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Mitigating the impact of explosive waste on the environment through compliance with applicable environmental legislation and environmental management systems ISO 14001:2015

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ABSTRACT

The improper disposal of explosive waste poses significant threats to the environment, including soil and water contamination, air pollution, and adverse effects on human and wildlife health. To mitigate these impacts, compliance with applicable environmental legislation and the implementation of environmental management systems (EMS) such as ISO 14001:2015 are crucial. This research aims to investigate the effectiveness of complying with environmental legislation and implementing ISO 14001:2015 in mitigating the impact of explosive waste on the environment.

The research will employ a mixed-methods approach, combining quantitative data analysis and qualitative case studies. The quantitative aspect will involve analyzing historical data on explosive waste incidents and environmental violations to identify trends and patterns. Additionally, surveys and interviews will be conducted to gather information on current compliance practices and the effectiveness of EMS implementation.

The qualitative aspect of the research will focus on conducting case studies at selected sites where explosive waste is generated and managed. These case studies will involve site visits, interviews with key stakeholders, and document analysis to assess the level of compliance with environmental legislation and the extent to which ISO 14001:2015 is being implemented. The case studies will also explore any barriers or challenges faced in achieving compliance and implementing EMS.

The findings from this research will contribute to a better understanding of the role of compliance with environmental legislation and ISO 14001:2015 in mitigating the impact of explosive waste on the environment. The results will inform policymakers, regulatory agencies, industry stakeholders, and environmental management professionals about effective strategies for minimizing the environmental risks associated with explosive waste.

Keywords: explosive waste, environmental legislation, ISO 14001:2015, compliance, environmental management systems

ABBREVIATIONS AND ACRONYMS

AITG - International Ammunition Technical Guidelines

BSI - British Standards Institution

CIE - Chief Inspector of Explosives

CWC - Chemical Weapon Conventions

DoD - Department of Defence

EIA - Environmental Impact Assessment

EMS - Environmental Management System

EPA - Environmental Protection Agency

FFCA - Federal Facilities Compliance Act

IAF- International Accreditation Forum

IAP- Interested and affected parties

ISO - International Organisation for Standard

NEPA - National Environmental Policy Act

PDCA- Plan, Do, Check, Act

RCRA - Resource Conservation and Recovery

SAATCA Southern African Auditors & Training Certification Authority

SAGE- Strategic Advisory Group on the Environment

KEY DEFINITIONS

Air pollution

Means any change in the composition of the air caused by smoke, soot, dust (including fly ash), cinders, solid particles of any kind, gases, fumes, aerosols and odorous substances. **NEMAQA (RSA, 2004b)**

Atmospheric emission

Means any emission or entrainment process emanating from a point, non-point or mobile source that results in air pollution. **NEMAQA (RSA, 2004b)**

Burning grounds

A fenced-in area with controlled entrance where explosives may be exposed to a naked flame under safe controlled conditions. **Explosives Regulations GNR.109 of 17 (RSA, 2003c)**

Disposal

The removal of ammunition and explosives from a stockpile utilising a variety of methods, (that might not necessarily involve destruction). **Wilkinson (2006)**

Disposal

Means the burial, deposit, discharge, abandoning, dumping, placing or release of any waste into, or onto, any land. **NEMWA (RSA, 2008a)**

Destruction

The process of final conversion of ammunition and explosives into an inert state that can no longer function as designed. **Wilkinson (2006)**

Explosives

Means a substance or a mixture of substances, in a solid or liquid state, which is capable of producing an explosion; (b) a pyrotechnic substance in a solid or liquid state, or a mixture of such substances, designed to produce an effect by heat, light, sound, gas or smoke, or a combination of these, as the result of non-detonative self-sustaining exothermic chemical reaction, including pyrotechnic substances which do not evolve gases; (c) any article or device containing one or more substances contemplated in paragraph (a); (d) any plastic explosive; or (e) any other substance or

article which the Minister may from time to time by notice in the Gazette declare to be explosive. **Explosives Act (15 of 2003)(RSA, 2003a)**

Explosives manufacture

The making or processing of any explosive including the division of any explosive from its component parts by any process, and the conversion of any explosive of one kind into an explosive of another kind, including the alteration, fitting for use, testing, on-site manufacture, repair or destruction of any explosive. **Explosives Regulations GNR.109 of 17 (RSA, 2003c)**

Waste

Means any substance, material or object, that is unwanted, rejected, abandoned, discarded or disposed of, or that is intended or required to be discarded or disposed of, by the holder of that substance, material or object, whether or not such substance, material or object can be re-used, recycled or recovered and includes all wastes as defined in Schedule 3 to this Act but it excludes explosives waste. **NEMWA (RSA, 2008a)**

Waste

Includes any solid material or material bat that is suspended, dissolved or transported in water (including sediment) and which is spilled or deposited on land or into a water resource in such volume composition or manner as to cause, or to be reasonably likely to cause the water resource to be polluted. **NWA(RSA, 1998b)**

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CHAPTER 1 INTRODUCTION

Background

Management of waste resulting from explosives presents unique difficulties due to its hazardous characteristics. In this study, we investigate the multifaceted sphere of legal compliance in managing explosives waste, concentrating on national, and regional regulations that oversee this crucial sector. Initially, an overview of explosives waste is provided, highlighting its environmental and safety ramifications. We then delve into the primary international treaties and conventions, followed closely by an in-depth analysis of national regulations, using the United States as a case study. Noticeably, we also accentuate disparities within regional legal structures and their effect on adherence efforts.

As a prominent global player, it's incumbent upon the South African economy to honor international commitments to reduce environmental degradation resulting from waste disposal. Such responsibility forms part of the comprehensive strategy designed by the South African economy to confront pollution issues and manage waste, thereby striving for sustainable development as suggested by Nahman & Godfrey in 2010. The embodiment of this strategy is found in their integrated waste and pollution management policy, which is underpinned by the drive for sustainable economic growth.

In the explosives sector, waste generation is quite important (Lèbre et al., 2017). This requires a review of regulatory measures for environmental damage caused by the production of such explosives. This is measured by the effectiveness of ISO 14001:2015's existing waste management legislation and regulation on explosive manufacturing activities.

This paper will look at mitigating the impact of explosives waste through regulatory measures assessing the environmental damages caused by manufacturing in the Explosive sector, the regulations surrounding the larger problem of explosive waste that inevitably arises on account of the Explosive sector and compliance to the environmental management systems ISO 14001:2015.

The manufacturing of explosives gives rise to the production of various hazardous chemicals. The explosives industry has been in operation since the discovery of gold in Witwatersrand in 1886, and

mining activities led to Johannesburg becoming the most effective international market for dynamite. This industry has grown exponentially since the production of dynamite in 1886.The production of explosives involves several chemical processes, inclusive of the nitration of organic compounds and associated operations that deal with the production and recycling of acids (Akhavan,2011). Consequentially, this manufacturing process results in the creation of waste in three forms: liquid, solid, and gas. The generation of such waste significantly impacts the environment and leads to various detrimental effects. These include an adverse effect on water quality due to acidification, impairment of air quality as a result of the emission of harmful gases, and the creation of solid waste in the form of incineration residue. This chain of repercussions affects both surface and groundwater quality, causing severe pollution of rivers, air, and has potential harmful effects on wildlife and human health, in addition to numerous negative social impact (Hudak and Parsons 2002; Shen 2009; Barreto-Rodrigues et al. 2009). The detrimental impacts extend to both terrestrial and aquatic ecosystems, expediting global issues such as ozone layer depletion and global warming (Duijm and Markert 2002; Zhou and Schoenung 2009).

The above adverse impacts are covered by relevant laws in the form of acts and regulations that comprise the overall regulatory framework in the context of which the explosives industry conducts its operations and compliance. In summary, the major laws in this regard are the National Environmental Management Air Quality Act 2004, the National Water Act 1998 and the National Environmental Management Waste Act 2008. All of these are important laws with respect to Environmental Management. These three Acts cover the major forms of environmental pollution on account of the waste generated from explosives sector, viz. air pollution, water pollution and waste. There are various other regulations in this context which have been specifically framed in relation to the Explosives sector namely, the Explosives Act, 2003, along with the related Draft Explosives Regulations 2007, the Mine Health and Safety Act, 1996, the Explosives Regulations 2003, the Explosives Regulations 2007 and the Occupational Health and Safety Act 1993.

All the above acts and regulations are specifically targeted towards the safety of humans but do not address any environmental consequences arising out of the manufacturing of explosives. However, in order to promote these laws and regulations, certain procedures have been set up for applying for developments in explosives and approving them by the Chief Explosives Inspectorate (CIE). This is

to ensure that explosives are manufactured in quantities and operate under conditions authorized by the Chief Inspector, and that the manufacture of explosives and explosives is adequate from a security point of view.

Explosive waste refers mainly to the substandard products, waste and waste of explosive property created during the manufacturing, marketing and use of explosives, and the end products resulting from the destruction process of the explosive. Large quantities of explosive waste are generated annually in different regions and contain potentially toxic or hazardous components such as high nitrogen, PCBs, PCBs, rotary kilns (see Noyes, 1996). The human health and environmental risks associated with the production, processing and disposal of waste related to explosives have been extensively studied and are well-known (see Cairns & Dickson (1973), Ryonet (1984), Steuckart et al., 1994), Siminiet (1995), Pennington (2002), Letzelet (2003) and Ana (2012).

The production of explosive waste may lead to environmental degradation through the use of nitrates and acids in manufacturing processes, the emission of dangerous gases, and the destruction of solid waste in sludge caused by incineration residue. These activities may have a detrimental effect on the quality of surface and groundwater, as well as air pollution and adverse health consequences (Hudak et al., 2002, Shen, 2009), and may potentially lead to global effects, such as the depletion of ozone and global warming, as suggested by Duijmand Markert, Zhou, and Schoenung, 2009).

The environmental impacts of activities, products, and services are fast-moving up the priority level of industries today. The 2002 World Environment Summit (Scherr and Gregg, 2005) and the Sustainable Development Goals (United Nations, 2015) emphasize the importance of sustainable development and its relationship to environmental protection. These requirements are equally applicable to the explosives sector. This implies that the activities related to the sourcing of the raw materials, manufacturing, use, and disposal of explosives need to be managed sustainably. Section 24 of the South African Constitution (Act 108 of 1996) provides everyone with the right to an *environment that is not harmful to their health and well-being, and the right to have the environment protected through reasonable legislative and other measures*.

In the South African context, there are various pieces of legislation for the management of explosives and explosive waste. Some of these focus on environmental protection, whilst others focus on the protection of the worker (employee) and workplace, and the protection of public safety. The Explosives Act (15 of 2003) (RSA, 2003) aims to provide for the control of explosives. This Act is supported by numerous other pieces of legislation. As far as environmental protection is concerned, the principles and requirements provided for in the National Environmental Management Act (107 of 1998) (NEMA) (RSA, 1998), the National Environmental Management Air Quality Act (39 of 2004) (NEMAQA) (RSA, 2004), the National Water Act (36 of 1998),(NWA) (RSA, 1998) and the National Environmental Management Waste Act (59 of 2008) (NEMWA) (RSA, 2008) aim to regulate activities with potential impacts on the environment. The disposal of explosives that is regulated by the Explosives Act, 2003 (15 of 2003) (RSA, 2003) is, however, excluded from the requirements of the NEMWA. The Hazardous Substances Act (15 of 1973) (RSA, 1973) aims to protect the public from the dangers of hazardous substances, which includes explosives, while the Mine Health and Safety Act (29 of 1996) (RSA, 1998) and the Occupational Health and Safety Act (85 of 1993) (RSA, 1998) and their regulations aim to protect the worker and workplace.

The main objective of the South African National Water Act is to ensure equitable water distribution for the people of the country. It is also to ensure that the management, protection, conservation, and controlling of the water resources for preparing a sustainable plan for the future. It also entails the protection of the water sources such that resource development is feasible.

The consequences of the destruction and disposal of explosives may vary depending on the technology or process employed (Poulin (2010), Dujimand (Markert (2002)), and each technology may have its own legal requirements which may be difficult to implement.

In 1996, ISO developed a set of standards to enhance environmental quality (Bansal and Bogner, 2002), This set of standards was later revised in 2004 and 2015. While ISO 14000 does not provide the only solution for effective environmental management, it does provide guidance to companies on how to develop more effective environmental policies. The set of standards includes ISO 14001, ISO 14000, ISO 14001 Audit, ISO 14001 Auditing, ISO 14001 Environmental Performance Evaluation, ISO 14000 Environmental Labelling, ISO 14001 Lifecycle Evaluation, and ISO 14001

Product Environmental aspects. ISO 14000 is the only ISO 14001 standard that has been specifically designed to address the needs of environmental management systems. As a result, ISO 14001 has become a requirement for customers and other stakeholders and has consequently become a conditionality in the supply chain (Nawrocka and Parker, 2009).

The ISO 14001:2015 tool has been extensively utilized as a means for implementation and to enable decision making in order to mitigate the environmental consequences of developmental projects and activities (Glasson, Therivel and Chadwick 2005). ISO 14001 EMS is a management system that is impact-oriented, with the aim of optimising the relationship between human activity and its effects on the natural world (Edwards (2004), stead, stead & starik (2004), von Zharen (2001). Governments, institutions and business organisations, motivated by the need to reduce adverse environmental effects, began to develop environment-related legislation, regulations and programmes in the early seventies (Portney (1981)). ISO 14001 (2015) ensures that all adverse environmental effects of a company are identified, tracked and compliant with the regulations.

An environmental management system (EMS) offers a systematic approach to help organisations understand their impacts and prioritise how they will be addressed. The best-known approach to EMS is laid out by the International Organisation of Standards (ISO) 14000 series of standards, with ISO 14001 providing the requirements for an EMS and ISO 14004 giving general EMS guidelines. The other standards and guidelines in the series address specific environmental aspects, such as labelling, performance evaluation, life-cycle analysis, communication, and auditing. ISO 14000 has been adopted by more than 300,000 organisations worldwide. The ISO 14001 and the Plan-Do-Check-Act (PDCA) cycle (Figure 1, which is the operating principle of all ISO management system standards) provided the framework for the management of environmental aspects. Most of the explosives manufacturing organisations have environmental policies in place that establish their commitments to minimise the climate and environmental impact of their activities. Environmental management systems such as ISO14001 have become a ubiquitous way for organisations to ensure compliance with environmental legislation and mitigate or minimise their environmental impact. This is equally true for private business and government organisations, where management systems have been developed.

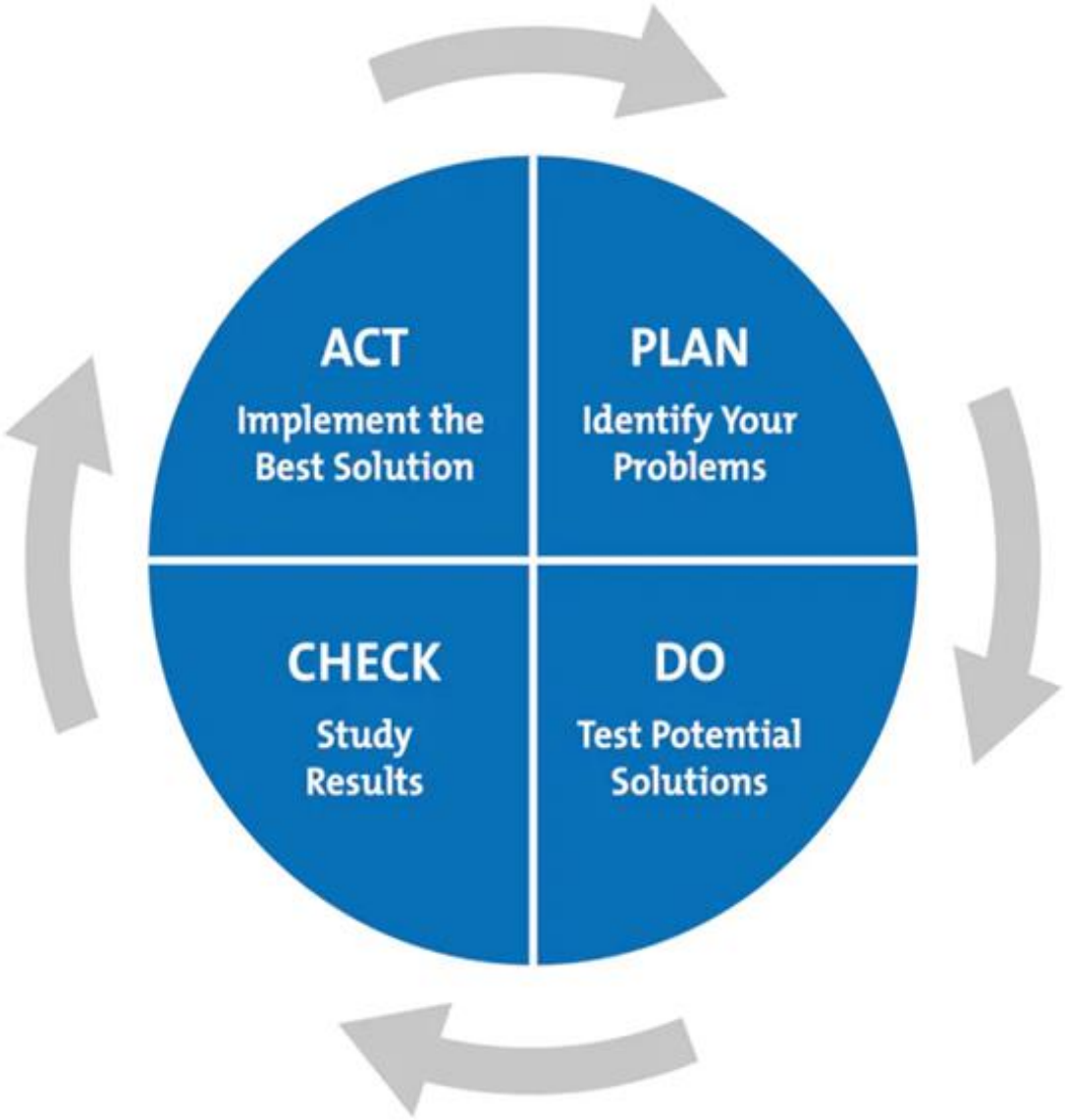

Figure 1-1: PDCA Cycle

Problem Statement and rationale for the study

It is increasingly recognized that all sectors need to minimize environmental impact, and explosives is no exception (Alverbro*et al*., 2009). The manufacture of explosives for the use of military or commercial products causes complex hazardous waste streams (Doel, 2011), which are unsafe to be treated by conventional hazardous waste management methods.

Various laws have been developed to regulate the management of explosives and their resulting waste, some of which focus on health and well-being, while others focus on environmental protection. At international level, the Environmental Protection Authority (EPA) has enacted the *Resource Conservation and Recovery Act* (RCRA), a public law that provides a framework for the proper management of hazardous solid waste (EPA, 1997) and a regulation of military ammunition (King, 1998).

There is a risk of conflict between the fragmented nature and the multiple requirements of the law as it pertains to the management of explosives wastes, which may result in difficulty in complying with and enforcing those rules.

