Environmental Risk Management of Cement Factories (Case Study in Iraq)

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This thesis was submitted in partial fulfillment of the requirements for Master's Degree in Engineering Project Management

January 2021

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Dedication

I dedicate this work to my country, IRAQ.

I dedicate this thesis to my father and mother, and my brothers and sisters.

Also, I dedicate this work to every individual who contributed towards the success of this dissertation.

I would also like to thank the Hashemite Kingdom of Jordan and their people, for hosting me and providing assistance through the entire course of my research.

Acknowledgement

I deeply respect and I am sincerely appreciative of my family for their kind and constant support and encouragement throughout the period of my undergraduate and graduate studies.

*I would like to express my profound thanks and heartfelt indebtedness to my supervisor, **Dr. Tariq J. Al-Musawi**, for his inestimable guidance, consistent support and exceptional understanding throughout the period of the present research, as well as for his encouragement, suggestions, and unswerving effort and interest that have contributed towards the successful completion of this work.*

*Also, my thanks are due especially to the staff of the Civil Engineering Department at Al Isra University, and **Dr. Ibrahim A. Mohammed** (Isra University), in particular, for their sustained support through the entire process of my research.*

Finally, I extend my gratitude to all my colleagues for providing support and helping me to feel a part of a team in our times of working together.

Ahmed

January 2021

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Abstract

Environmental Risk Management of Cement Factories (Case Study in Iraq)

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Cement industry is considered as one of the main sources of environmental pollution in several areas in the world. This type of industry ranks among the largest types of construction industries that are a threat to the environment, particularly in terms of air quality and human health. Several risks and hazards are encountered right from the mining of the raw material to the dispatching of the cement products, which harm the environment. Hence, the reduction and control of risks resulted from cement industry is of great importance to keep the Environment. In Iraq, it is well known that the projects in cement factories lack both the experience and implementation of risk management strategies. Therefore, the risks management of cement factories in this country should be studied. The aims of this study is the studying the application parameters of Environmental risk management methodology for the accounting the mitigated risks from three cements factories in Iraq. Therefore, the most vital indicators of risk that influence the type and nature of the environment scrounging these three factories was focused in this study, which were judged based on the questionnaire results from experts and engineers in this field, to evaluate the implementation. The principal risks arising from the cement industry are also discussed, and the management of the potential environmental risk is explained. Furthermore, the degree to which these risks affected the environment was studied using the questionnaire technique. It was found that the used methodology using questionnaire technique was an effective method of assessing the environmental risks in cement factories. Based on the results determined from the questionnaire, the environmental risks considered in the present work, ranked in the order of priority, are: Air Pollution> Exposure to Noise> Electrical Hazards and consumption> Land Pollution> Greenhouse gas emissions> Generation

of solid and hazardous wastes> Water Resources pollution> Public health effect. In addition, results showed that a high risk level was observed to arise from air pollution and exposure to noise from all three cement factories under consideration in this study. As a result, the cement industry needs to be submitted to various risk management strategies to reduce the risk intensity of air pollution and exposure to noise. From this study, it can be concluded that the Environmental risk management studies must be applied as they are vital to the mitigation of the impacts of many risk sources in the cement factories. Therefore, the recommendations of the present study suggest initiating a comprehensive study that considers the methods that can ensure a significant degree of risk mitigation in cement industry in Iraq. In addition, a study that outlines the risk criteria for cement factories should be conducted.

Chapter One: Introduction

1.1 Background

Currently, environmental issues rank high among the principal problems affecting mankind. These problems frequently arise from a variety of activities, the industrial ones in particular, which finally cause the environmental components such as air, water, soil and vegetation to deteriorate, thus becoming a threat to human health (Manisalidis et al., 2020; Al-Jalaby and Al-Taee, 2009).

According to the 'Central Pollution Control Board' classification, the construction industry is among the high risk industries, from the perspective of polluting the environment. It is one of the largest contributors of a variety of harmful air emissions which release pollutants like particulate matter (dust, ash, smoke, and salt), nitrogen and sulfur oxides, as well as carbon dioxide (Baby et al., 2008). Based on particle size, these particulate matters are categorized under two classes:

i) PM10: coarse particles ($d \leq 10$ µm) which can enter the circulatory system.
ii) PM2.5: fine particles ($d \leq 2.5$ µm) which remain embedded in the lungs.

