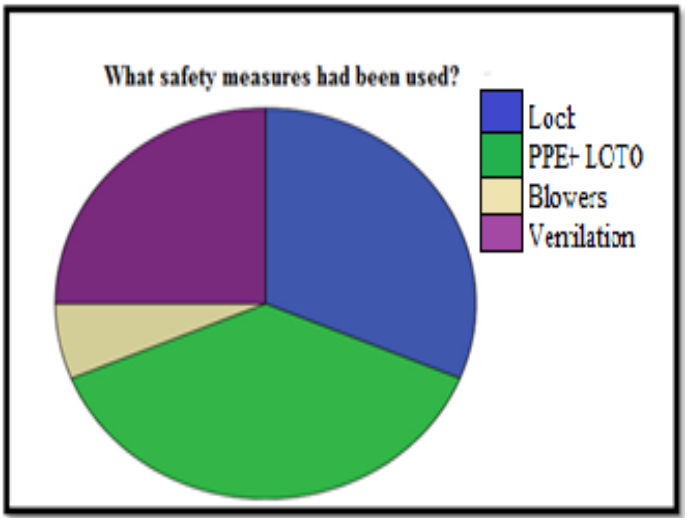

Fig. 9: The safety measures used

NO.1910.147 the control of energy (Lockout/Tag out), the employer is responsible for protecting the employees from hazardous energy sources in machines and equipment during services and maintenance. Suitable blowers must be used when ventilating the confined space. If there was no test for the space conditions while ventilating this may put the space in risk by altering the space condition.

The result in Table 2 and Fig. 10 suggest that 38% of the sample faced difficulties while entering and during work, the reasons behind this might be:

- Physical hazards were not removed before entry (e.g. Entrapment materials).
- The PPE wasn't provided and the available equipment was not in a good manner.
- Illumination and lighting sources were unavailable.
- Un-effective means of communications.

For the subsequent result in Table 3, 44% of the employees had faced and suffered from accidents. Some accidents were not acute (small wounds and fractions) and the others were acute (employee unconsciousness).

Form the results above it may be concluded that accidents are less than logically expected, for untrained employees and incomplete safety system. Many reasons led to this reality it is because of constraints the study faced (no records available) and the tough security procedures. In relation to the safe entry program, rescue team must be effectively train and ready, as shown before that the majority of accidents occur during rescuing.

The data in Fig. 11 show that 12.5% of the employees reported that the civil defence rescuer perform the rescue. Slightly below 19% indicated that the attendant is the one who applied the rescue. Rescue must be as quick as possible with properly trained person (from civil defence, fire department or organizational emergency rescue team) and within three minutes from the time communication was lost with the worker in the space. As in regulation 5 of the safety, health and welfare at work "a person shall not enter a confined space to carry out a work activity in a confined space unless suitable and sufficient arrangements for the rescue of persons are secured."

Summary; No comprehensive entry program was developed in any of the industries in the study. The American National Standard stated that if the employer determines that employees will enter confined spaces, the employer shall develop and implement a written confined space entry program. This written program shall include a requirement to develop specific entry procedures for the permit spaces identified during the survey. Procedures shall identify known hazards as well as the actions required to eliminate or control them.

Table 2. Difficulties employees had faced

Valid	Frequency	Percentage	Cumulative Percentage
Yeas	6	37.5	37.5
No	10	62.5	100
Total	16	100	

Table 3. Accidents employees had faced

Valid	Frequency	Percentage	Cumulative Percentage
Yeas	7	43.8	43.8
No	9	56.3	100
Total	16	100	

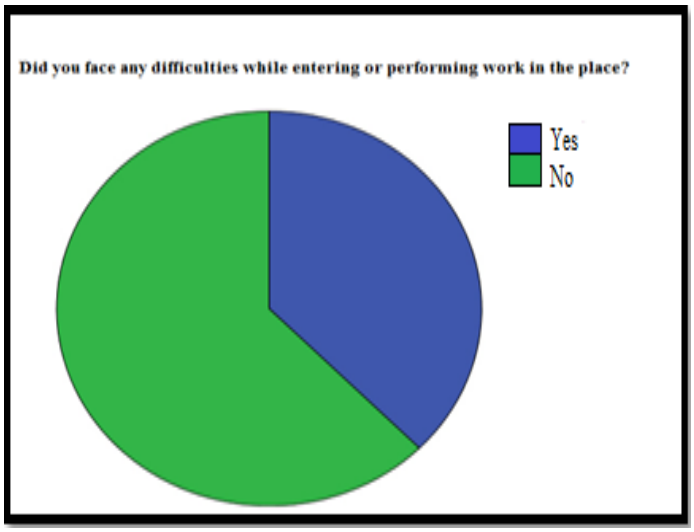

Fig. 10. Difficulties employees had faced

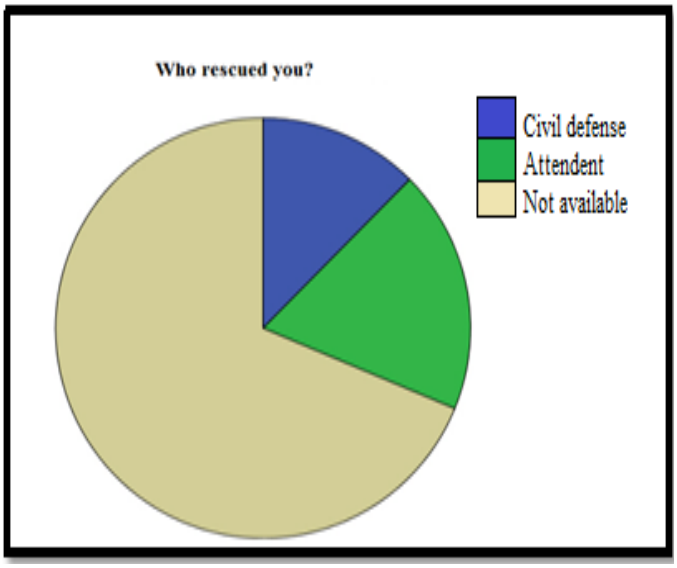

Fig. 11. Employees Rescue

4. CONCLUSIONS

Many work places contain spaces considered to be "confined" because of their configurations hinder the activities of employees who must enter into or work in. Confined spaces were significantly more hazardous than normal workplaces while serious accidents occur in confined spaces.

The study evaluates Khartoum North Industrial area; by evaluating the employees' awareness about the hazards from working in confined spaces and the entry programs used to access these spaces.

The study shows that over 56% of the employees don't recognize confined spaces definition. Up to 80% of the employees haven't been trained to recognize the confined space hazards. They demonstrate the lack of employee's awareness and knowledge about the basic concepts of confined spaces and the hazard associated with them.

In many of the cases there was little evidence of a safe system of work. In these cases safe system was found to have been poorly implemented. As the results show over 82% of the spaces were permitted to be entered without pre-entry hazards identification. 0% of space's atmospheric conditions have been monitored during entry. Over 80% of the spaces expected to cover atmospheric hazards depend on the type of work performed and the confined space condition. In addition, no adequate emergency rescue procedures were present.

There are no comprehensive safe and committed systems of work to guarantee employee's safety and health. Employers should comply with the local act "Industrial work and security Act of 1997" and "The compensation for work accidents law of 1981"; to develop and implement safety confined spaces entry program at Khartoum North Industrial Area. Employers should implement proper, effective and comprehensive identification training for authorized entrants before holding any work in the confined space.

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