Limited studies have been carried out in South Africa, focusing on compliance with the statutory requirements for the disposal of explosives, and compliance with ISO 14001. The aim of this study is to understand the impact of compliance with legal requirements and environmental management systems in reducing the impact of explosive waste on the environment.

Research aim and objectives

In the context of the complex legislative environment created by numerous pieces of legislation applicable to the management of waste from the explosives sector, the aim of the research is to critically evaluate the impact of ISO 14001:2015 Environmental Management System on preventing environmental degradation from the management of waste from the explosives sector.

The objectives of the study are the following.

- Assessing the effectiveness of ISO 14001 in reducing the impact of explosive waste on the environment: This objective would include assessing the effectiveness of ISO 14001 certification and compliance measures in real life to minimize the negative impact of explosive waste on the environment.

- Identify best practices and strategies for managing explosive waste within the scope of ISO 14001: This objective will include research into successful case studies and examples of companies that have successfully implemented ISO 14001 standards to manage and

mitigate the environmental impact of explosive waste.

- Assessing the economic and operational benefits of ISO 14001 certification for explosive companies: This objective includes analysing the cost-effectiveness and efficiency improvements that can be achieved through the implementation of ISO 14001 for the management of explosive waste. This could include factors such as reducing waste disposal costs, enhancing resource efficiency, and improving regulatory compliance.

- Identify challenges and opportunities for achieving legal compliance while managing explosive waste. This objective his objective aims to identify the challenges and opportunities that explosives manufacturing companies face in achieving legal compliance while managing their explosives waste.

4.5 Scope and Delineation of the research

The explosives waste life cycle consists of five major stages, starting from the generation of explosives waste and moving on to the handling and storage of these explosives waste in the second stage. From there, these wastes are destroyed through technological methods in the third stage, known as the destruction of explosives waste. Next, the waste residue classification, storage, and handling are conducted in the fourth stage, when it finally moves to the fifth stage where the waste residue is transported for final disposal. However, due to the main focus of the study on the environmental impacts of explosives waste disposal, its scope ranges from the second to the fourth stage consisting of 3 key stages. Each stage has been discussed in detail to clearly understanding the effect each of these stages might have on the environment.

Handling and Storage of Explosive Wastes: The handling of explosive wastes as well as the storage of the explosives is a big task as many of the accidents are directly related to the mishandling and storage faults of the explosives. Rucevska et al. (2017) have also stated that handling and storage of explosive wastes in South Africa as one of the most prominent reasons for accidents. For example, Enviroserv Holdings Limited dumps more than a quarter of medical wastes that are produced by the company illegally, which shows the degradation of the water quality in the country. A safe framework for the safe and secure handling of explosives safely and securely would ensure

that the rate of the issues that the country can also be minimized in the process. Education about the handling of the explosives in the country is also necessary for the dissemination of knowledge.

Destruction of Explosives Wastes: Hart and Stock (2019) stated that the destruction of explosive wastes of the country is a trifaceted ambition by the Department of Defence (DoD). The Installation Restoration Programme (IRP) is also incorporated into the Department of Defence for handling of the destruction of explosive waste from the country. The destruction of explosives wastes in the country would also have a lasting impact to ensure the safety and the security of the disposal personnel.

Waste (Residue) Classification, Storage and Handling: The destruction process as well as the handling and storage of explosives is different and is based on the nature of the explosives that professionals are being handled by the professionals. Therefore, the classification of waste becomes very important for professionals. The classification of the residues is also necessary to establish a uniform system for the destruction of the waste and standardization of the process can be done.

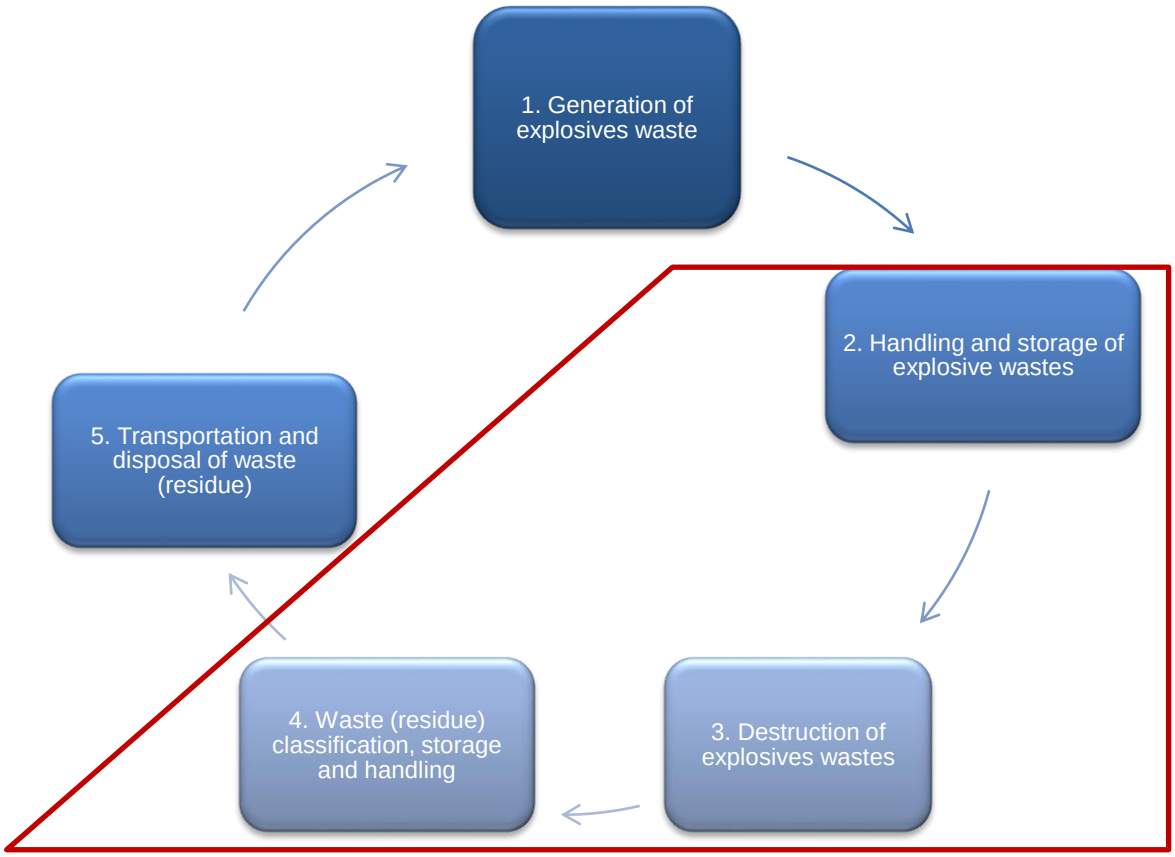

Figure 4-1: The explosives waste life cycle in manufacturing industries

4.6 Assumptions and limitations of the research

Despite the comprehensive and detailed information included in the research study, there are some major limitations to it that need to be addressed in this report section. Although the research focusses on the environmental implications and associated issues of explosive waste disposal, the research is mainly based on the literary and scholarly work conducted by other authors in the past. For this reason, the environmental implications are based on previously available data and do not include the current impact. With the various technological advancements in explosive waste disposal, the current effects might have changed, and the research fails to conduct a study or analysis on its own. The legal compliance for disposing of explosive waste follows the Manufacture and Storage of Explosive Regulations 2005 under the Approved Code of Practise (ACOP). The research follows legislations as per Regulation 6 of the ACOP that provides the four most effective ways to dispose of or destroy explosives. However, this regulation fails to consider the updated

environmental consequences mentioned in Earth Summit, and hence the data are not accurate and up to date.

4.7 The Possible Contribution of the research

The research conducts a comprehensive examination of the explosives, their handling and storage, and residue classification are some of the features of this study. The contribution of the research is to build a comprehensive detailed study that focusses on the development of an understanding of the application of the legal frameworks and the environmental management system for waste management. The main objective of the study is to assist in the decision making process for the protection of the environment and the focus of the study has been on explosives that are used by mining and power stations. This research aims to determine the best practice for mitigating the impact of explosive waste to the environment.

4.8 Structure and outline of the dissertation

The structure of the dissertation is outlined as follows:

Chapter 1: Introduction

This chapter presents the background to the research problem statement, research aim, objectives of the research, research questions, problem statement, and the outline of the rest of the study.

Chapter 2: Methodology

This chapter focusses on the collection of data that would be essential for the study. A design appropriate to answer the research questions will be identified, defined, and motivated. The population, the sampling method and strategy to be used, and the proposed sample size will be clearly described in line with the study. Specific and appropriate measuring instruments will be chosen for each of the identified variables. The credibility, reliability, and validity of the measuring instruments will also be addressed.

Chapter 3: Literature review

In this chapter, the literature review gives an overview of the ISO 14001:2015 standard and national and international legislation and the role it plays in business with a special emphasis on creating competitive advantage. All variables involved in the study will be clearly defined from the literature. The results of the most pertinent studies in the field (both internationally and nationally) will be integrated into a coherent discussion, considering corresponding and contradictory viewpoints.

Chapter 4: Mitigation of explosives waste to the environment through compliance with ISO 14001:2015

In this chapter, the researcher explores the benefits and challenges of managing explosives waste through implementation of environmental management system based on ISO14001:2015. Explosives waste can present a unique environmental and safety challenges, and ISO 14001:2015 offers a structured framework for organizations to address these challenges. These chapter will examine case studies, practical applications, and real-world examples to illustrate how ISO 14001:2015 can enhance environmental sustainability, safety and compliance in the management of explosives waste.

Chapter 5: State of ISO 14001:2015 compliance in explosives manufacturing process

This chapter will explore the state of ISO 14001:2015 compliance within explosives manufacturing organizations and discuss the challenges and benefits associated with implementing this standard. ISO 14001:2015 standard is an internationally recognized environmental management system (EMS) that provides a framework for organizations to develop and implement environmentally sustainable practices. In the context of explosives manufacturing organizations, adherence to this standard is essential to ensure the safe and responsible management of hazardous materials and the reduction of environmental impact.

Chapter 6: State of legal compliance in explosives waste management

The manufacturing and distribution of explosives is a critical industry with significant implications for public safety, national security, and environmental concerns. As such, organizations involved in the production of explosives are subject to a range of laws and regulations designed to ensure the

safe and responsible handling of these materials. This chapter aims to provide an in-depth analysis of the state of legal compliance within the explosives manufacturing industry, highlighting the key issues and challenges faced by these organizations, as well as the measures they have taken to improve their adherence to legal requirements.

Chapter 7: Disposal of munition and explosives waste

This chapter offers a comprehensive examination of the disposal of munition and explosives waste. This chapter delves into the various disposal methods, including controlled detonation, demilitarization and recycling, while also assessing their environmental consequence. The chapter also explores the critical role of international treaties and agreements, national regulations, and emerging technologies in shaping disposal practices. The chapter concludes by highlighting the need for a holistic approach that balances security concern with environmental sustainability and public safety.

Chapter 8: The benefits of ISO 14001:2015 in explosives waste management

The chapter explores the advantages of implementing ISO 14001:2015 for the management of explosives waste management. The chapter discusses the key components of ISO 14001:2015, its relevance to explosives waste management and its potential benefits. The chapter also explores the key provisions of ISO 14001:2015, the relevance of environmental management system in the explosives manufacturing sector and the benefits of compliance.

Chapter 9: Results/ Data Analysis and discussion

The chapter will present the results from the data gathered in the analysis of the ISO 14001:2015 and all relevant legislations and their role on the level of success or otherwise within a competitive framework. Specific and appropriate data analysis techniques will be described to address each of the 3 objectives of the study. A clear motivation for the use of the technique is suitable to use will also be provided. Presentation of results will be made in the form of tables, graphs, and charts.

Chapter 10: Conclusion and Recommendation

This chapter will provide detailed discussions of the findings made during the research. Furthermore, suggestions for further study will be highlighted, and recommendations deemed beneficial to the industry understudy will be made at this stage.

4.9 Chapter summary

Examination of explosives, their storage, handling, destruction and other associated tasks would ensure the safety of the environment as well as the safety of the people and professionals involved. The research path would prove to be crucial in the evaluation and examination of the legal framework of South Africa. The legal frameworks would facilitate the establishment of a uniform waste and explosive management throughout the country. A succinct overview of the literature would also be examined to corroborate the claims.

CHAPTER 2 METHODOLOGY

2.1 Introduction

The methodology of the research is the determinant of the path and the direction that the research project. According to Kumar (2019), there are several methodologies that the researcher and the intention of the investigation would dictate the choice of the research methodologies for the proper determination of the conclusions. The extensive subjective opinions and legislation of explosive wastes in South Africa can be done with the help of the examination of the secondary data from credible literary sources. This part deals with the methodologies that were observed for the conduct of the research along with the reasons for their choice.

2.2 Research design

Creswell and Creswell (2017) state that the design of the research should be considerate of the intended outcomes, as well as the factors that are available at the disposal of the researcher. This research was designed in such a way as to examine the legislation and regulation for the management of explosive wastes in South Africa. In addition to that, the secondary sources of literature were examined with analysis and correlation of the same to account for the environmental impacts of the same through an exploratory design. The literature review was also comprehensive and included the legislative frameworks of international standards, as well as a national standard.

2.3 Data Collection

Paradis et al., (2016) iterated that among the primary and the secondary methods of data collection, the research objectives would dictate the choice of the data collection procedures. To address the research questions and achieve the objectives, this research adopted a mixed-methods approach. The research will involve a combination of quantitative data collection and analysis, as well as qualitative methods such as interviews and case studies.

This research had used secondary methods for the data collected by examining literary sources pertaining to explosive wastes in the country. In addition to that, information on the environmental impacts was also collected for a more relevant analysis of the topic.

Justification: The reason for the choice of secondary methods of data collection is due to the subjective nature of the topic. Information on the impacts of explosive waste on health and environment cannot be gathered primarily and so the assessment of the secondary sources is the appropriate method for progressing this research.

Description of secondary sources

The validity and accuracy of the collected information must be critically evaluated, and a source must be chosen in order to obtain the necessary data. Websites, government websites, journals, and other reliable literary sources were used as secondary sources. A thorough review of the sources and a close examination of the journals were also conducted to obtain relevant information regarding the research.

Justification: The secondary sources are chosen in order to enhance the accuracy of the information collected. The quality of the information collected determines the quality of the research, as a result, it is imperative to choose a source that can be trusted, so the secondary source is carefully considered. These sources are a treasure trove of information.

Description of the data sample

Most of the data available for this research were extracted from government websites, and keywords such as explosive waste, environmental impact, ISO 14001 were used to find relevant information. The generated search results were also evaluated and further analysed to add value to the research. The scope of the study also includes the examination of samples.

During the research process, most of the data available for this project were taken from government websites where keywords like explosives waste, environmental impacts, health impacts, and others were used to find relevant information. A screening of the generated search results was also conducted in order to add value to the research by further analysing them. An examination of the sample is also included in the scope of the study.

2.3.1 Interviews

Interviews were used to gather the opinions and perceptions of respondents on the challenges and areas for improvement, as it relates to explosives waste management.

2.3.1.1 Developing semi-structured questionnaires.

A researcher created a semi-structured questionnaire consisting of a list of questions to investigate the management of explosive waste throughout its lifecycle and the challenges faced within the system, as well as the adherence to legal regulations (Table 1-1). The questionnaire included both closed-ended and open-ended questions in order to explore the reasons behind non-compliance and gather suggestions on how to prevent future instances of non-compliance. The interview questions were designed to assess the level of awareness regarding legal compliance and the day-to-day practices implemented to ensure compliance at the manufacturing site. To maintain anonymity, the interviews were conducted without revealing the identities of the participants.

Table 1-1: Structure of the questionnaires

	Question	**Focus**	**Motivation**
Q1	Designation	Level of responsibility and accountability	According to De Hoogh and Den Hartog (2008) the level of learning and socialization experiences are critical in developing a sense of responsibility and accountability
Q2	Can you provide an overview of your company's journey towards obtaining ISO 14001 certification	Practice	Zhao and Ke (2017) emphasise the importance of sorting explosives waste as hazardous waste, during the process of collection, transportation, and temporary storage because it poses immense threats to the environment and human health
Q3	How has ISO 14001 certification impacted your company's environmental performance		
Q4	What specific measures have been implemented to address environmental management within your organization		
Q5	How does your company ensure compliance with ISO 14001 requirements on an ongoing basis		
Q6	What challenges, if any, have you encountered during the implementation and maintenance of ISO 14001 certification		

	Question	Focus	Motivation
Q7	Can you describe any improvements in waste management and reduction achieved through ISO 14001	Awareness	Schubert (2004) says throughout the whole munition life cycle, the environment is threatened by the munition and its components because of its energetic content, which may cause detrimental chemical pollution.
Q8	How has ISO 14001 certification influenced stakeholder engagement and relationship building		According to Samiha (2013) awareness/knowledge of waste influences recycling behaviour
Q9	What initiatives or strategies have been implemented to reduce the environmental impact of your operations		The National solid waste management policy aims are: (1) to establish a solid waste management system that is integrated, sustainable, cost effective, and acceptable to the community which emphasises environmental conservation, selection of economical technology while ensuring safe public health, (2) to efficiently implement a solid waste minimization strategy which is based on the waste hierarchy emphasized through the 3R (reduce, reuse and recycle)
Q10	Have you noticed any positive changes in employee awareness and involvement in environmental sustainability since obtaining ISO 14001 certification		
Q11	How has ISO 14001 certification affected your company's reputation and competitiveness in the market		
Q12	Can you discuss any cost savings or financial benefits that have resulted from ISO 14001 certification		
Q13	Are there any specific industry-related challenges that you believe ISO 14001 certification has helped overcome		According to the manufacture's special safety rules, it is important for employees to demonstrate or provide proof of adequate training or experience in the duties when handling explosives.
Q14	How do you monitor and measure the effectiveness of your environmental management system	Practice	As iterated by Perinel and Adham (2020), Measuring compliance is essential to analyse the success of policy and procedure implementation into daily practice
Q15	Has ISO 14001 certification opened up new business opportunities or partnerships for your company	Practice	
Q16	Can you provide examples of any continuous improvement initiatives that have been implemented as part of ISO 14001 certification	Awareness	According to (Stratta et al., 1998) the explosives industry should start considering alternatives to open burning for destruction of production-related explosives waste
Q17	How have your employees been trained or educated to support the		

	Question	Focus	Motivation
	requirements of ISO 14001		
Q18	Can you share any best practices or lessons learned from your experience with ISO 14001 certification?		
Q19	What role does top management play in driving environmental sustainability within your organization		
Q20	How do you ensure effective communication and collaboration among departments regarding environmental management		
Q20	In your opinion, what are the key benefits of ISO 14001 certification for South African explosives companies		

2.4 Data Analysis

According to Quinlan et al., (2019) the data analysis strategy employed by the researcher affects the accuracy of the research results and outcomes. Data analysis techniques can be classified into two main types: quantitative and qualitative. The data collected in this study were analysed using qualitative research analysis methods, which enhance the knowledge base and complement the exploratory research approach. With qualitative data analysis, subject information on explosive waste can be included.