Cement industry ranks among the largest types of construction industries that are a threat to the environment, particularly in terms of air quality and human health (Devi et al., 2017). This industry has extended internationally because cement is a raw material, crucial to construction and infrastructure development. This simply means, the cement industry plays a vital role in the development of almost all building constructions because it is the basic constituent in the concrete used to build various types of structures. At present, around 5% of the total anthropogenic CO_2 emissions have been attributed directly to the activities of cement factories.

Within the next 30 years this percentage is only likely to rise, due to the rapidly growing cement demand. Under such circumstances, the traditional strategies currently in place to lower the emissions will not be able to match this increase (Damineli et al., 2010; Dosumu, 2018). Therefore, a clear accounting must be taken of the cement industry in terms of the environmental risk it poses, including its negative impacts, as a very necessary means of protecting the environment, which in turn results in saving human lives. Besides, risk management must be studied for cement factories from the perspectives of development and sustainability (Chen et al., 2010).

1.2 Aims and objectives

The following objectives of the current research are listed below.

1) Perform a comprehensive study to identify the likely environmental risks caused by cement industries.
2) Estimate the environmental risks identified, employing the statistical approach.
3) Suggest a model which is required to minimize or completely eradicate the hazards linked to the risks arising from cement industries.

1.3 Importance of risk management study

The role played by environmental risk management in construction projects like the cement industry is a vital issue in planning and managing such projects. As the construction industry is highly complex, the risks and uncertainties involved will more likely be faced in this industry compared to many others. In Iraq, the implementation of risk management strategies in the cement industry is poor compared to other industries, which encompass the identification, analysis and assessment of all the various risk categories. This research is definitely viewed as advancement, adding onto the earlier research, to gain clearer understanding of implementing risk management strategies in the industries in the country. This research also emphasizes the most vital indicators of risk that have been identified as the main factors that influence the prosperity or recession in this sector, by applying the judgments of experts in this field, to evaluate the implementation.

One of the principal organizational practices is the investigation of risk management in industrial activities. Any uncertain condition or event that can affect an activity is considered a risk. It is noteworthy that not all the risks that arise from a specific activity are negative, for instance a factor like low costing for particular materials or certain events like identifying a simpler way to perform an activity, can help the affected activities (Ayyub, 2003; Dosumu, 2018).

Human activities have been identified as the main risks which affect the environment and, therefore, must be reduced and governed by human beings (Sereshki and Saffari, 2016). In terms of the field of environmental management, one of the most crucial tools employed in the Environmental risk assessment studies is to discover and determine the risks arising from different human activities (Folchi, 2003). Primarily, the risks produced are due to both natural and man-made activities. In the civil engineering field, an accounting of the total risks faced by the industrial and construction projects constitutes a very significant method, in order to estimate the positive and negative effects exerted by these projects on the environment. In addition, risk assessment and management investigations are vital to the prevention and control of the environmental issues. In several instances, such risk assessment studies are performed during the design phase, to anticipate the likely risks and thus prevent these from happening (Feridun, 2006; Mahendra et al., 2013).

Risk assessment is a method involving systematic analyses employed to develop a thorough and conclusive understanding of the specific potential risks which can possibly exert the highest negative impact on the project and have the greatest probability of taking place - likelihood (Parker and Mobey, 2004). Figure 1.1 shows the interaction between both the fundamental risk concepts of likelihood and impact. It is noteworthy that several papers report that likelihood and impact represent frequency and severity, respectively. In risk management studies, high values for impact at high likelihood are indicative of the worst scenario.