Justification: The qualitative data analysis process adds opinionated information on the effects of explosive wastes on South African health and the environment. It also contributes to increasing the research's applicability in the future.

2.5 Ethical Considerations

According to Iphofen and Tolich (2018), the researcher's ethical considerations while conducting the research determine the project's acceptance and the researcher's goodwill. The acknowledgement of the literary sources used is the most important ethical consideration for this project. The researcher was meticulous in mentioning and acknowledging the importance of the

information and sources in the project's completion. Another aspect of the project's ethical consideration was the legal implications of the explosive waste generated in the country.

This research was carried out in compliance with ethical considerations of the Selinus University. A permission was sought and obtained from the relevant explosives manufacturing companies to collect data. The participants gave permission for notes to be taken. The right to anonymity, voluntary participation, and the right to refuse participation was respected at all levels, including the individual, the explosives manufacturing companies and other institutions. The observation schedules were numbered instead of names to prevent participants from being identified; principles of protecting information were observed to ensure confidentiality, anonymity, and privacy.

2.6 Methodological Limitations

The only limitation of the methodologies chosen for this study is that the researcher's exploratory intention cannot be fulfilled due to the limited time available and allocated for project completion. Another limitation was the sporadic use of qualitative analysis methods, which made assimilation of the required information difficult. It jeopardized the project's quality. These limitations were unintentionally introduced into the research, which was mitigated by the inclusion of multiple references for the arguments and claims made in the project.

2.7 Summary of the chapter

This chapter of the description of the methodologies provided here informs readers about the process of conducting the research itself. The methods used were chosen after careful consideration of several factors. Each component of the methodology adds value to the research and assists the researcher in achieving the established aims and objectives. The correct methodology selection also aided the research directions.

CHAPTER 3 LITERATURE REVIEW

3.1 Introduction

Due to its potential to significantly contaminate the environment and harm ecosystems, explosive debris is a serious environmental hazard. Usually, pyrotechnic displays, industrial activities, and military actions produce this waste. Unsafe disposal of explosive trash can harm both the environment (by contaminating the air and water) and people's health. Environmental management systems, such as ISO 14001:2015, have been shown to be efficient tools for reducing the environmental impact of explosive debris. Explicit ammunition, explosives, and other pyrotechnics can be considered explosive trash. Hazardous substances included in these materials have the potential to have disastrous consequences on ecosystems if released into the environment (Amaral, 2019). For example, improper disposal of explosive trash might result in contamination of the soil, groundwater, and surface water. Negative waste substances that enter the soil can harm microorganisms, people, and animals while reducing agricultural production. Aquatic ecosystems and biodiversity are endangered by explosive waste dumped on waterways.

Explosive waste combustion produces harmful gases and particulates, which contribute to air pollution. Asthma and cardiovascular disease are more likely to occur as a result of this pollution, which has a negative impact on both human health and air quality. The uncontrolled explosion of explosive trash results in noise pollution that is harmful both to people and animals. To solve these environmental problems, environmental requirements must be met (Ibenrissoul *et al.* 2023). International, national, and local environmental rules specify the proper handling, transportation, storage, and disposal methods for explosive waste. These rules are in place for the benefit of society and the environment as a whole. Companies and people are required by these regulations to employ ethical refuse management techniques. The separation, handling, and disposal of explosive materials are required in authorised facilities.

For the management of combustible waste to be effective, environmental rules must be adhered to, and an environmental management system (EMS) must be put in place. A globally accepted EMS standard, called ISO 14001: 2015, can help companies evaluate and reduce their environmental effect. Businesses can improve their environmental performance by conducting risk assessments and developing emergency action plans for the management of explosive waste using the resources

provided by ISO 14001:2015. Numerous advantages can be attained by adhering to environmental rules and ISO 14001:2015 (Pantelic *et al.* 2023). First, it ensures that firms only use waste management techniques that are less harmful to the environment and ecosystems. By showcasing a dedication to environmental sustainability and legal compliance, a company can improve its reputation. Competition, collaboration with authorities, and the confidence of interested parties may all profit from this. By following environmental regulations and implementing an EMS, a business may save money by using resources more effectively, reducing pollution and avoiding penalties and legal responsibilities.

Explosive waste creates serious environmental risks that require the adoption of efficient waste management techniques. Explosive waste poses environmental difficulties that can be overcome if companies adopt ISO 14001:2015 and follow environmental laws (Givano, & Sholichah, 2019). By establishing waste management procedures that safeguard the environment and their financial line, businesses can help the environment. With the help of environmental laws and the implementation of EMS, explosive waste may become less of a concern, ecosystems may be conserved, and a sustainable future may be ensured.

3.2 Explosive Waste and Environmental Challenges

Explosive waste is made up of a diverse spectrum of substances, such as spent ammunition, pyrotechnics, explosives used in mining, and explosives used in building. Heavy metals, toxic chemicals, and energetic compounds are just a few of the many potentially dangerous ingredients that these materials include. Improper handling of these materials can have negative environmental effects. Combustible trash disposal is a serious problem, as it can harm the environment if not done properly. Unsuitable disposal methods, such as burying or leaving explosive debris outside, can pollute the soil (Santosa, 2020). The harmful substances in the waste may enter the soil and contaminate groundwater, which would then contaminate surface water. The aquatic ecosystems and human populations that depend on these water sources for drinking, irrigation, and other uses are put in danger by the presence of poisonous compounds in them. Ecosystems can be harmed and biodiversity may be decreased, by the long-term impacts of heavy metals and toxic chemicals on plant, animal, and microbial health.

In addition to contaminating land and water, inappropriate handling and disposal of hazardous waste can also cause air pollution. Toxic gases, particle matter, and other airborne pollutants are created when explosive materials are burnt or exploded. Pollutants such as sulphur dioxide, nitrogen oxides, and volatile organic compounds are released into the atmosphere during combustion. Due to the presence of these pollutants, both people and animals nearby can be at danger for respiratory and cardiovascular conditions, and they may also be disturbed by the excessive noise pollution caused by the unrestrained detonation of explosive rubbish. The public's health and safety are also at risk from explosive waste. Improper handling, storing, or transport of explosive materials can cause significant injury or death. These substances are hazardous to workers and nearby populations due to their combustibility and flammability (Mohammed Yazen *et al.* 2022). Anyone exposed to or in an environment where hazardous material has exploded is at risk of developing long-term health issues.

Combustible waste should be handled properly if we want to solve these environmental problems. Using waste management, storage, and disposal techniques that are ecologically responsible for reducing or eliminate soil, water, and air pollution. To reduce the risks involved with managing hazardous waste, training and education are crucial. The construction of authorised storage facilities and disposal sites that comply with strict environmental norms and standards is necessary for the safe and proper disposal of explosive waste. Explosive waste has the potential to harm the environment in a number of ways, such as by contaminating soil and water, air, upsetting ecosystems, and endangering the health and safety of people. Effective management practises must be implemented right once to reduce the impact of these downsides. All applicable environmental rules and regulations, as well as the proper methods for handling, storing, and disposing of waste, must be followed. Effective management of explosive debris can reduce its harmful consequences and protect ecosystems and human wellbeing for future generations.

3.3 Environmental Legislation and Regulatory Frameworks

Environmental rules at the international, national, and local levels play a key role in environmentally responsible treatment of explosive waste. This regulation defines standards for the collection and disposal of explosive waste in an effort to protect the environment and ensure public safety. International agreements and covenants regulate the proper disposal of explosives and other

dangerous items (Vásquez *et al.* 2021). Conventions such as the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal have created transport criteria to guarantee that explosive waste is disposed of correctly and in accordance with international law. The agreement aims to stop illegal garbage dumping and trafficking, as well as to reduce waste output and improve waste management procedures. To put the agreement into effect, each member state must create domestic legal and regulatory structures.

Environmental regulations that were separately designed and put into effect control the disposal of explosive waste at the national and regional levels. Businesses can be certain that they are following optimal waste management practises by following the standards and procedures defined by these rules for trash processing, transportation, storage and disposal. They outline who is responsible for producing waste, transporting it and disposing of it, as well as how to characterise, package, label and record garbage in an accurate manner. The preservation of the environment is improved by legislation that requires specific rubbish disposal procedures. One such safeguard is the use of storage facilities that adhere to legal requirements and have enough safety measures in place to prevent mishaps such as spills, leaks, and explosions. The kind of packing and containers required to carry explosive waste can be prescribed by legislation. It could be necessary to implement recycling, neutralisation, or incineration procedures to reduce environmental effects. Effective waste management methods can only be implemented by companies that abide by environmental standards. It may be necessary to obtain a permit or licence in order to legally dispose of, transport, or treat trash. Documentation and verification may be necessary to comply with environmental requirements. You must provide yearly reports on the creation and disposal of trash, as well as manifests for the debris, to comply.

Regulatory bodies may conduct audits and inspections of waste management facilities to ensure they are following the law. Businesses that violate the guidelines risk being closed, fined, or taken further to court. These tactics encourage companies to prioritise environmental stewardship and adapt their activities as necessary to adhere to the law. Compliance with environmental laws also fosters openness and accountability. A culture of environmental stewardship is cultivated by informing companies of their responsibility to properly dispose of hazardous waste. Improved industry-government cooperation and communication on waste management concerns is another benefit of increased compliance. To deal with hazardous waste, it is crucial to adopt global,

national, and even regional environmental rules. To protect the environment and ensure public safety, it specifies rules for all aspects of waste management (collection, transportation, storage, and disposal). Combustible residue can have a detrimental impact on a company, but it can be mitigated if the company follows environmental rules. Enforcement actions are used in conjunction with compliance requirements to increase responsibility and promote environmental stewardship. Businesses can improve the security and well-being of the ecosystem by properly disposing of hazardous waste.

Businesses of all stripes must take environmental laws and regulations into account when deciding on policies and practises. The regulations specify the requirements that enterprises must meet to offset the harmful consequences of their activities on the environment. Here are a few companies whose operations were impacted by strict environmental rules.

Environmental protection laws place restrictions on Tesla, a maker of electric vehicles. Businesses like Tesla have been impacted by environmental legislation and regulatory incentives that promote the development and use of sustainable technology. Just two examples of how nations like the United States and China have advantageous legislative frameworks for Tesla's goods are pollution laws and subsidies for electric automobiles. The company's commitment to these standards has helped position it at the forefront of the industry for sustainable transportation.

Due to being an international beverage firm, Coca-Cola must comply with a number of regulations. These regulations have an effect on everything from the way the company manages recyclables and effluent to the package design it uses. All purchases of water, waste disposal, and packaging made by the company are required to comply with environmental regulations in all respects. Coca-Cola has responded to these demands by developing packaging that is less harmful to the environment, enhancing its waste management practises, and making significant reductions in its water consumption. The company is dedicated to maintaining a healthy business strategy, as seen by the hard it works to fulfil environmental regulations.

Unilever, being a large corporation that produces a wide range of market items, is required to comply with stringent environmental, waste and product safety regulations. There has been a concentrated effort to develop environmentally friendly policies and techniques as well as to ensure that environmental criteria are met. Unilever intends to improve its waste and water management,

emit less greenhouse gases and utilise more materials derived from sustainable sources in its production operations. The planet has fared better as a result of Unilever's efforts to obey environmental regulations. As a result, the corporation is regarded a model of corporate responsibility and environmental stewardship.

To satisfy the criteria of the laws that stimulate the use of solar and wind power while restricting the use of coal and oil, the Danish green energy provider must comply with these pieces of law. Although it was once traded in fossil fuels, it is now a global leader in the transition to renewable power. The transition away from fossil fuels was a major factor that brought about this modification. Progress towards rsted's environmental goals, such as reducing carbon emissions and increasing the proportion of energy derived from renewable sources, has been proven. Rsted has been an international pioneer in the shift to renewable energy sources by closely following rules and funding a diverse portfolio of renewable energy projects. As a result, Rsted is now in the forefront of this change.

Patagonia, a company that makes outdoor clothing and gear, is committed to protecting the environment. The company is required to adhere to regulations that regulate the manufacture of textiles, the disposal of waste, and the acquisition of morally responsible. Patagonia engages in a number of forward thinking practises throughout its supply chain, such as the use of recyclable materials, the reduction of water consumption, and the promotion of fair employment practises. Patagonia has been successful in expanding its brand and attracting clients who are concerned about the environment due to the commitment it has made to environmental responsibility.

These examples illustrate the far-reaching effects that environmental laws and regulations have on businesses of varying sizes and operating in a wide variety of fields. By adhering to these guidelines, not only will you be able to avoid legal trouble but you will also inspire environmentally responsible behaviour, stimulate creative thinking, and enhance the reputation of your business. Companies that adhere to environmental standards and actively incorporate sustainability into their operations will have an advantage over their competitors because they will be able to satisfy the needs of their clients for environmentally responsible products and services.

3.4 Environmental Management Systems (EMS) and ISO 14001:2015

When a business deploys an EMS, it is supplied with a rational structure that guides them towards lowering the negative effects they have on the surrounding environment. The ISO 14001:2015 environmental management system (EMS) standard, which is widely used, outlines the components and methods for establishing, maintaining and developing an EMS. ISO 14001:2015 was released in 2015. The implementation of ISO 14001: 2015 is one strategy that can considerably improve both the management of flammable residues and the effect that it has on the environment in its immediate vicinity. An environmental management system (EMS) is a tool that can be used by a company can use to assess the effects of its operations on the surrounding environment and develop and implement strategies to improve its environmental performance. Provides assistance to companies in defining what it is that they want from the environment and how to acquire it in order to meet their needs. If environmental concerns are taken into account at each stage of the process of finding a solution to the problem, it is feasible that long-term solutions will be found that will resolve problems that have been caused by flammable residue.

The procedures that must be followed in order to successfully implement an EMS system are laid out in detail in ISO 14001:2015. This guide offers an all-encompassing structure to build and sustaining an environmental management system that is in compliance with international standards. This criterion places a significant amount of weight on leadership, in addition to ongoing development and input from all relevant stakeholders. Companies can apply ISO 14001:2015 in a variety of scenarios, including the management of hazardous waste, in order to detect and decrease the negative effects their activities have on the environment in their surrounding community. It is feasible to use a structured assessment process in order to examine both the potential adverse impacts that waste management can have on the environment as well as the potential advantageous advantages that it may have on the environment. Companies could use the results of the study to focus their attention and resources on those aspects of their operations that will have the most significant effect on the surrounding environment. The formulation of environmental goals is given a considerable amount of weight in importance by the ISO 14001:2015 standard. When it comes to the management of explosive waste, companies can improve their efficiency by setting SMART objectives (that is, they are specific, measurable, achievable, relevant and have a set deadline). These goals might involve anything from reducing the amount of hazardous trash that is produced

to improving the methods that are presently used for waste management to expanding the number of programmes that recycle and reuse materials. All of these things are important steps towards achieving a cleaner environment.

In addition to this, ISO 14001:2015 places a strong emphasis on the controls and operational procedures that must be adhered to. Explosive waste management is only one of the many aspects of environmental responsibility that businesses are obligated to address. It is very necessary to have clearly defined responsibilities, adequate training, and well-established protocols for the secure management of explosive waste throughout its entire life cycle, from the point where it is collected to the point when it is disposed of for good. In addition, the specification several times how essential it is to maintain a state of ongoing development. The use of key performance indicators and metrics should be used by businesses to do careful environmental impacts. Routine management assessments and internal audits can help companies better managing their environmental impact by highlighting problem areas and providing potential solutions to those problems. It is possible that ISO 14001:2015 will be of great use to companies that manage hazardous waste. It provides a methodical approach to identify environmental concerns and formulating legal solutions to address these risks. The improved management of resources, the decrease in the amount of trash produced and the decreased costs associated with waste management all contribute to an increase in productivity. If you want to advance your career and demonstrate to potential employers that you are concerned with the environment, include ISO 14001:2015 on your resume is a smart move. By implementing an environmental management system similar to ISO 14001:2015, companies have the ability to adopt a stringent approach to regulate and minimising the effects of their operations on the surrounding environment. Hazardous waste management is significantly improved as a result of the successful implementation of ISO 14001:2015 by companies, which assists in the identification, management and reduction of organisations' respective environmental impacts of organisations. Companies that define their goals precisely, implement stringent operational controls, and work assiduously to improve their environmental performance may be able to alleviate some of the environmental challenges that are caused by combustible waste and pave the way for a future that is more sustainable.

3.5 Real Cases examples

Compliance with Environmental Regulations on the Part of the United States Army: The United States Army has created a worldwide environmental management system that is consistent with ISO 14001:2015. This approach takes into account the fact that demilitarisation, training exercises, and other activities associated with the military all result in the production of hazardous waste. Using ISO 14001:2015, which complies with environmental criteria, the US Army has improved its waste management practises, decreased the impact that hazardous waste on the environment, and raised the level of regulatory compliance it maintains.

Hanwha Defence Systems: Hanwha Defence Systems, a South Korea, has chosen ISO 14001:2015 as the standard for its environmental management system. The company has instituted stringent waste management practises, which include procedures for the storage, processing, transportation, and disposal of flammable and explosive items (Janse van Rensburg *et al.* 2019). Through the implementation of ISO 14001:2015, Hanwha Defence Systems has improved its waste management practices, reduced concerns regarding the potential for environmental contamination, and achieved regulatory compliance. Due to the company's unwavering commitment to the protection of the natural world, it has established a solid track record of excellence in the field of waste management for the military industry.

Disposal of NATO Munitions: When it comes to the disposal of explosive waste, NATO nations have realised how important it is to respect environmental regulations and set up environmental management systems. This is especially true when dealing with munitions. The North Atlantic Treaty Organisation (NATO) has developed, through a variety of cooperative and cooperatively undertaken actions, guidelines for the safe and effective disposal of obsolete weapons and explosives. Countries that are members of NATO are obligated to comply with international standards for waste management, in accordance with the Basel Convention and other environmental regulations. Countries that are members of NATO have made significant progress in the field of waste management by pooling their knowledge, resources, and technology in an effort to improve waste management practises and lessen the impact of hazardous waste on the environment.

Administration of Fireworks Displays: The clean-up of the pyrotechnic material left behind by large-scale fireworks shows presents a unique set of challenges. To combat these issues, several

municipalities and organisations that organise events have implemented environmental management systems based on the ISO 14001:2015 standard. Pyrotechnic presentations that are respectful of the environment do not put the audience or the animals at risk. Companies that have an EMS have devised procedures for recycling, composting, and the safe storage and disposal of pyrotechnics debris. These plans may be seen on their websites. As a direct result of these efforts, the general public now has the impression that pyrotechnics are safer to use and do less damage to the surrounding environment.

Practises Common in the Mining Industry: The mining industry often generates combustible waste as a byproduct of the activities involved in of extraction and processing the raw materials. The mining industry has comply with environmental regulations and adopted ISO 14001:2015 to reduce the amount of damage that is caused by explosive debris. Companies that use of environmental management systems (EMS) have stringent protocols in place for waste management of waste at each and every stage of the process, from the initial collection to the ultimate disposal. The mining industry is required to comply with environmental rules to safeguard the local population, wildlife, and water supplies. This initiative helps to increase the commitment of the waste management sector to sustainable practises and to maintaining a positive social licence to operate.

These case studies illustrate that applying ISO 14001:2015 and meeting environmental standards results in a number of benefits to an organisation. These benefits include improved methods to reduce negative impacts on the environment, increased compliance with relevant regulations, and improved strategies for managing trash. By implementing these measures, companies have the potential to lessen the impact of their combustible waste on the surrounding environment and raise the standard for ethical waste management.

3.6 Empirical studies

Researchers investigated the effectiveness of ISO 14001 certification in reducing the harmful impacts of flammable waste in an Indian mining firm was investigated by researchers (Carmona, *et al.* 2021). Waste collection, categorisation, and disposal of waste were all significantly improved when ISO 14001:2015 was implemented, according to the study's authors. The adoption of ISO

14001:2015 and other environmental laws led to a decrease in environmental emissions and improved regulatory compliance. In a case study, Zhang *et al.* 2022 looked at how applying ISO 14001:2015 and following environmental standards changed how an Egyptian military manufacturing dealt with explosive waste. The results show that environmental restrictions played a role in the development of strict trash management procedures. The company's ability to identify and manage environmental factors related to hazardous waste grew after implementing ISO 14001:2015, leading to a decrease in waste generation and improved disposal techniques. The effect of using ISO 14001:2015 on mitigating the harmful environmental effects of explosive residue in the construction sector was examined by Ikram *et al.* 2021. Waste management practises improved significantly when Azerbaijani construction enterprises adopted ISO 14001:2015 and environmental legislation, according to researchers. The adoption of ISO 14001:2015 enhanced waste segregation, promoted recycling and reuse of hazardous waste, and raised environmental awareness.

Implementing ISO 14001:2015 can lessen the negative environmental consequences of explosive debris, according to a study by Lee *et al.* 2022. The pyrotechnics sector in Spain has improved its waste management processes after implementing ISO 14001:2015 and becoming more in compliance with environmental requirements, according to a study. Businesses that adhere to ISO 14001:2015 have improved their waste management processes, including systems for storage, transportation, and disposal. This study shows that EMSs can reduce the harm that pyrotechnic waste from fireworks displays causes to the environment. In order to ascertain how attempts to lessen the environmental effect of combustible waste may be impacted by the adoption of ISO 14001:2015, Mesarch, *et al.* 2021 undertook a case study in the petrochemical sector. The results showed that waste management is improved when the regulatory criteria are met and ISO 14001:2015 is put into practise. The environmental effect of hazardous waste has decreased as a result of improvements in waste segregation, recycling programmes, and cutting-edge technology since the adoption of ISO 14001: 2015. These empirical investigations show that when ISO 14001:2015 is applied and rules are followed, less combustible trash is created. The results support the idea that companies that prioritise following waste management regulations and using environmental management systems (EMS) perceive their waste management practises as being more effective, having less of an impact on the environment, and being more likely to comply with

regulations (Lee, 2021). These studies highlight the relevance of implementing sustainable waste management practices in conformity with environmental rules and widely accepted standards like ISO 14001:2015. They also highlight the importance of exercising caution when managing hazardous waste.

3.7 Compliance with environmental legislation and ISO 14001:2015

An organisation's dedication to ecologically responsible waste management may be seen in its adoption of ISO 14001:2015 and compliance with environmental regulations. Businesses can successfully deal with the problems associated with combustible waste and support environmental sustainability by adopting ISO 14001:2015 and following the rules and regulations already in place regarding the environment. Organisations that follow environmental rules and adopt ISO 14001: 2015 often have better waste management practises. Companies create reliable processes for the safe and ethical treatment of explosive waste by adhering to the standards and requirements of environmental legislation (de Araujo *et al.* 2021). This requires adhering to all handling, shipping, storage, and disposal guidelines. By following the law, businesses reduce their risk of environmental contamination and ecological harm.

Waste management procedures can be enhanced by incorporating ISO 14001:2015 into an environmental management system (EMS). The standard provides organisations with a systematic framework for evaluating and controlling the effects of their combustible residues on the environment. Businesses will be able to create and practise effective waste management practises by choosing ISO 14001:2015 as their environmental management standard (Gnanamangai *et al.* 2022). By defining clear objectives, creating waste reduction strategies and putting these plans into action, the harmful effects of explosive waste on the environment can be reduced. Examples and case studies are presented to demonstrate how an organisation can benefit from adhering to environmental regulations and ISO 14001:2015. These techniques have helped firms cut waste dramatically and have also improved their environmental effect. Excellent examples include reduced garbage production, enhanced waste processing and recycling initiatives, and decreased administrative expenses. Businesses have been able to limit the release of hazardous substances, stop pollution accidents, and protect the environment by adhering to legislation and implementing an EMS.

Both observing environmental laws and putting a management system in place for the environment help satisfy regulatory obligations. Businesses can ensure that they are abiding by the legal framework for waste management by verifying that all applicable laws and regulations are being followed. Penalties for breaking the rules are less likely. A way to guarantee continued regulatory compliance that covers all parts of environmental management, including trash management, is to comply with ISO 14001:2015. Strong leadership, staff participation, training, ongoing monitoring, and assessment are necessary for compliance and effective implementation of an EMS. To advance environmental projects and foster a company culture of environmental responsibility, upper-level management support is essential (Trifoni, 2019). It provides regulations for waste management and ensures that sufficient resources are available. Given their significance on a daily basis, employees' support is crucial for the implementation of refuse management practises to be successful. Employees are more likely to take the initiative to do their part if they have access to education and awareness campaigns on waste management and environmental preservation.

Progress requires assessing how well environmental and waste management strategies work. Businesses can more quickly identify problem areas and implement remedies by regularly performing assessments, audits, and inspections. Businesses can retain their focus and enhance their waste management procedures by measuring their progress toward reducing rubbish, environmental goals, and regulatory compliance with the help of monitoring and assessment (Barley, 2020). As a result, organisations that are concerned with reducing the negative effects of combustible residues on the environment should implement ISO 14001:2015 and adhere to relevant environmental requirements. Adopting ISO 14001:2015 as their standard of environmental management demonstrates a company's dedication to environmental care. Improved waste management, less environmental impact, higher levels of regulatory compliance, and a greater sense of corporate environmental responsibility have been linked to regulatory compliance and the deployment of an EMS. Businesses may be in a position to adhere to legal requirements and handle explosive waste safely if they prioritise effective leadership, employee engagement, training, and evaluation.

3.8 Strategies for Mitigating the Impact of Explosive Waste

At each and every phase of waste management, effective strategies and industry best practises must be used in order to lessen the adverse effects that might be caused by combustible waste. The development of appropriate storage, management, transportation, and disposal practises for explosive waste is the primary focus of these initiatives. These projects also emphasise innovative solutions and the participation of relevant stakeholders. When storing waste that could potentially explode, one must observe additional protocols must be followed for their protection. As a consequence of this, things have to be kept in storage areas that are in accordance with the requirements. Safe storage must be followed to safeguard both the environment and the general population from potential harm. In warehouses, precautionary measures such as containment walls and fire extinguishers should be installed and routine maintenance checks. When dealing with hazardous trash, there are some preventive measures that must at all times (Surisetti *et al.* 2021). Organisations must adopt policies for safe handling processes, which should involve teaching staff members about safe handling methods, enforcing the use of personal protective equipment, and sustaining stringent protocols for the transfer and transportation of objects. If these instructions are followed, there will be a significantly reduced risk of accidents, spills, or releases that could put workers or bystanders in danger.

Transporting explosive waste requires extra prudence. They must employ containers or trucks designed to transport hazardous items if they want to comply with the regulations set forth by transportation authorities. There must be a system of labelling, paperwork and monitoring in place to correctly identify and manage explosive waste. By always following safe operating standards and regularly inspecting your trucks, you can lessen the likelihood of accidents occurring when hauling garbage. Combustible waste disposal errors may necessitate costly repairs (Mucavele, 2022). Businesses run the danger of paying fines if they do not properly and legally dispose of their garbage. To reduce harmful impacts on the environment, several solutions may be implemented, such as neutralisation, recycling, and incineration. Businesses should work with approved waste disposal facilities to dispose of garbage in a way that does not impact the environment, the water supply, or the health of people.

New techniques and technologies are being developed to lessen the environmental destruction caused by explosive residue. Using chemical and biological neutralisation procedures, modern technology can make explosive waste harmless or much less harmful. Explosive materials can be recycled and used where appropriate to encourage sustainable practises and reduce waste. Scientists are always looking for novel mitigation measures due to the destruction that catastrophic debris can cause to ecosystems. All necessary parties must work together for waste management to be successful (Mmolai, 2021). To create and implement sustainable waste management policies, communicate crucial information, and promote best practises, government agencies, industry professionals, academic institutions, and local communities must work together. Cooperation could possibly lead to improved waste management practises and a more coordinated and sustainable approach to reducing the effect of hazardous waste by enabling the sharing of knowledge, resources, and technology. Waste management can also benefit from public involvement and education. Campaigns to raise public awareness of the dangers of inappropriate garbage disposal can stop the development of explosive debris and boost community involvement in waste management initiatives. Better and longer lasting solutions may be obtained with greater participation in decision-making and the execution of waste management projects.

It is crucial to follow best practises, implement creative techniques and include all key parties in order to lessen the harm caused by flammable debris (Smit, 2020). To reduce environmental pollution and guarantee public safety, certain processes must be followed when storing, handling, transporting, and disposing of hazardous items. New neutralisation and recycling technologies are helping to reduce the detrimental environmental effects of explosive waste (Coglianese, 2020). When government organisations, industry professionals, and local governments work together, they may share knowledge and create detailed waste management legislation. If we collectively take these steps, we can safeguard future generations' access to a healthy environment by lowering the effect of hazardous waste.

3.9 Conclusion

Combustible waste management must take a complete strategy that includes both adhering to environmental laws and applying ISO 14001:2015 to reduce its negative effects on the environment. These two components work well together to give companies a robust framework for

reducing the negative environmental consequences of combustible trash and defending local ecosystems and public health. Environmental rules establish tight limitations and procedures for handling explosive waste; thus they must be properly followed. Businesses can reduce the chance of local, national, and even global environmental pollution and harm by complying with these guidelines. Businesses are urged to practise appropriate waste management to avoid fines and other legal repercussions related to environmental regulation compliance and enforcement methods.

An organisation's attempts to lessen the harm caused by explosive debris are supported by the application of ISO 14001:2015, a globally recognised standard for environmental management systems. Businesses can reduce their environmental effect in a number of ways, including by managing hazardous waste, with the help of ISO 14001:2015 (ASIEDU, 2021). The standard gives enterprises a roadmap to create goals, implement processes controls, and tracking environmental performance, while underlining the value of leadership commitment, stakeholder involvement, and continuous improvement. Organisations that have adopted ISO 14001:2015 have shown their commitment to environmental sustainability and have foster an environment-friendly culture.

The handling of explosive waste requires significant study and attention in a number of areas. One field of research is the creation of cutting-edge tools for resource recovery and waste management. Improved neutralisation or recycling methods for explosive waste might be created with the use of current technology, lowering the total environmental effect. This study may be applied to the development and assessment of economically viable practises. How to evaluate the efficacy of compliance tactics should be the subject of future studies. The efficacy of compliance techniques can be determined by seeing how environmental rules are actually enforced. Through the identification of problem areas and the formulation of policy recommendations, this research has the potential to improve the regulatory framework for handling hazardous waste. One way to ensure that businesses follow waste management requirements is by evaluating the effectiveness of the compliance procedures already in place.

Explosive disposal poses serious ethical and financial problems that need to be looked into. It is advantageous for everyone involved to reduce the harm that hazardous waste disposal causes to the environment, society, and economy. The consequences of waste management practises on the economy, local communities, and the availability of new employment prospects are a few potential

study subjects. Understanding the social and economic effects of waste management operations can help companies and policymakers adopt practises that are in line with sustainable development goals and make better informed decisions. Implementing ISO 14001:2015 and adherence to environmental standards are required to reduce the adverse impacts of pyrotechnic residue on the environment. Prioritise the study of the social and economic elements of hazardous waste as well as the analysis of cutting-edge technology for waste reduction and recycling, in future research. By addressing these challenges, we may enhance waste management, lower contamination, and get support for a long-term, accountable strategy to dispose of hazardous material.

CHAPTER 4 MITIGATION OF EXPLOSIVES WASTE TO THE ENVIRONMENT THROUGH COMPLIANCE WITH ISO 14001

4.1 Limitations or challenges in implementing ISO 14001:2015

4.1.1. Regulatory compliance: Compliance with ISO 14001 standards may require significant changes to existing processes and procedures, which could be challenging for companies already operating under strict regulatory requirements.

4.1.2. Cost implications: Implementing ISO 14001 standards may involve upfront costs for training, policy development, and infrastructure upgrades. Companies may also incur ongoing costs related to monitoring and auditing compliance with the standards.

4.1.3. Cultural and organizational resistance: Resistance to change within the organization could pose a challenge in implementing ISO 14001. Some employees may be resistant to new procedures or may not fully understand the benefits of adopting environmentally friendly practices.

4.1.4. Knowledge and expertise: Companies may need to invest in training and hiring personnel with the necessary knowledge and expertise to implement and manage ISO 14001 standards effectively.

4.1.5. Supply chain management: Managing the environmental impact of explosives waste requires collaboration with suppliers and subcontractors. Ensuring that they also adhere to ISO 14001 standards may be challenging, particularly if they are located in different regions with varying regulations.

4.1.6. Continuous improvement: ISO 14001 requires companies to continuously improve their environmental performance. This can be an ongoing challenge, as companies must regularly review and update their systems and processes to meet evolving environmental regulations and societal expectations.

It is important for companies to consider these potential limitations and challenges when implementing ISO 14001 for managing explosives waste to ensure a successful and effective implementation process.

4.2 Changes that companies may need to make to ensure regulatory compliance with ISO 14001:2015

4.2.1. Establishing a systematic approach: Companies need to establish a systematic approach to identify, assess, and manage the environmental aspects associated with explosives waste. This includes determining the sources and types of waste generated, the potential environmental impacts, and implementing controls to prevent or minimize those impacts.

4.2.2. Developing an environmental policy: Companies should develop and communicate an environmental policy that demonstrates their commitment to managing explosives waste in an environmentally responsible manner. The policy should outline the company's objectives and targets for reducing the environmental impact of waste, as well as its commitment to comply with applicable laws and regulations.

4.2.3. Implementing waste management procedures: Companies need to implement procedures for the proper handling, storage, transportation, and disposal of explosives waste. This may involve implementing containment measures, such as storage tanks or secure containers, to prevent spills or leaks. Companies should also establish procedures for monitoring and documenting waste quantities and characteristics and implement appropriate labelling and signage to ensure proper identification and handling of the waste.

4.2.4. Training and awareness programs: Companies should provide training and awareness programs to employees involved in the handling or management of explosives waste. This includes educating employees on the environmental risks associated with the waste, as well as providing instruction on proper handling procedures, emergency response protocol, and waste minimization techniques.

4.2.5. Monitoring and measurement: Companies need to establish procedures for monitoring and measuring the environmental performance of their explosives waste management activities. This may involve conducting regular inspections, sampling and analysis of waste streams, and tracking key performance indicators related to waste generation, recycling, and disposal.

4.2.6. Continuous improvement: Companies should establish processes for evaluating and continuously improving their explosives waste management system. This may include conducting regular management reviews, analysing data and trends, and implementing corrective actions to address any identified gaps or areas for improvement.

By implementing these changes, companies can align their operations with ISO 14001 requirements and effectively mitigate the environmental impact of explosives waste.

4.3 Strategies that companies can employ to effectively manage and mitigate the environmental impact of explosives waste:

4.3.1. Waste Minimization: Companies can focus on minimizing the amount of explosives waste generated in the first place. This can be achieved through efficient production processes, proper inventory management, and careful handling and storage practices.

4.3.2. Recycling and Reuse: Companies can explore opportunities to recycle or reuse explosives waste instead of disposing of it. This can involve recovering valuable materials or repurposing the waste for other applications.

4.3.3. Proper Disposal: When disposal is necessary, it is important for companies to follow proper protocols and regulations to ensure safe and environmentally responsible disposal of explosives waste. This may involve working with certified waste management facilities or implementing on-site treatment technologies.

4.3.4. Environmental Monitoring: Regular monitoring of environmental indicators can help

companies assess the effectiveness of their waste management practices and identify areas for improvement. This can include monitoring air and water quality, soil contamination, and the presence of hazardous substances.

4.3.5. Education and Training: Providing education and training to employees is crucial for ensuring that proper waste management practices are followed consistently. This can involve awareness campaigns, training programs, and ongoing communication to promote a culture of environmental responsibility.

4.3.6. Collaboration and Stakeholder Engagement: Engaging with relevant stakeholders, such as local communities, regulatory agencies, and industry associations, can help companies stay informed about best practices and regulatory changes. It also allows for collaboration and knowledge-sharing to develop innovative solutions for managing explosives waste.

By implementing these strategies, companies can effectively manage and mitigate the environmental impact of explosives waste, reducing their ecological footprint and promoting sustainability.

CHAPTER 5 STATE OF ISO 14001:2015 COMPLIANCE IN EXPLOSIVE MANUFACTURING PROCESS

The current state of ISO 14001:2015 compliance in South African explosives manufacturing companies varies across different organizations. While some companies have successfully implemented and maintained robust EMSs aligned with the standard, others may face challenges in fully complying with all requirements.

5.1 Factors influencing compliance levels include:

5.1.1 Company Size: Larger explosive manufacturing companies may have dedicated resources for implementing EMS, while smaller entities may struggle with capacity constraints.

5.1.2 Industry Culture: Companies that prioritize environmental sustainability as part of their corporate culture are more likely to achieve levels of compliance.

5.1.3 Regulatory Oversight: The level of enforcement by regulatory authorities can influence the extent to which companies adhere to ISO 14001:2015

Conclusion

While there are challenges associated with implementing ISO 14001:2015 in South African explosives manufacturing companies, the benefits of compliance are substantial. By addressing these challenges through best practices and leveraging the potential benefits, these companies can contribute to sustainable development while ensuring responsible environmental stewardship.

CHAPTER 6 STATE OF LEGAL COMPLIANCE IN EXPLOSIVE WASTE MANAGEMENT

The disposal of explosive waste is a crucial issue that requires strict legal compliance to ensure environmental and health safety. This paper examines the status of compliance with the legal system for the disposal of explosive waste, both internationally and in South Africa. It will explore international regulations and conventions on explosive waste disposal and the specific legal framework in South Africa. In addition, it will discuss challenges and best practices related to the disposal of explosive waste and provide an analysis of the current state of legal compliance in this area**.**

6.1 International Regulations and Conventions

The management and disposal of explosive waste is regulated by various international regulations and conventions to ensure the protection of the environment and public safety (Peggy Hinman, 2010). One of the key international instruments in this regard is the Basel Convention on the Control and Disposal of Hazardous Wastes across borders. The 1992 Basel Convention aims to minimize the production of hazardous waste and promote environmentally friendly management and disposal practices (*Basel Convention on the control of Transboundary Movements of Hazardous Wastes and their disposal* 2023).