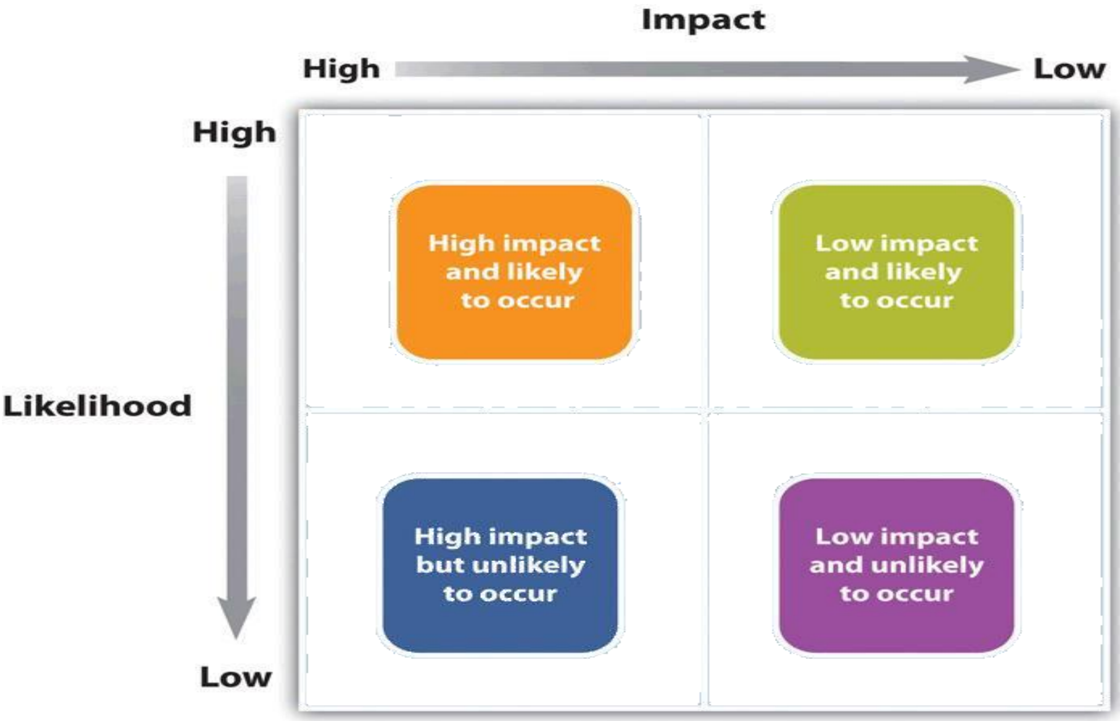

Figure 1.1. Risk and impact interaction (Parker and Mobey, 2004)

A risk is defined as any variation in the negative result that is present in or produced through a specific case (Kumar and Mishra, 2019; Albogamy et al., 2013). In light of this, risk management includes a sequence of actions involving the identification, measurement, analyses and treatment of the risks that arise from any particular process. While risk management study is unconnected to deliberately manipulated activities, it is rather a method of managing business-related risks better, by minimizing the impact of the risks. Generally, risk management studies involve eight steps, as listed below (Kumar and Mishra, 2019):

1) Enumerate the work task. This involves four steps:

- People: The most crucial unit
- Location: Any change in the location will affect the risks negatively or positively
- Location: Any change in the location will affect the risks negatively or positively
- Equipment: This includes all the equipment used in the process, namely ladder, scaffold, machinery etc.

2) Discover the risks, a process involving three principal steps:

3) Name the hazards caused.

4) Identify the ones who may suffer harm from the resultant hazards (worker, visitor, engineer, manufacturer, supervisor, environment… etc.).

5) Explain the type of harm or degree of harm they may suffer. For instance, the lack of safety may cause harm to the workers.

6) Estimate the risks. The Figure (1.2) reveals the methodology of risk estimation.

7) Assess the likelihood of risks

8) Record all the findings

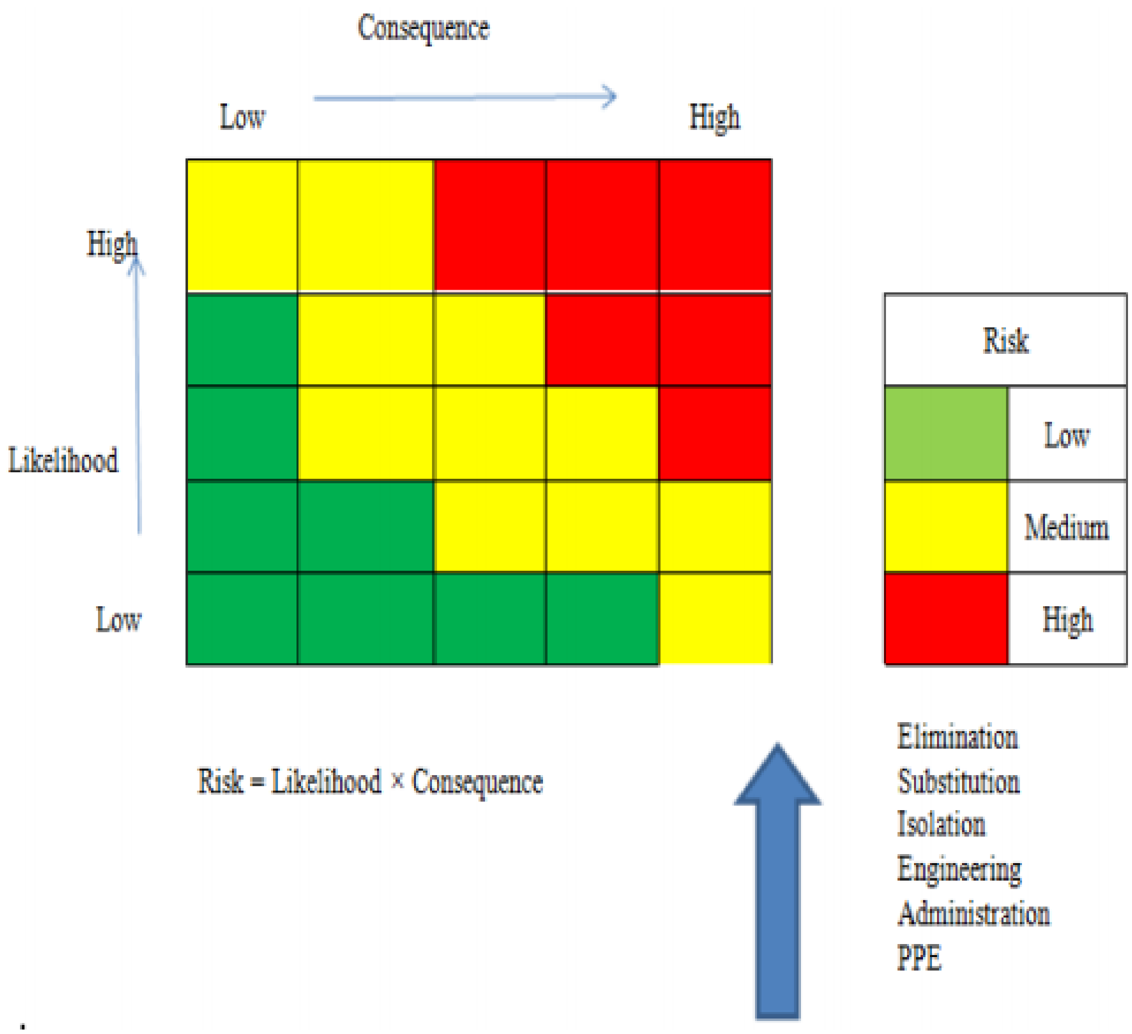

Figure 1.2. Matrix of Risk (Kumar and Mishra, 2019)

1.4 Environmental risks

The reports from many studies indicate that risk management study is a crucial tool that helps to estimate the likely impacts of a variety of engineering structures in the pre- and post-construction stages (Ilalokhoin et al., 2013; Sereshki and Saffari, 2016). In reality, such a study is regarded as an effective decision-making technique to gauge the harmful, as well as the beneficial effects that are caused by the various activities (Ataei et al., 2016). The study of environmental risk management is recommended for the efficient monitoring, management, and mitigation of problems in a plant (U.S. EPA, 2004).

The performance of industrial plants is affected by several environmental parameters like, transport sources, noise pollution and the pollutants generated during production (Zolfagharian et al., 2012). Furthermore, the nature of the construction of the buildings may directly or indirectly affect the environment surrounding the industries. From this angle, studies on environmental risk management are crucial to the derivation of a comprehensive view on the environmental impacts caused by the industries (Abidin, 2010). For instance, in the cement production processes, right from the commencement of the pre-production stage to the final one, the degree of environmental impact must be identified (Zainudeen and Jeyamathn, 2004).

1.5 Study problem

In Iraq, it is well known that the projects in cement factories lack both the experience and implementation of risk management strategies. Risk management, in fact, may be crucial to all stakeholders. The returns on investment for the contractor are closely linked to the risks and the way it affects the costs involved in the work. Additionally, many decisions rely on the related risks. The structure of the work, from a contractual and monetary standpoint, are highly biased by the apparent risk. Therefore, in this sector, regarding the process of risk management must be assessed to determine the best possible and efficient ways for risk management and mitigation. Eventually, this will lead to a reduction in cost and time, while raising the quality of the projects.