The Stockholm Convention on Persistent Organic Pollutants (POPs) is another important international treaty aimed at reducing or restricting the production and use of persistent organic pollutants, including certain types of explosive waste, which pose a significant risk to human health and the environment (T. Zacharia, 2019).

Regional agreements, such as the Waste Framework Directive of the European Union and the Resource Conservation and Recovery Act (RCRA) of the United States, also play an important role in regulating the disposal of explosive waste.

These international regulations and conventions establish specific requirements for the management, transportation, treatment, and disposal of explosive waste, and highlight the need for an adequate risk assessment, monitoring and reporting to competent authorities.

6.2 Legal Framework in South Africa

In South Africa, the management and disposal of explosive waste is governed by comprehensive legal frameworks, including national legislation, regulations, guidelines and standards. The main legislation on hazardous waste management in South Africa is the 2008 National Waste Management Act (NEMWA) (Baloyi & Masinga, 2010). NEMWA provides legal frameworks for the management of hazardous waste, including explosive waste, during its life cycle – from production to final disposal.

The Department of Forestry, Fisheries and Environment (DFFE) is responsible for monitoring compliance with NEMWA and has developed specific regulations and guidelines for managing hazardous waste, including explosive waste. The NEMWA Hazardous Waste Management Regulation sets out the detailed requirements for the storage, transport, treatment and disposal of hazardous waste, including the requirements for permits for hazardous waste management activities (Varshney et al., 2022).

In addition to the NEMWA, other laws, such as the National Environmental Management Act (NEMA), the Industrial Health Safety Act (OHSA) and the Mine Health Safety Act (MHSA), are also applicable to the management of explosive waste generated by mining activities. A summary of the legislative framework is provided in **Errore. L'origine riferimento non è stata trovata.**.

Explosives manufacturing organizations are subject to a complex web of local, national, and international laws and regulations. These include the United Nations Recommendations on the Transport of Dangerous Goods, the International Maritime Dangerous Goods Code, and various national and regional explosives control acts. The specific requirements of these regulations vary, but they generally cover aspects such as the production, storage, transportation, and use of explosives, as well as the licensing and certification of individuals and organizations involved in the industry.

The legislative framework for managing explosives waste, as discussed in this study, is outlined in Section 3.3 of the Literature Review chapter. This framework is also summarized in Table 2.1. It establishes the minimum requirements for explosives waste management in South Africa, covering topics such as environmental pollution control, occupational health and safety, and public

protection from potential injuries or property damage caused by waste generated from the explosives manufacturing industry.

Table 2- 1: Legal framework applicable to the management of explosives wastes

Legislation/regulation	Applicability
The Constitution, Act 108 of 1996	**Section 24**: Every person has the right to an environment that is not detrimental to their health and well-being
Explosive Act 15 of 2003	This Act emphasised on the authorisation or permission of the explosive manufacturing by maintaining the safety standards. This act also ensures safe transportation of explosive materials by maintaining proper guidelines.
National Environmental Management Act 107 of 1998	**Section 28**: **Duty of care and remediation of environmental damage** - The organization should have measures in place to prevent pollution **Section 30: Environmental Emergency** - The organization should have an emergency procedure in place and all environmental emergencies should be reported.
National Environmental Management Air Quality Act 39 of 2004	**Section 40(1) (A): Category 8: Thermal Treatment of Hazardous and General Waste, Sub-category 8.3: Burning Grounds** – Described as facilities where waste material from the manufacture of explosives and contaminated explosive packaging material are destroyed. – Applicable to all installations disposing of more than 100kg of material per week
GN 1210 of 2009: National Ambient Air Quality Standard	This regulation defines the value must need to be maintained during the manufacturing of explosive to prevent air pollution. It also helps to restrict the emission in order to protect human health.
GN R 238 of 2015: National Atmospheric Emission Reporting Regulation	This regulation throws light on the permissible pollution that can be discharged from the explosive manufacturing units. Apart from that, it also defines the safe value for the emission of greenhouse gases from the explosive sector.
GNR 827 of 2013: The National Dust Control Regulation	This particular regulation employs the American standard for collecting and measuring the dust fall and the dust in any material that are composed of small particles that are enough to pass through a 1 mm screen as well as large enough to settle as per their weight for being in the sampling container from the ambient air.

National Water Act 36 of 1998	This Act elaborates the safe waste disposal process in order to prevent harmful effects of explosive wastes. This act also ensures proper waste disposal infrastructure in the explosive sector to improve the safety.
National Environmental Management: Waste Act 59 of 2008	This Act aims to change how waste management is regulated; the change is made for the beneficiating of the environment and protection of the human health. As mentioned earlier, Section 4 of the NEMWA excludes explosive wastes that are provided for in terms of the Explosives Act. The NEMWA does, however, regulate the components of explosives wastes remaining after the destruction up to landfilling. **Section 21**: **Storage, Collection and Transportation of Waste**-Any person who stores waste must ensure containers are intact, not corroded or rendered unfit for the safe storage of waste prevent accidental spillage or leaking; cannot be blown away; Nuisances do not arise pollution of the environment and harm to health are prevented **Duty of Care Principle**: The generator of waste retains the ultimate responsibility for ensuring that the waste is handled, stored, transported and disposed of according to legislation and on an environmentally sound and responsible manner. **Polluter Pays Principle:** Person or organization causing pollution is liable for any costs involved in cleaning it up or rehabilitating it's effects. **Duty of Care Principle**: The generator retain the ultimate responsibility for ensuring that the waste is handled, stored, transported and disposed of according to legislation and on an environmentally sound and responsible manner. **Extended Producer Responsibility (EPR) policy**: The explosives manufactures are responsible for their products until post-usage stage of those products **The precautionary principle**: The explosives manufacture should take immediate control of process and activities that may have detrimental consequences to the environment rather than to wait for incontrovertible scientific evidence **Waste Classification:** All waste (remaining after the explosives destruction process) needs to be classified according to SANS 10234, except the waste listed in Annexure 1. **Norms and Standards**: Waste (remaining after the destruction process, requiring landfilling) **MUST** be assessed in accordance with the **Norms**

	and Standards for Assessment of Waste for Landfill Disposal prior to the disposal of waste to landfill. This is the **generator's** responsibility. **Record Keeping:** Waste generators **MUST** keep up to date records of the management of waste they generate.
Occupational Health and Safety Act 85 of 1993 and its regulations	**Section 43 (1) b**: Make provision for the minister to make regulations on the interest of health and safety of people at work, and the conditions under which the manufacture of explosives and the activities incidental thereto may take place. **Section 47:** Binds the state, who should also license its explosive workplaces.
Explosives Regulations GNR.109 of 17 2001	**Regulations 1-20:** The regulations makes provision for the classification of explosives for manufacturing; licensing of explosives workplaces; danger area and danger buildings; safeguarding of explosives workplace; design, construction and manufacture; importation of explosives; supervision of explosives workplace; safe handling of explosives; emergencies; incidents; closure of explosives workplace; National Explosives Council; approved inspection authorities; standards of training; as well as offences and penalties.
Mine Health and Safety Act 29 of 1996 and its regulations	**Section 4.2 - Receipt, storage, issuing, transportation and destruction of explosives-** This section gives the manufacture guidelines on how to handle explosives during transportation, storage, issuing and destruction.
The Hazardous Substances Act 15 of 1973	**Section 29 (1) a**: The Act sets requirements on the prohibition and control of the importation, manufacture, sale, use, operation, application, modification, disposal or dumping of hazardous substances.

The management of explosives wastes is a complex process that requires adherence to various legal frameworks and guidelines. In this context, the National Environmental Management Act (NEMWA) plays a crucial role in regulating the disposal and management of explosives wastes. After destruction, the waste generated needs to be classified and assessed according to the Waste Classification and Management Regulations before being disposed of in landfills. Furthermore, the management of all remnants or waste generated after destruction from the burning grounds must comply with the provisions of the NEMWA.

The regulation of explosive destruction at OB/OD facilities in South Africa is governed by the Explosives Act 15 of 2003 and NEMAQA 39 of 2004. Due to the inherent dangers involved in the

production of energetic materials, there are strict control measures in place to ensure health and safety procedures at OB/OD facilities. Additional requirements, particularly related to permitting procedures, are being developed with a focus on assessing risks and managing air quality at OB/OD facilities.

6.3 Challenges and Best Practices

Despite the existence of a solid legal framework at the international and national levels, there are still several challenges in ensuring full compliance with the provisions on explosive waste disposal. One of the main challenges is the insufficient infrastructure for safe disposal facilities, especially in developing countries where resources may be limited. This can lead to improper storage or illegal disposal of explosive waste and pose serious risks to human health and ecosystems (Bhardwaj et al., 2023).

Furthermore, there is an increasing need to raise awareness among stakeholders of best practices in handling explosive waste. This includes the promotion of safe treatment and disposal technologies, such as cover-up, neutralization or controlled explosion under controlled conditions.

Effective monitoring and enforcement mechanisms are also essential to ensure compliance with legal requirements. Regular inspections by regulatory authorities can help to detect early issues of non-compliance and prevent potential environmental disasters.

6.4 Current State of Legal Compliance in South Africa

The current legal compliance with respect to the disposal of explosive waste varies from region to region. In many developed countries, compliance levels are relatively high due to stringent enforcement measures and advanced hazardous waste management infrastructures.

However, in some developing countries, including some of Africa, the challenge of inadequate resources, technical capabilities and enforcement mechanisms contributes to a lower level of compliance with regulations on the disposal of explosive waste.

In South Africa in particular, while considerable progress has been made in establishing a comprehensive legal framework for the management of hazardous wastes, including explosive

waste, there are still concerns about the practice of illegal disposal in some areas. The regulators are making efforts to strengthen enforcement measures by increasing inspections and penalties for non-compliance (Banerjee et al., 2023).

6.5 Measures to improve legal compliance.

To address these challenges and improve the state of legal compliance within the explosives manufacturing industry, organizations can take several steps, including:

- Regularly reviewing and updating their knowledge of relevant laws and regulations to ensure they remain current and compliant.
- Investing in employee training and education to promote a culture of safety and compliance.
- Implementing effective management systems, such as ISO 14001, to ensure that processes and procedures are in place to prevent non-compliance.
- Collaborating with industry associations, government agencies, and other stakeholders to share best practices and promote a consistent approach to compliance.
- Regulatory Enforcement and Compliance Monitoring:
    - Governments and regulatory agencies play a crucial role in enforcing legal compliance within the explosives manufacturing industry. This includes conducting regular inspections, audits, and investigations to identify non-compliant organizations and taking appropriate enforcement actions.
    - Additionally, these agencies can work with industry stakeholders to develop and implement voluntary codes of practice, which can help to raise the overall standard of compliance across the industry.

6.6 Conclusion

In conclusion, the status of legal compliance with respect to the disposal of explosive waste is a complex issue, influenced not only by international regulations, but also by the national legal framework. Although significant progress has been made in establishing comprehensive regulatory measures aimed at ensuring the safe management and disposal of explosive waste at international and South African level, challenges persist, particularly in developing countries where resources may be limited. It is important to increase awareness among stakeholders about best practices for

the treatment of explosive waste and to integrate effective monitoring mechanisms to improve overall compliance. Also, through a combination of proactive measures, such as regular training and updating of knowledge, as well as support from regulatory agencies and industry partners, the industry can continue to improve its overall state of legal compliance and ensure the safe and responsible production and use of explosives.

CHAPTER 7 DISPOSAL OF MUNITION AND EXPLOSIVES WASTE

7.1 Introduction:

The disposal of munition and explosives waste is a pressing issue that involves intricate environmental, safety, and security considerations. This essay provides an in-depth analysis of the challenges and strategies associated with the disposal of such hazardous materials, emphasizing the importance of responsible management practices.

This essay offers a comprehensive examination of the disposal of munition and explosives waste, a complex and highly sensitive issue with profound environmental, safety, and security implications. Munition and explosives waste, comprising unexploded ordnance, expired munitions, and residues from military activities, poses significant challenges for responsible management and disposal. The study delves into the various disposal methods, including controlled detonation, demilitarization, and recycling, while also assessing their environmental consequences. It explores the critical role of international treaties and agreements, national regulations, and emerging technologies in shaping disposal practices. The essay concludes by highlighting the need for a holistic approach that balances security concerns with environmental sustainability and public safety.

7.2. Disposal Methods and Technologies

7.2.1 Controlled Detonation

The controlled detonation of munition and explosives waste is a common disposal method. This section discusses the process, safety measures, and environmental impacts of this approach**.**

7.2.2 Demilitarization.

Demilitarization involves the disassembly and destruction of munitions and explosives waste. The essay examines various demilitarization techniques and their advantages.

7.2.3 Recycling and Reuse

The potential for recycling or reusing certain components or materials from munition and explosives waste is explored, highlighting its environmental and economic benefits.

7.3. Environmental Implications of Disposal

7.3.1 Soil Contamination

The disposal of munition and explosives waste can result in soil contamination, affecting terrestrial ecosystems. The mechanisms and long-term consequences of soil contamination are discussed.

7.3.2 Water Pollution

An examination of the risks of water pollution associated with the disposal of munition and explosives waste, particularly the contamination of groundwater and surface water.

7.3.3 Airborne Contaminants

The release of particulate matter, gases, and pollutants into the atmosphere during disposal activities and its implications for air quality and human health.

7.3.4 Habitat Disruption and Biodiversity

Explosives waste disposal often leads to habitat destruction and fragmentation, with implications for biodiversity and endangered species.

7.4 Regulation of Explosive Destruction at OB/OD Facilities in South Africa

Explosive destruction at OB/OD (open burn/open detonation) facilities in South Africa is subject to regulation under the Explosives Act 15 of 2003 and NEMAQA (National Environmental Management: Air Quality) 39 of 2004. These regulations aim to ensure the safe handling and disposal of explosive materials while minimizing potential risks to human health and the environment.

7.4.1 Stringent Control Measures for Health and Safety Procedures

Given the inherent risks associated with the manufacturing and handling of energetic materials, OB/OD facilities have high levels of control over health and safety procedures. These measures are put in place to protect workers, nearby communities, and the environment from potential accidents or adverse effects caused by explosive substances.

The control measures encompass various aspects such as training programs for personnel involved in handling explosives, strict adherence to standard operating procedures, regular safety inspections, proper storage practices, and emergency response protocols. By implementing these stringent control measures, OB/OD facilities aim to prevent accidents, minimize exposure to hazardous materials, and ensure the overall safety of operations.

7.4.2 Development of More Stringent Requirements

In recognition of the evolving understanding of risks associated with OB/OD facilities, efforts are underway to develop more stringent requirements. These requirements primarily focus on permitting procedures, risk characterization, and air quality management.

Permitting procedures involve obtaining the necessary authorization and licenses for operating OB/OD facilities. The aim is to ensure that only qualified and responsible entities are granted permission to handle explosive materials. By implementing more rigorous permitting procedures, regulatory authorities can assess the capabilities, experience, and track record of applicants to minimize the potential for mishandling or accidents.

Risk characterization is an essential aspect of managing OB/OD facilities. It involves identifying, assessing, and quantifying potential risks associated with the handling, storage, and disposal of energetic materials. By comprehensively characterizing risks, regulators can develop targeted mitigation strategies and ensure that appropriate safety measures are in place at OB/OD facilities.

Air quality management is another critical area of focus. The burning and detonation of explosives can release various pollutants into the atmosphere, potentially affecting air quality and human health. Therefore, regulations are being developed to monitor and control emissions from OB/OD activities. This includes setting limits on pollutant concentrations, establishing monitoring requirements, and implementing measures to mitigate any adverse impacts on air quality.

In summary, the regulation of explosive destruction at OB/OD facilities in South Africa is governed by the Explosives Act 15 of 2003 and NEMAQA 39 of 2004. These regulations ensure that strict control measures are in place to protect health and safety at OB/OD facilities. Ongoing efforts aim to develop more stringent requirements related to permitting procedures, risk characterization, and air quality management to further enhance safety standards in these facilities.

7.5. Regulatory Framework and International Agreements

7.5.1 International Treaties and Agreements

An overview of international treaties and agreements that govern the disposal of munition and explosives waste, including the Chemical Weapons Convention and the Ottawa Convention on Landmines**.**

7.5.2 National Regulations

Discussion of national regulations and policies that guide disposal practices, emphasizing the importance of compliance and enforcement.

7.6. Emerging Technologies and Innovations

7.6.1 Advances in Demilitarization

Exploration of emerging technologies and innovations in munition and explosives waste disposal, such as robotic demilitarization and environmentally friendly methods.

7.6.2 Remote Sensing and Detection

The use of remote sensing technologies for the detection and clearance of unexploded ordnance and explosive remnants of war.

7.7. Security Concerns and Challenges

7.7.1 Unexploded Ordnance Removal

The challenges and risks associated with the removal of unexploded ordnance, particularly in conflict-affected areas.

7.7.2 Balancing Security and Environmental Sustainability

The need for a balanced approach that addresses security concerns while minimizing the environmental and human health impacts of disposal.

7.8. Case Studies and Best Practices

In the mining, construction, and defence industries, explosives waste management and disposal are critical issues. Managing and disposing of such waste in the proper manner can prevent accidents, protect the environment, and ensure public safety. Using a hypothetical scenario to illustrate key principles in explosives waste management, this case study examines best practices in explosives waste disposal. The case study is based on the operations of a mining company in South Africa and for confidentiality reasons, the company is referred to as XYZ.

Mining Company XYZ is a large-scale mining operation that uses explosives to extract valuable minerals from the earth. Over the years, the company has generated a significant amount of explosives waste, which it stores in a designated area on its property. However, recent inspections by regulatory agencies have raised concerns about the company's waste management practices, prompting XYZ to seek guidance on best practices for managing and disposing of explosives waste.

7.8.1 Best Practices in Management and Disposal

Waste Characterization and Quantification: The first step in managing explosives waste is to characterize and quantify the waste generated. This involves determining the types and quantities of explosives waste produced, as well as identifying any hazardous components. By understanding the nature of the waste, XYZ can develop appropriate management strategies and select suitable disposal methods.

Waste Storage and Handling: Proper storage and handling of explosives waste are crucial to prevent accidents and protect the environment. XYZ should store the waste in a secure, well-ventilated, and dry area, away from sources of ignition and public access. The company should also follow strict handling procedures, such as wearing personal protective equipment (PPE) and using appropriate tools and equipment when handling the waste.

Waste Treatment and Neutralization: In some cases, it may be necessary to treat or neutralize explosives waste to reduce its hazardous properties. XYZ could consider methods such as neutralization with a non-hazardous substance, solidification, or stabilization. These treatments can help to reduce the risk of accidents and minimize the environmental impact of the waste.

Waste Disposal: The choice of disposal method depends on the type and quantity of waste, as well as local regulatory requirements. XYZ could consider options such as landfill disposal, recycling, or reuse of the waste. The company should ensure that the selected disposal method is safe, environmentally sound, and compliant with relevant laws and regulations.

Monitoring and Maintenance: Regular monitoring and maintenance of the waste storage area are essential to ensure the safety and effectiveness of the management and disposal practices. XYZ should conduct inspections and tests to identify any potential hazards, such as leaks, corrosion, or structural damage, and address them promptly.

7.8.2 Successful Disposal Programs

Case studies of successful munition and explosives waste disposal programs, highlighting best practices and lessons learned.

In recent years, the proper disposal of munition and explosives waste has become an increasingly important issue, particularly for countries with a history of military conflicts or weapons manufacturing. This case study aims to highlight successful munition and explosives waste disposal programs and discuss the best practices and lessons learned from these initiatives.

7.8.1.1 Best Practices in Munition and Explosives Waste Disposal

- ***Comprehensive Assessment and Planning***: Before initiating any waste disposal program, it is crucial to conduct a thorough assessment of the affected areas, identifying the types and quantities of munitions and explosives present. This information is vital in determining the appropriate disposal methods and resources required.

- ***Safe Transportation and Storage:*** Munitions and explosives must be handled with extreme care during transportation and storage. Proper packaging, labelling, and transportation routes must be followed to minimize the risk of accidents or leaks.

- ***Use of Experienced Professionals***: Disposal of munitions and explosives should be carried out by trained and experienced personnel who are familiar with the risks associated with such materials. This ensures a higher level of safety and efficiency in the disposal process.

- ***Advanced Disposal Technologies:*** Innovative technologies, such as controlled detonation chambers and underwater disposal systems, can help minimize the environmental impact of munitions and explosives waste disposal. These technologies should be considered and utilized when appropriate.

- ***Public and Stakeholder Engagement***: Communication and transparency are key in managing the public's expectations and concerns regarding munition and explosives waste disposal. Regular updates and engagement with local communities and stakeholders can help build trust and support for the program.

- ***Monitoring and Evaluation***: Ongoing monitoring and evaluation of the waste disposal program are essential for identifying potential issues, adjusting strategies, and ensuring the program's effectiveness.

7.8.1.2 Successful Munition and Explosives Waste Disposal Programs

Several countries and organizations have implemented successful munition and explosives waste disposal programs. Some notable examples include:

- ***The U.S. Department of Defense (DoD) Munitions Response Program***: This program focuses on the safe and environmentally sound removal and disposal of munitions and explosives from former military installations and training areas. The program has been successful in reducing the risk of accidents, protecting human health, and preserving the environment.

- ***The NATO Science for Peace and Security (SPS) Program***: The SPS program supports research and development projects aimed at addressing the challenges of munition and

explosives waste disposal. One such project, the Environmental Impact Assessment of Explosive Waste Disposal Technologies, has helped identify best practices and develop new technologies for safe and environmentally friendly disposal.

- ***The United Nations Mine Action Service (UNMAS):*** UNMAS works to reduce the threat posed by mines, explosive remnants of war, and improvised explosive devices in conflict-affected countries. Through partnerships with local governments and organizations, UNMAS has successfully implemented munition and explosives waste disposal programs in numerous countries.

7.8.3 Lessons Learned

- The importance of proper planning and assessment cannot be overstated, as it lays the foundation for a successful waste disposal program.
- The use of advanced technologies and innovative techniques can significantly reduce the environmental impact of munition and explosives waste disposal.
- Engaging with the public and stakeholders is crucial in building trust and support for the program, ensuring its long-term success.
- Monitoring and evaluation are essential components of any waste disposal program, allowing for continuous improvement and adaptation to changing circumstances.

7.8.4 Challenges and Failures

Munition and explosives waste disposal programs face numerous challenges and failures due to the hazardous nature of the materials involved, the complexity of the processes, and the stringent regulations in place. In this case study, we will discuss some of the key challenges and failures encountered in these programs and explore the reasons behind them.

Challenge 1: Handling hazardous materials:

One of the primary challenges in munition and explosives waste disposal programs is the safe handling and management of hazardous materials. These materials, including high explosives,

propellants, and pyrotechnics, are extremely dangerous and can cause significant harm if not managed correctly. The disposal process requires specialized equipment, skilled personnel, and strict adherence to safety protocols to minimize the risk of accidents and injuries.

C***hallenge 2: Environmental impact:***

Munition and explosives waste disposal programs must also address the environmental impact of their operations. The improper disposal of these materials can lead to contamination of soil, water, and air, which can have long-term detrimental effects on ecosystems and human health. Furthermore, the cleanup and remediation of contaminated sites can be costly and time-consuming, adding to the overall challenges faced by these programs.

Challenge 3: Regulatory compliance:

Munition and explosives waste disposal programs must comply with numerous local, national, and international regulations, such as the Basel Convention, the United Nations Convention on the Law of the Non-Navigational Use of International Watercourses, and the Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction. Non-compliance with these regulations can lead to fines, sanctions, and reputational damage, making it essential for programs to adhere to the strict guidelines set forth by regulatory authorities.

Challenge 4: Funding and resources

Munition and explosives waste disposal programs often face funding constraints and resource limitations, which can hinder their ability to carry out their operations effectively. The high costs associated with acquiring specialized equipment, training personnel, and conducting extensive site assessments and remediation efforts can be difficult to justify in an increasingly cost-conscious world.

Challenge 5: Public perception

Public perception of munition and explosives waste disposal programs can be a significant challenge. Communities living near disposal sites may be concerned about the safety of the

operations and the potential environmental and health risks associated with them. Addressing these concerns and maintaining open communication with affected communities is crucial for the success of these programs.

CHAPTER 8 THE BENEFITS OF ISO14001 EMS IN MANAGING EXPLOSIVE WASTE

8.1 Introduction

The management of explosive waste is a complex and critical endeavour with far-reaching environmental and safety implications. It involves handling hazardous materials, mitigating risks, and complying with stringent regulations. This essay explores the utility of adopting Environmental

Management Systems (EMS) based on ISO 14001:2015 standards as a strategic approach to managing explosive waste. ISO 14001:2015 provides a structured framework that can help organizations enhance their environmental performance, ensure compliance with regulatory requirements, and improve safety protocols in the management of explosive waste.

8.2. Explosive Waste Management: Challenges and Context

8.2.1 Environmental and Safety Concerns

Improper handling, storage, and disposal of explosive waste can lead to soil and water contamination, air pollution, and severe safety risks. This section highlights the environmental and safety challenges associated with explosive waste management.

Munition and explosives waste disposal management is a process that is fraught with environmental and safety concerns that need to be addressed to protect both human health and the environment. This chapter will discuss the key environmental and safety concerns in munition and explosives waste disposal management, highlighting the importance of proper management and the use of authoritative references to support the findings. The following Environmental Concerns in Munition and Explosives Waste Disposal Management have been identified:

8.2.1.1 Contamination of soil and groundwater

The improper handling and disposal of munition and explosives waste can lead to contamination of soil and groundwater. The chemicals and heavy metals present in these wastes can leach into the soil, affecting the quality of the water and posing a risk to aquatic life and ecosystems. Furthermore, the chemicals can migrate into nearby water sources, posing a significant threat to human health and the environment.

8.2.1.2 Explosive residues and unexploded ordnance

Explosive residues and unexploded ordnance pose a significant risk to the environment, as they can cause accidental detonations and release harmful chemicals into the environment. These residues can also contaminate soil and water sources, affecting plant and animal life. Proper management of

munition and explosives waste is essential to minimize the risk of accidental detonations and prevent further environmental damage.

8.2.1.3 Greenhouse gas emissions

The disposal of munition and explosives waste can generate greenhouse gas emissions, particularly during the transportation and final disposal phases. The use of hazardous chemicals and the energy required for disposal processes contribute to these emissions, which can exacerbate climate change and its associated impacts on the environment and human health.

8.2.2 Safety Concerns in Munition and Explosives Waste Disposal Management

8.2.2.1 Human health risks

The improper handling, storage, and disposal of munition and explosives waste can pose serious health risks to workers and local communities. Exposure to hazardous chemicals, explosive residues, and unexploded ordnance can result in acute and chronic health effects, including respiratory issues, skin irritation, and even cancer. Ensuring proper safety measures are in place is essential to protect the health and well-being of those involved in munition and explosives waste disposal management.

8.2.2.2 Accidents and incidents

Mishandling of munition and explosives waste can result in accidents and incidents, such as fires, explosions, and releases of hazardous chemicals. These events can have severe consequences, including injuries, fatalities, and damage to property and the environment. Proper management of munition and explosives waste, along with strict adherence to safety protocols, is crucial to minimize the risk of accidents and incidents.

8.2.2.3 Compliance with regulations and international standards

Compliance with local, national, and international regulations and standards is essential to ensure the safe and environmentally sound management of munition and explosives waste. Non-

compliance can lead to penalties, fines, and reputational damage, as well as increased risk to human health and the environment.

Environmental and safety concerns in munition and explosives waste disposal management are significant challenges that must be addressed to protect human health and the environment. Proper management, adherence to regulations, and the use of authoritative references, such as those listed below, can help ensure the safe and environmentally sound handling, storage, transportation, and disposal of these hazardous materials.

8.3. ISO 14001:2015 Environmental Management Systems

8.3.1 Overview of ISO 14001:2015

ISO 14001:2015 is an internationally recognized standard that provides a framework for organizations to establish, implement, maintain, and continually improve their Environmental Management Systems. It outlines key principles, such as leadership commitment, risk-based thinking, and a focus on environmental performance.

8.3.2 Key Components of ISO 14001:2015

The critical components of ISO 14001:2015, includes the Plan-Do-Check-Act (PDCA) cycle as illustrated in Figure 1-1, environmental policy, environmental objectives, legal compliance, and stakeholder engagement. The following components provides a framework for organizations to develop, implement, and maintain effective EMS that helps them minimize their environmental impact and improve their overall environmental performance.

8.3.2.1: Plan-Do-Check-Act (PDCA) Cycle

The PDCA cycle is the backbone of ISO 14001:2015. It is a continuous improvement model that guides organizations through a four-step process: planning, implementation, monitoring, and

review. In the planning stage, organizations set their environmental goals and objectives, identify risks and opportunities, and determine the resources needed to achieve their targets. During the implementation phase, they put the plans into action, while monitoring involves regularly assessing the performance of the EMS against the set objectives. Finally, the review stage involves evaluating the EMS's effectiveness and making necessary improvements to ensure continuous improvement.

8.3.2.2: Environmental Policy

The environmental policy is a high-level statement that outlines an organization's commitment to environmental sustainability and sets the direction for its EMS. It communicates the organization's environmental goals, priorities, and responsibilities to stakeholders, employees, and the public. A strong environmental policy helps guide decision-making, ensures that the organization is compliant with relevant environmental laws and regulations, and fosters a culture of environmental awareness and responsibility.

8.3.2.3: Environmental Objectives and Targets

Environmental objectives and targets are specific, measurable, achievable, relevant, and time-bound (SMART) goals that an organization sets to achieve its environmental policy. These objectives and targets help organizations identify areas of improvement and prioritize their efforts in reducing environmental impacts. Regular monitoring and evaluation of these objectives and targets enable organizations to track their progress and make necessary adjustments to their EMS.

8.3.2.4: Legal Compliance

Compliance with relevant environmental laws and regulations is a fundamental requirement of ISO 14001:2015. Organizations must identify and understand the legal requirements that apply to their operations, integrate these requirements into their EMS, and ensure that they are consistently met. Legal compliance not only helps organizations avoid penalties and fines but also demonstrates their commitment to responsible environmental practices.

8.2.3.5: Stakeholder Engagement

Stakeholder engagement is an essential aspect of ISO 14001:2015, as it involves communicating with and seeking input from individuals and organizations that have an interest in or are affected by the organization's environmental performance. This includes employees, customers, suppliers, local communities, and regulatory agencies. Engaging with stakeholders helps organizations better understand their environmental impacts, identify opportunities for improvement, and build trust and credibility with their stakeholders.

8.4. Benefits of Using ISO 14001:2015 in Explosive Waste Management

8.4.1 Enhanced Environmental Performance

ISO 14001:2015 helps organizations improve their environmental performance by identifying environmental aspects, setting objectives and targets, and implementing control measures to mitigate environmental impacts. This is particularly relevant in the context of explosive waste management.

8.4.2 Legal Compliance and Regulatory Alignment

ISO 14001:2015 assists organizations in achieving and maintaining compliance with environmental laws and regulations. This section discusses how ISO 14001:2015 can help organizations navigate the complex regulatory landscape of explosive waste management.

8.4.3 Risk Mitigation and Safety Improvement

Explosive waste management poses inherent risks. ISO 14001:2015 promotes risk-based thinking, enabling organizations to identify and mitigate safety risks effectively. Case studies and practical examples illustrate how ISO 14001:2015 can enhance safety protocols.

8.4.4 Transparency

Engaging stakeholders is crucial in explosive waste management, as it builds trust and fosters transparency. This section explores how ISO 14001:2015 facilitates stakeholder engagement and communication.

Table 3- 1: Benefits of implementing ISO 14001:2015

Benefits	Description
Improved Environmental Performance	ISO 14001:2015 helps organizations to identify and manage their environmental impact, leading to improved environmental performance. This can include reduced waste, energy conservation, and lower emissions.
Legal and Regulatory Compliance	Compliance with environmental laws and regulations is a crucial benefit of ISO 14001:2015. By implementing the standard, organizations can ensure they are meeting legal requirements related to environmental management.
Cost Savings	Effective environmental management can result in cost savings for organizations. This may come from reduced resource consumption, waste management efficiencies, and avoidance of fines or penalties related to environmental non-compliance.
Enhanced Reputation and Stakeholder Relations	ISO 14001:2015 certification can enhance an organization's reputation by demonstrating a commitment to environmental responsibility. It can also improve relationships with stakeholders, including customers, suppliers, and the community.
Competitive Advantage	Achieving ISO 14001:2015 certification can provide a competitive advantage in the marketplace. Many customers and partners prefer to work with organizations that have demonstrated their commitment to sustainable practices.

8.5. Potential Challenges and Considerations

8.5.1 Integration with Existing Systems

Organizations may face challenges when integrating ISO 14001:2015 with existing management systems. This section provides guidance on overcoming potential hurdles.

8.5.2 Resource Allocation and Training

Implementing and maintaining ISO 14001:2015 requires resource allocation and training. Strategies for effective resource management are discussed.

Table 4- 1: Challenges of Implementing ISO 14001:2015

Challenge	Description
Resource Allocation	Implementing ISO 14001:2015 requires allocation of resources, including time, personnel, and financial investment. This can be a challenge for organizations, especially smaller ones with limited resources.
Organizational Change	Adopting ISO 14001:2015 often necessitates changes in organizational processes and culture to align with environmental management requirements. Resistance to change within the organization can pose a significant challenge.
Complex Documentation	The documentation requirements of ISO 14001:2015 can be complex and time-consuming. Developing and maintaining the necessary documentation for compliance may present challenges for organizations.
Training and Awareness	Ensuring that employees at all levels are aware of and trained in environmental management practices as per ISO 14001:2015 can be a challenge. This includes raising awareness about environmental impact and the importance of compliance.
Continuous Improvement	Sustaining compliance with ISO 14001:2015 over time requires a commitment to continuous improvement in environmental performance. This ongoing effort can be challenging for organizations to maintain effectively.
Resource Allocation	Implementing ISO 14001:2015 requires allocation of resources, including time, personnel, and financial investment. This can be a challenge for organizations, especially smaller ones with limited resources.

This section emphasizes the potential of ISO 14001:2015 as a valuable tool for improving the management of explosive waste. It underscores the importance of responsible explosive waste management for environmental sustainability, safety, and regulatory compliance. The chapter concludes by calling for increased adoption of ISO 14001:2015 in explosive waste management practices worldwide and highlights the role it can play in advancing global efforts towards responsible hazardous waste management.

CHAPTER 9 RESEARCH RESULTS

9.1 Introduction

Explosive waste management is an important issue that requires proper handling, disposal and compliance with environmental and legal regulations. One of the most widely recognized environmental management frameworks is ISO 14001. This chapter aims to discuss the results of research that highlight the benefits of ISO 14001 certification in connection with legal compliance in the management of explosive waste. The chapter explores how these combined approaches can improve overall waste management effectiveness, reduce potential environmental impact, and ensure compliance with the laws of explosive waste management organizations.

To better understand compliance with legal requirements and ISO 14001:2015 to reduce the impact of explosive waste on the environment, the subsequent collection and analysis of data processes were conducted with the aim of achieving the following three objectives.

- ***Research objective (RO) 1:*** Assessing the effectiveness of ISO 14001 in reducing the impact of explosives waste on the environment,
- ***Research objective (RO) 2:*** Identify best practices and strategies for managing explosives waste within the scope of ISO 14001,
- ***Research objective (RO) 3:*** Assessing the economic and operational benefits of ISO 14001 certification for explosives manufacturing companies,
- ***Research objective (RO) 4:*** Identify challenges and opportunities for achieving legal compliance while managing explosive waste.

9.2 Results related to RO1: Assessing the effectiveness of ISO 14001 in reducing the impact of explosives waste on the environment.

Organisations that have implemented ISO 14001, have demonstrated their commitment to environmental sustainability and ensured compliance with legal requirements. The benefits of implementing ISO 14001 certification and legal compliance in reducing the impact of explosives waste can be categorized into environmental, operational, and strategic advantages.

9.2.1 Environmental Advantages

- Reduced Environmental Impacts: Adherence to ISO 14001 and legal compliance standards ensures that organizations minimize the adverse effects of their operations on the environment. This includes proper waste management, pollution prevention, and resource conservation.

- Enhanced Waste Management Practices: Implementing a comprehensive waste management plan, in line with ISO 14001 and legal requirements, can lead to better waste handling, treatment, and disposal methods, ultimately reducing the potential for environmental harm.

9.2.2 Operational Advantages

- Improved Efficiency: ISO 14001 certification and legal compliance can help organizations identify opportunities for improving operational efficiency and reducing costs associated with waste management.

- Risk Management: By incorporating environmental management practices into business operations, organizations can identify, assess, and manage potential risks associated with explosives waste, thus minimizing legal and financial consequences.

9.2.3 Strategic Advantages

- Enhanced Reputation: Adherence to ISO 14001 and legal compliance demonstrates an organization's commitment to environmental sustainability and responsible management practices, which can enhance its reputation and attract new customers, investors, and partners.

- Competitive Advantage: Implementing an EMS, such as ISO 14001, can provide a competitive edge in the marketplace, as it demonstrates the organization's ability to manage environmental risks and comply with legal requirements effectively.