1.6 Thesis structure

This thesis includes five chapters, as mentioned:

- Chapter One is the introductory chapter, which deals with the issues of formulation, statement of the problems, research objectives, and methodology.

- Chapter Two relates to the literature review. Here, the researcher includes a review of the recent literature connected with environmental risk management topics and problem-solving techniques.
- Chapter Three deals with the methodology. It clarifies the data collected and discusses the risk management methods employed in the industries. Moreover, details regarding the case study are also presented here.
- Chapter Four provides the analysis of the data collected, apart from the findings of the study and discussion. The mitigation methods of the risks generated are also explained here.
- Chapter Five is the final one, which includes the main conclusions drawn in this study and suggests recommendations for the related works to be done in the future.

1.7 Case study

Cement plants located in Iraq are shown below in Figure 1.3.

Figure 1.3. Cement factory locations in Iraq

For this study three cement plants in Iraq were chosen, as mentioned:

1) <u>Al-Faluja factory</u>

Earlier operated by the Iraqi government, from 1978 to 1986, the Fallujah Cement Factory closed operations. This factory had been started in 1977 with a single production line and a 90-

thousand ton per year design capacity. Production was begun in 1978 and it is recognized as among the first factories to operate using the dry process of cement manufacture in Iraq. In 1980, the plant was expanded with the addition of two production lines with an annual 200,000-ton capacity. These two production lines were started in 1984, so that the production capacity was increased to an annual output of 290,000 tons.

This factory is the only one in Iraq performing white cement production with a capacity capable of meeting the demands of the local market at that point in time. However, negligence and the absence of proper maintenance in this factory resulted in work being periodically suspended. Besides, mismanagement and lack of modernized equipment for pollution control and other devices have resulted in this factory being among the most notable sources of pollution in the country.

2) Al-Kubaisa factory

Located in Kubaisa City (Al-Anbar Province) about 200 km west of Baghdad, the Al-Kubaisa factory has an annual one million tons of OPC as the current production capacity. In view of this update, the risk management strategies for this laboratory are a significant step in the process of environmental management.

3) Al-Qaim factory

The Al-Qaim Cement Factory recognized as one of the principal factories in the Iraqi cement industry has the benefit of being strategically located, because its specialty is to produce salt-resistant cement with exceptional "dry" capabilities. Situated in Al-Qaim city (Al-Anbar Province) this factory is close to the Jordanian-Syrian border. At present, the Al-Qaim cement factory is regarded as one of the major market suppliers in the central region of Iraq for SRC Cement (Sulfate – Resisting Cement) with an annual 840-ton production capacity.

Figure 1.4. Three pictures from the Al-Kubaisa cement factory.

Figure 1.5. Three pictures from the Al-Qaim cement factory.

Chapter Two: Literature Review

2.1 Introduction

Risk management ranks high among the vital systems and techniques crucial to organizational practice; however, poor risk management will result in unfavorable outcomes and even loss for the organization. Although there is a general framework for such a system, each organization or institution works towards the development of risk management strategies that will suit their needs to accomplish the desired effects and facilitate dealing appropriately with their specific issues, which will result in tackling the risks wisely and gain an edge over other competitive industries (OECD, 2014; WHO, 2001). Therefore, the main aim of the risk management policies developed by most organizations or institutions is to minimize the risks generated to the lowest possible degree and to maintain them at tolerable levels (WEF, 2012; Smith, 2011). Risk management is most often a difficult process and it has been recognized that risk management outcomes do not give any assurance that the activity being managed will not suffer losses (in other words, there is no such thing as zero risk) (Dziadosz and Rejment, 2015). In Figure 1.2 (Chapter One) the visual representation of the risk factors is given, related to the pertinent construction projects, or the “risk matrix”, as it is termed. However, in the present study, risk management first needs to be clearly defined, before beginning to describe this system.

What is Risk? To answer this significant question, the following points are listed:

- The likelihood of expecting and preventing the negative and unfavorable outcomes of a particular occurrence. For instance, floods fires, pollution, construction failure, etc.

- The probability of a poor consequence. For instance, high costs, longer hours of work.

- Generally nothing suggestive of an activity of zero risk.