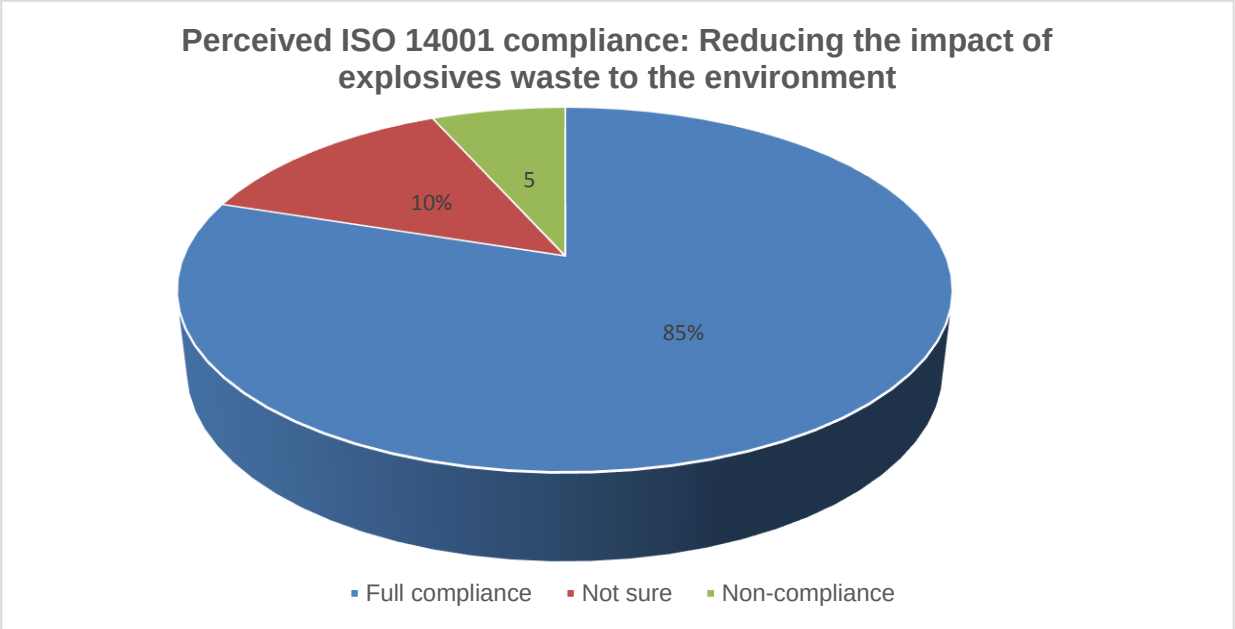

Figure 3- 1: Perceived ISO 14001 compliance in mitigating the impact of explosives waste.

Most respondents (85%) perceived the compliance to ISO 14001 offers organization an opportunity to reduce and mitigate the impact of explosives waste to the environment. Only 5% (two respondents) indicated that they perceived compliance to ISO 14001 to be non-beneficial to their organization, while 10% indicated that they were uncertain about the level of ISO 14001 compliance (**Errore. L'origine riferimento non è stata trovata.**). The concerns mentioned included a lack of proper training to the requirements and benefits of implementing and environmental management system like ISO 14001.

Conclusion

The integration of ISO 14001 certification and legal compliance in the management of explosives waste offers numerous benefits to organizations, including reduced environmental impacts, improved operational efficiency, and enhanced strategic positioning. By implementing these practices, organizations are able to ensure compliance with environmental and legal requirements while demonstrating their commitment to environmental sustainability and responsible management practices.

9.3 Results relating to RO2: Identify best practices and strategies for managing explosives waste within the scope of ISO 14001

The second research question aimed to determine the best strategies and practices for managing explosives waste within the scope of ISO 14001. This section will discuss the best practices and strategies for managing explosives waste within the scope of ISO 14001, with a focus on key areas such as waste minimization, proper storage, transportation, and disposal.

9.3.1 Waste Minimization and Management

Waste minimization is a crucial aspect of managing explosives waste within the scope of ISO 14001. 80% of the respondent demonstrated that they strive to reduce the amount of explosives waste generated through the implementation of waste reduction programs, such as:

- Conducting regular waste audits to identify waste sources, types, and quantities generated within the organization.
- Implementing process changes or improvements to minimize waste production, such as optimizing manufacturing processes, using alternative materials, or redesigning products to reduce waste generation.
- Promoting waste reduction initiatives among employees, such as waste segregation, recycling, and reusing materials whenever possible.

9.3.2 Proper Storage of Explosives Waste

Storage of explosives waste is another critical aspect that needs to be managed in accordance with ISO 14001. Proper storage ensures the safety of employees, the environment, and the surrounding community. Some best practices adopted by most of the organizations that participated in the interviews include:

- Designating specific storage areas for explosives waste, ensuring they are separate from other waste materials and hazardous substances.
- Implementing safety measures such as fire protection systems, ventilation systems, and regular inspections to prevent accidents and ensure compliance with regulatory requirements.
- Proper labelling and documentation of stored waste, including information on the type of waste, storage location, and any specific handling instructions.

9.3.3 Transportation of Explosives Waste

Transporting explosives waste also requires careful consideration and adherence to the guidelines set forth by ISO 14001. Some best practices for the transportation of explosives waste as demonstrated by the interviewed companies include:

- Choosing reputable and licensed transporters who are familiar with the specific regulations and requirements for transporting explosives waste.
- Ensuring proper packaging and labelling of waste materials to prevent any accidents or mix-ups during transportation.
- Implementing a tracking system to monitor the movement of waste materials from the point of generation to final disposal, ensuring compliance with regulatory requirements and minimizing the risk of loss or theft.

9.3.4 Disposal of Explosives Waste

The final stage in managing explosives waste is proper disposal, which should be carried out in accordance with the guidelines set forth by ISO 14001. Some best practices for disposing of explosives waste include:

- Selecting an authorized and licensed waste disposal facility that follows the relevant regulatory requirements and guidelines for the handling and treatment of explosives waste.
- Ensuring proper documentation and record-keeping for all waste disposal activities, including tracking the movement of waste materials from the point of generation to final disposal.

- Regularly reviewing and updating the waste disposal process to ensure compliance with changing regulatory requirements and to minimize the environmental impact of waste disposal activities.

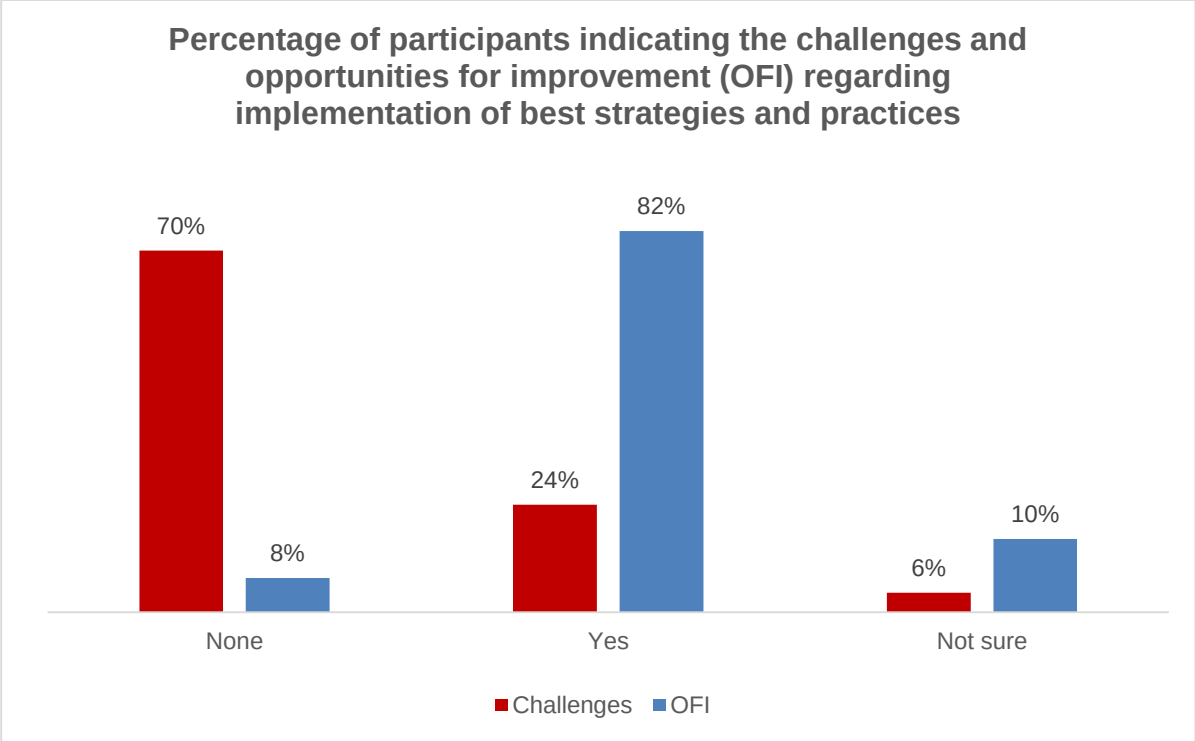

Figure 4- 1: Opportunities and challenges while implementing best strategies and practices.

From the interview responses shown in Figure 4-1, it has been determined that 70% of respondents believe that there are no challenges associated with the management and compliance of explosive wastes. Approximately 24% of respondents indicated that compliance with explosives waste management was a challenge, while 6% reported being unsure. While most respondents (82%) indicated that there were limited challenges, they agreed that there were opportunities for improvement. Approximately 8% of respondents indicated that there are no opportunities for improvement, while 10% were uncertain.

Conclusion

To effectively manage explosives waste while minimizing environmental impact and ensuring the safety of employees, the surrounding community, and the environment, a comprehensive approach

is required within the framework of ISO 14001. This approach encompasses waste minimization, proper storage, transportation, and disposal, which can be achieved by implementing best practices and strategies in these areas.

9.4 Results relating to RO3: Assessing the economic and operational benefits of ISO 14001 certification for explosives manufacturing companies**.**

Implementation of ISO 14001 certification can bring about various economic and operational benefits.

9.4.1 Economic Benefits of ISO 14001 Certification

There are numerous economic benefits to be gained by organizations by implementing an Environmental Management System (EMS). As a structured approach to managing an organization's environmental performance, EMS integrates environmental considerations into daily operations and decision-making processes. The economic benefits of implementing EMS can be categorized into several key areas.

- **Improved Brand Image and Customer Confidence**: Obtaining ISO 14001 certification demonstrates to customers and other stakeholders that the company is committed to environmental sustainability. This can lead to increased customer trust and loyalty, resulting in a competitive advantage for the company.
- **Cost Savings through Efficient Resource Use**: Implementing an EMS can lead to more efficient use of resources, such as energy, water, and raw materials. This can result in cost savings for the company and contribute to a more sustainable operation. By identifying and addressing inefficiencies in resource consumption, waste generation, and energy usage, companies can reduce their operational costs. EMS helps organizations identify opportunities for waste reduction, recycling, and resource conservation, leading to lower procurement costs and decreased waste disposal expenses. Moreover, EMS encourages the adoption of cleaner technologies and practices that improve energy efficiency and reduce emissions. This can result in lower energy bills and reduced environmental impact. By optimizing processes and reducing waste, organizations can achieve cost savings while simultaneously improving their environmental performance

- **Access to New Markets and Business Opportunities**: Some clients and regulatory authorities require suppliers to hold an ISO 14001 certification. By obtaining this certification, explosives manufacturing companies can access new markets and business opportunities that may otherwise be inaccessible. ISO 14001 certification can open up new market opportunities for organizations. Many customers, particularly in the business-to-business sector, prioritize working with environmentally responsible suppliers. By implementing an EMS, companies can meet customer requirements for sustainable practices and gain a competitive edge in the marketplace.

  Furthermore, EMS can help organizations identify new business opportunities related to environmental products or services. For example, by optimizing resource use and waste management practices through an EMS, companies may discover opportunities to develop and sell eco-friendly products or offer consulting services to other businesses seeking to improve their environmental performance.
- **Reduced Liability and Insurance Costs**: Companies with a well-established EMS may be able to reduce their exposure to environmental liabilities and related insurance costs. This can lead to long-term financial savings for the company.
- **Risk Management and Resilience:** Environmental risks, such as climate change, natural disasters, and resource scarcity, can have significant impacts on businesses. Implementing an EMS helps organizations identify and manage these risks by integrating environmental considerations into their risk management processes. By understanding the potential environmental risks they face, companies can develop strategies to mitigate those risks and enhance their resilience.

  Additionally, EMS facilitates proactive monitoring and assessment of environmental performance indicators. This enables organizations to detect emerging issues early on and take appropriate actions to prevent or minimize potential negative impacts. By effectively managing environmental risks through an EMS, organizations can safeguard their operations, assets, and reputation.
- **Regulatory Compliance:** Compliance with environmental regulations is a legal requirement for businesses operating in many jurisdictions. Failure to comply with these regulations can result in fines, penalties, and legal liabilities. Implementing an EMS helps

organizations ensure compliance with environmental laws and regulations by establishing procedures and practices that align with legal requirements.

By proactively addressing potential environmental risks and hazards through an EMS, companies can avoid costly legal disputes and reputational damage associated with non-compliance. Furthermore, maintaining a good environmental track record can enhance a company's reputation, attracting environmentally conscious customers and investors.

- **Enhanced Reputation and Competitive Advantage:** Implementing an EMS demonstrates an organization's commitment to environmental stewardship and sustainability. This commitment can enhance the company's reputation among stakeholders, including customers, employees, investors, regulators, and the general public.

  A positive reputation as an environmentally responsible organization can differentiate a company from its competitors and attract environmentally conscious consumers.

  A strong reputation for environmental performance can also lead to increased customer loyalty and trust. Consumers are increasingly demanding products and services from companies that demonstrate social and environmental responsibility. By implementing an EMS, organizations can align their operations with consumer expectations, leading to improved brand image, customer satisfaction, and market share.

9.4.2 Operational Benefits of ISO 14001 Certification

- **Improved Environmental Performance**: Implementing an EMS based on ISO 14001 requirements helps organizations identify and manage their environmental impacts more effectively. This can lead to a reduction in pollution, waste, and the consumption of natural resources.
- **Streamlined Environmental Compliance**: A well-implemented EMS can help organizations comply more easily with relevant environmental laws and regulations. This can save time and resources that would otherwise be spent on managing non-compliance issues.
- **Enhanced Employee Engagement**: Implementing an EMS can lead to increased employee engagement and satisfaction, as employees feel that their organization is taking

environmental issues seriously. This can lead to a more productive and motivated workforce.

- **Continual Improvement and Innovation**: The ISO 14001 standard requires organizations to continually improve their EMS. This can lead to the development of new technologies, processes, and practices that help organizations become more environmentally responsible and efficient.

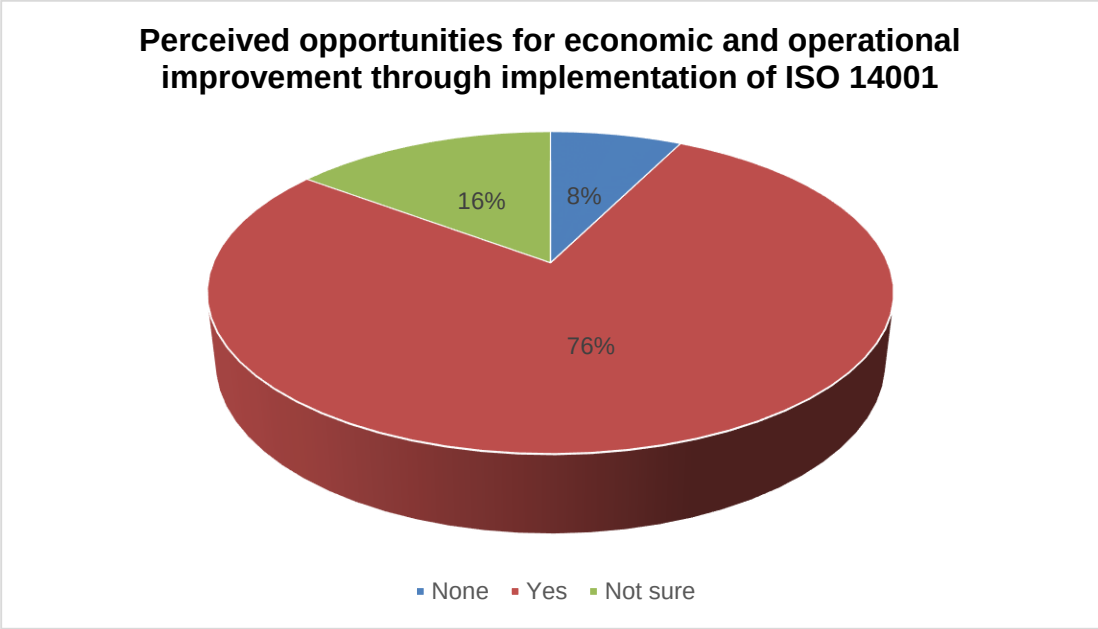

Figure 5- 1: Economic and operational benefits for implementing ISO 14001

Respondents were requested to indicate whether they perceive economic and operational opportunities to exist when it comes to ISO 14001 implementation. As presented in Figure 5-1 approximately 76% of the respondents indicated that they feel that there are economic and operational benefits through the implementation of ISO 14001. However, approximately 8% of respondents indicated that they do not perceive any economic nor operational benefits through implementation of ISO 14001, while 16% indicated that they were uncertain.

Conclusion,

Implementation of ISO 14001 certification offers significant economic and operational benefits to organizations. The cost savings achieved through waste reduction and resource optimization can

improve the bottom line. Improved efficiency resulting from a systematic approach to environmental management enhances overall operational performance. The enhanced reputation gained from ISO 14001 certification attracts environmentally conscious stakeholders. Lastly, the focus on regulatory compliance helps organizations avoid legal issues and maintain a proactive stance towards changing environmental regulations.

9.5 Results relating to RO4: Identify challenges and opportunities for achieving legal compliance while managing explosive waste.

The fourth research question aimed to determine the challenges and opportunities for achieving legal compliance by the explosives sector while managing their waste. It has been observed from interview responses as shown in **Errore. L'origine riferimento non è stata trovata.**6-1 that 80% of the respondents perceive that there are no challenges related to explosives waste management and legal compliance. Approximately 16% of respondents indicated that there were challenges with compliance related to explosives waste management, while 4% indicated that they were unsure.

9.5.1 Challenges for legal compliance:

- **Regulatory Complexity**: The explosives manufacturing industry is subject to a wide range of regulations at the international, national, and local levels. These regulations may include permits, licenses, reporting requirements, safety standards, environmental regulations, and transportation restrictions. Navigating this complex regulatory landscape can be challenging for companies, especially when operating across multiple jurisdictions.
- **Safety and Security Measures**: Ensuring the safe handling, storage, and transportation of explosives is a primary concern for these companies. Compliance with safety standards and security measures is essential to prevent accidents, unauthorized access, theft, or misuse of explosive materials. Implementing robust safety protocols can be demanding in terms of training, equipment maintenance, and adherence to strict procedures.
- **Environmental Impact**: The production and use of explosives can have significant environmental implications. Compliance with environmental regulations is necessary to mitigate any adverse effects on air quality, water resources, soil contamination, and wildlife

habitats. Proper waste management practices must also be implemented to handle hazardous materials generated during the manufacturing process.

- **Employee Health and Safety**: Explosives manufacturing involves working with hazardous materials that pose risks to employee health and safety. Companies must comply with occupational health and safety regulations to protect their workers from potential hazards such as chemical exposure, fires, explosions, and ergonomic issues. Providing appropriate personal protective equipment (PPE), conducting regular safety training programs, and maintaining a safe working environment are essential compliance measures.
- **Transportation and Logistics**: The transportation of explosives is subject to strict regulations to ensure public safety. Compliance with transportation requirements, such as proper packaging, labelling, and documentation, is crucial to prevent accidents during transit. Companies must also consider security measures to protect against theft or unauthorized access during transportation.
- **Record-Keeping and Reporting**: Maintaining accurate records and submitting timely reports is an essential aspect of legal compliance for explosives manufacturing companies. This includes records related to inventory management, safety inspections, incident reporting, training programs, and environmental monitoring. Failure to maintain proper documentation can lead to regulatory penalties and legal consequences.

9.5.2 Opportunities for Legal Compliance:

- **Adoption of Technology**: Utilizing advanced technologies can help improve compliance efforts within explosives manufacturing companies. For example, implementing automated systems for inventory management, record-keeping, and reporting can streamline processes and reduce the risk of errors or omissions. Additionally, leveraging data analytics and monitoring tools can enhance safety measures by identifying potential risks or non-compliance issues.
- **Collaboration and Industry Networks**: Engaging in industry associations and networks can provide valuable opportunities for sharing best practices, knowledge exchange, and staying updated on regulatory changes. Collaborative efforts can help companies identify common challenges and work collectively towards achieving legal compliance. Sharing

experiences and lessons learned can contribute to continuous improvement in safety standards and operational practices.

- **Proactive Risk Assessment**: Conducting regular risk assessments allows companies to identify potential compliance gaps or vulnerabilities before they become critical issues. By proactively assessing risks associated with manufacturing processes, storage facilities, transportation routes, or employee practices, companies can implement preventive measures to address these risks effectively.
- **Training and Education**: Investing in comprehensive training programs for employees is crucial for ensuring legal compliance within explosives manufacturing companies. Training should cover topics such as safety procedures, regulatory requirements, emergency response protocols, environmental protection measures, and ethical conduct. Regular refresher courses and continuous education can help reinforce compliance practices and promote a culture of safety and responsibility.
- **Engagement with Regulatory Authorities**: Building strong relationships with regulatory authorities can provide valuable guidance and support in achieving legal compliance. Proactive engagement can help companies stay informed about regulatory changes, seek clarifications on requirements, and receive feedback on their compliance efforts. Collaborating with regulators can foster a cooperative approach towards ensuring safety and legal compliance.

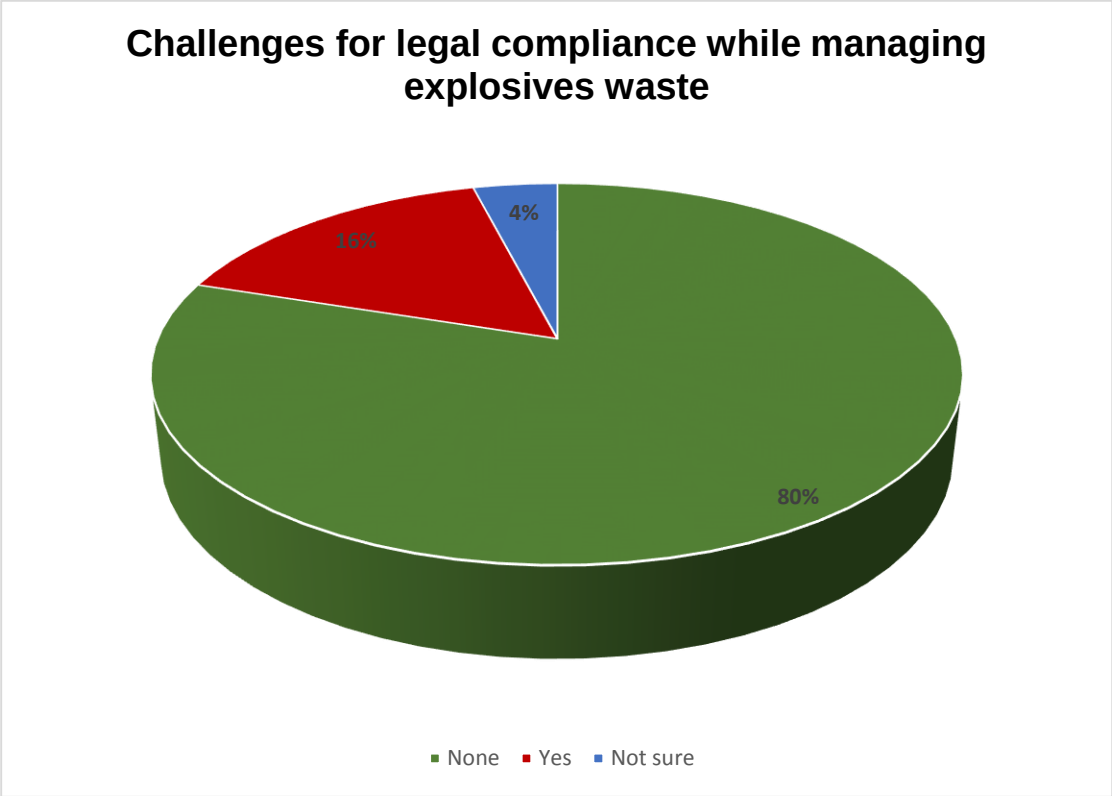

Figure 6- 1: Challenges for legal compliance while managing explosives waste

In conclusion, the objective of identifying challenges and opportunities for legal compliance within explosives manufacturing companies is crucial for maintaining safety, protecting the environment, and meeting regulatory requirements. While the industry faces complex regulations and inherent risks, proactive measures such as adopting technology, collaborating with industry networks, conducting risk assessments, investing in training, and engaging with regulatory authorities can enhance compliance efforts.

CHAPTER 10 CONCLUSION AND RECOMMENDATION

10.1 Conclusion

The critical components of ISO 14001:2015, such as the PDCA cycle, environmental policy, environmental objectives, legal compliance, and stakeholder engagement, are essential for organizations to develop and maintain effective EMS. These components work together to create a comprehensive framework that enables organizations to minimize their environmental impact, improve their overall environmental performance, and demonstrate their commitment to sustainable practices.

Successful munition and explosives waste disposal programs rely on a combination of best practices, innovative technologies, and effective stakeholder engagement. By learning from these programs and implementing best practices, countries and organizations can more effectively address the challenges posed by munitions and explosives waste disposal, ensuring a safer and more sustainable future.

Munition and explosives waste disposal programs face a range of challenges and failures, including handling hazardous materials, environmental impact, regulatory compliance, funding and resources, and public perception. These challenges require a comprehensive approach, which includes adherence to strict safety protocols, compliance with regulations, and effective communication with stakeholders, to ensure the safe and efficient disposal of these dangerous materials.

By following best practices in the management and disposal of explosives waste, many companies can minimize the risks associated with such waste and protect the environment and public safety. The key principles include waste characterization and quantification, proper storage and handling, waste treatment and neutralization, appropriate disposal methods, and regular monitoring and maintenance**.**

It is important for explosives manufacturing organization to understand the urgency of responsible munition and explosives waste disposal, considering its multifaceted implications. Explosives manufactures should advocate for a holistic approach that integrates security, environmental

sustainability, and public safety in disposal practices also emphasize the importance of international cooperation, technological advancements, and adherence to regulatory frameworks to ensure a safer and more sustainable future.

10.2 Recommendations and areas of future research

10.2.1 Recommendations

Recommendations are further provided to ensure that waste management is accurately done. In addition to that, recommendations are further provided so that waste generated by the explosive sector of South Africa can be accurately handled and on the other hand, negative impacts of explosive waste materials on the environmental constituents are further minimised to some extent. As influenced by the viewpoint of Sotamenou*et al.*(2019), the recommendations are mentioned in the following.

Recommendation 1

In order to effectively handle the waste management procedures, ***the explosive manufacturing sectors of SA need to maintain these factors***. In fact, accurate ***waste management, waste keeping, waste handling and manufacturing-site production plan*** is highly necessary. In compliance with that, sufficient amounts of non-reactive containers are required to contain those explosive contaminated wastes. Moreover, the explosive sectors of SA must accurately and cautiously analyse the primary. In accordance with the viewpoint of Ghosh *et al.* (2016), inaccurate placing of contaminated waste material, in turn, leads to hazardous as well as dangerous consequences and can further mix with soil and cause soil pollution as well. However, the primary explosives that are stored in plastic containers by these explosive sectors must have high polyethylene content, so that chances of contamination might have been reduced to some extent.

Recommendation 2

Protection and preparation of burning ground for accurately handling Waste

Along with accurately handling production plants, it might be the sole responsibility of the explosive manufacturing organisations of SA that waste burning ground should be accurately

maintained. In addition to that, it can be recommended that the collection of accurate base material needs to be maintained in order to ensure the successful destruction of the contaminated waste materials. However, in order to minimise the impact of environmental pollution (such as air and soil pollution) the explosive manufacturing sector of South Africa needs to take confirmation or permission from the fire department of the municipality of that concerning area in order to ensure whether the weather will permit the destruction or not. Apart from taking confirmation, the fire-department of the explosive manufacturing organisations needs to verify and accurately prepare the burning ground so that they ensure a very little and minimum amount of environmental impact.

Recommendation 3

Improvement of the waste separation site

Based on the viewpoint of Ghinea and Gavrilescu (2019), by releasing the explosive liquids (such as liquid petroleum and as well as hydrocarbons) various dangerous consequences can occur, which in turn create a deep negative impact on the environment such as both air as well as water pollution might have happened due to lack of cautiousness. In order to effectively handle ***"unlikely events"*** that generally happened in these kinds of explosive manufacturing sites, the explosive manufacturing sectors of SA must incorporate a section in their ***"Incident reporting methods or procedures". Additionally, it is also legally justified and also helps them to deal with "Environmental emergencies" with no legal complications.***

Recommendation 4

Necessity of undertaking internal and external Audits regarding the waste storage area

Along with all the other recommendations, this recommendation at the same time is considered to be highly necessary for accurate handling of waste management. In accordance with the viewpoint of Godfrey and Oelofse (2017), audits at the same time help to create an accurate data analysis. By both internal as well as external audits of the waste storage area, total number of destructed and storage waste and number of contaminated wastes can be predetermined, which on the one hand help these explosive manufacturing organisations to create a correct calculation of destructive wastes and on the other hand, sufficient containers for contaminated waste can be arranged. As a

resultant factor, these organisations might have to justify themselves legally and can accurately handle legal compliance as well. In fact, with this initiative, the explosive manufacturing units of South Africa might have to maintain legal norms and standards necessary for storing waste as per the rules of 2013. In compliance with that, in regard to this research, it can be further recommended that, these organisations need to do internal and external audits bi-annual and biennial basis respectively. Based on the ideas of Gobbi*et al.*(2017), internal auditors in turn can determine several issues of an organisation and can analyse various critical situations or upcoming risks. Contrastingly, external auditors basically analyse the financial records of the organisation and might help the organisation by issuing an opinion regarding financial clearance. However, by internal audit, the explosive manufacturing organizations can easily determine those areas that need further rectification or re-evaluation (Linkov et al., 2014). Additionally, by clear financial statements, these explosive manufacturing organizations can easily deal with various legal challenges and can represent their sectors as a fair one.

Thus, it can be further recommended that in order to effectively handle legal challenges or in order to accurately deal with challenges reading legal compliance, not only bi-annual internal audits but at the same time biennial external audits are considered to be highly necessary for every explosive making sectors of South Africa.

In reference to this research, as the research has already highlighted 5 stages of the explosive life cycle, so it might be highly necessary for South African explosive making sectors that employees or workers must have adequate knowledge regarding the life cycle and its five different stages. Only by this way, legal compliance challenges can be maintained and fewer accidents can occur within these manufacturing sectors. Thus, by having all this knowledge regarding the entire explosive life cycle, employees can easily or acutely handle these hazardous waste materials in a systematic and scientific way.

Recommendation 5

Training of the employees for safety handling of explosive wastes

The ultimate necessary thing, that an organisation is highly required to effectively handle all internal procedures. According to the viewpoint of Sotamenou *et al.* (2019), for an explosive

manufacturing sector, employee training would be considered to be vital as in each sector, various kinds of risk factors as well as unlikely events might have happened. Ghosh *et al.* (2016) opined that in order to effectively handle emergency situations as well as various critical incidents, employees need an appropriate training session. Not only that, for managing waste, handling those contaminated wastes with accurate techniques, the explosive manufacturing organisations needs to incorporate various training sessions within their working sectors. In addition to that, it can be highlighted that the physical safety of the workers might be an integral part of explosive making organisations. In order to ensure physical safety of the employees or in order to create alert from the several unintentional unlikely incidents, training must have to be provided. However, for accurately handling solid, liquid, gaseous as well as different contaminated waste, it might be the ultimate responsibility of the all explosive manufacturing sectors of South Africa that all of these organisations should incorporate some appropriate and beneficial training sessions. Godfrey and Oelofse (2017) mentioned that, handling of wastes is not easy as due to the different nature and state of these wastes various serious hazards might have happened within an organisation. In fact, in order to effectively understand the consequences of several different environmental pollution, explosive manufacturing organisations must provide accurate training to their workers. Though previous year audit reports reveal that these explosives making organisation's waste management practices seem to be in good control, in spite of that as per NEMWA, under section 25 in order to accurately handle transportation of the explosive waste, more training sessions need to be implemented by these organisations.

However, in reference to the ***"Data analysis explosive wastes",*** (process flow observation), it can be further revealed that explosive wastes of the production plant need to be handled more accurately. Additionally, some fault services are further visualised in that sector. Thus, in order to accurately handle the duties of production plant skilled employees are needed and it might be only created by initiating several more effective training sessions in the working sectors of these explosives manufacturing organisations.

Recommendation 6

Accurate implementation of legislations for handling legal compliance challenges

Research suggests that an explosive manufacturing organisation might have to maintain several rules or regulations in order to accurately handle challenges regarding legal compliance. In addition to that, for appropriately handling entire waste management procedures, along with ***EPA, RCRA, GNR 634 of august 2013, NEMWA, Explosives Act, NEMAQA*** and many more should have to be accurately followed. It is recommend that for handling legal compliance challenges, along with accurate implementation of the legislations, all the employees should accurately follow these laws or legislations for effectively handling wastes as well as explosives. Gobbi*et al.*(2017) highlighted that compliance basically referred to conforming to a policy or legislation, rules or law. In addition to that, regulatory compliance in turn depicts the future objective of a company which an organisation basically aspires to achieve through its constant efforts or practices.

Thus, it can be further recommended that in order to accurately handle both internal practices, as well as the burning ground, production plant, laboratory of the manufacturing site and so on, the explosive making organisations need to implement accurate laws. Not only that, in order to accurately maintain each and every constituent of explosives, along with implementing appropriate laws, each and every employee of all the departments must obey those implemented regulations.

However, by maintaining or following all the above-mentioned recommendations on one hand, the South African explosive manufacturing organizations can effectively handle the entire waste management process. On the other hand, by these recommendations or suggestions, the organisation can deal with various regulatory and legal compliance challenges, which in turn proves to be effective to fulfil its business objectives.

10.2.2 Recommendation for future Research

The topic is considered to be so unique that researchers can easily look forward to further study. Evaluating the scope of this study, it is ascertained that a researcher can accurately understand the 5 stages of the explosive life cycle, which in turn help them to conduct a study regarding **"*technological management of the explosive waste material"***. In fact, a study can be conducted

regarding ***"maintenance of the waste residue collection in a scientific way or a scientific treatment"***. Hence, it can be further added that, by conducting this study, negative environmental impact caused by hazardous wastes can be minimised to some extent (Yang *et al*., 2017).

In addition to that, a detailed study has been conducted regarding ***"classification of the explosive waste residues"*** along with conducting a study on legal compliance challenges. As per the scope of this study, a researcher can conduct a research upon ***"significance of PEP composition, reject plastic materials and munitions on generation of the hazardous and explosive waste"*** (Bereikienė, 2020)**.** With this research, the researcher can delineate or gather information regarding ways to manage these explosive wastes and also with this study, ways to minimise environmental impact due to this explosive waste material can be understood appropriately. Hence, furthermore from this research further studies can be conducted upon these topics.

As the topic is quite illustrated and broad, there might be several different research areas or subjects that can be found by utilising this particular aspect.

With the help of this topic or after gathering ideas from this topic, the researcher can further focus on ***"Waste management by Modern technologies"***. In fact, with the help of this research, along with gathering knowledge about constituents and nature of the different kinds of wastes, with this study, a researcher can further focus in managing those wastes by using proper tools or technologies. In compliance with that, the study at the same time helps to provide a researcher accurate knowledge regarding waste assessment, waste lifecycle, waste classification, waste transportation and so on. Moreover, with the help of all these knowledges regarding waste management, a researcher can easily conduct a study on this particular research area. Meanwhile, by gathering knowledge about the nature of wastes, waste treatment might be a more interesting topic for that researcher. Not only that, which tools or technologies can be used to treat and manage various types of wastes are further determined by the researcher. In fact, the entire study might be considered as fruitful for a researcher as without this research ways to manage different wastes cannot be understood. As stated earlier, waste management as well as waste treatment is not an easy task. Additionally, in order to understand the depth of a study, at first the thing which is extremely necessary is to collect accurate data and gather relevant information. After conducting this study, it can highlight that the research provides all the information accurately. In compliance with that several other information regarding

waste management are further provided through spreadsheets, audit reports (from 2009-2019), which in turn considered to be beneficial for some other researcher areas that relate with this topic.

Thus, from this study, it can be stated that ***"Waste management and waste treatment by modern technologies",*** can be a potential future research area, that this particular topic can further be indicated through its research style.

Like the previously discussed research area, knowledge regarding ***"Operational environment for effective waste management and explosive production"*** can be acquired by this research topic. Through ***spreadsheets, audit reports, process flow diagrams or current compliance verification*** and so on, the study further manages to give several different as well as valuable information regarding waste management as well as production of explosives. Along with that, by effectively discussing constituents of explosives, its nature, impact on environment the study at the same time not only justifies with the topic but also attract a researcher to conduct more deeper study from this topic. In addition to that, by giving knowledge about explosives act, the research at the same time not only enhances its strength but further forces a researcher to conduct more studies regarding this topic. Meanwhile by focusing on various different related aspects regarding the waste management and waste handling at the same time, the study once again highlights its effectiveness and as a resultant factor due to these aspects, a researcher can further urged to gather more information regarding this topic. By showing production plant management aspects or by discussing the production plant laboratory once again the topic highlights the accurate ways to produce various kinds of explosives. Though, it basically sheds its light on ***legal compliance challenges of waste management*** however, no one can deny or refuse that it failed to give accurate information about waste management or exclusives.

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