Besides, the three compartments of risk management are also largely employed in the literature in the arena of risk assessment in civil engineering (Ilalokhoin et al., 2013; Sereshki and Saffari, 2016; Kumar and Mishra, 2019; Tamošaitienė and Lapeikytė (2019), as mentioned below:

- Risk assessment: This refers to the possible adverse effects on the health of human beings exposed to agents that are potentially hazardous.

- Risk communication: This includes a crucial procedure that attempts to cause the outcomes of risk assessment and management coherent to lawyers, judges, environmental scientists, politicians, business, decision-making, workers, and community groups.

The links among the definitions stated above with risk management are depicted in the diagram shown.

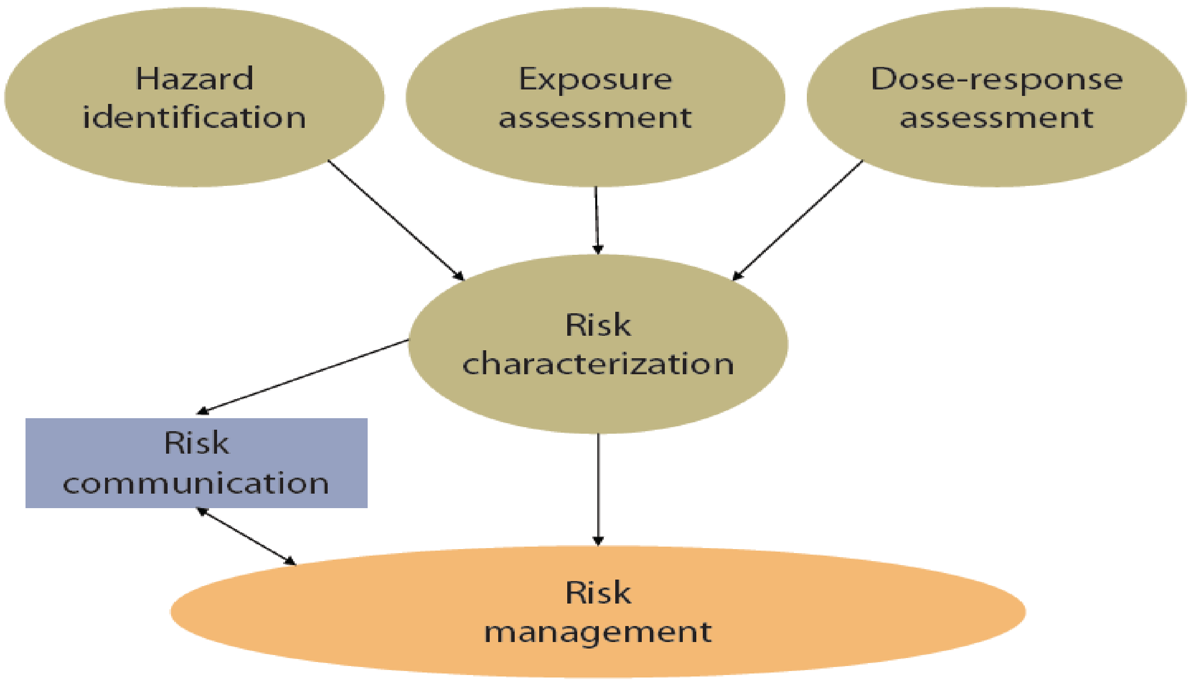

Figure 2.1. Steps of risk management (Ilalokhoin et al., 2013; Kumar and Mishra, 2019)

The processes of risk evaluation and communication are recognized as a complex technique necessitating comprehensive information linked to the hazard it poses, dose-response, and human exposure to minimize the risks that human beings encounter (see Figure 2.2). Risk assessment and its management pose a challenge for institutions, particularly in the ones involving finances (Feridun, 2006). Earlier, it included market risks that had become prominent with regards to quantitative risk management; however, credit risk management has slowly gained more importance. Quantitative risk management is a challenge on several levels, plus it involves opportunities for the personnel. These challenges encompass quantitative problems in modeling and issues of change management (Feridun, 2006). The following sections present a detailed discussion of the risks encountered in the cement industry.

Figure 2.2. Risk assessment process (Feridun, 2006; Kumar and Mishra, 2019)

2.2 Fundamentals of cement industry work

Cement ranks high among the significant and extensively used building materials in the manufacture of concrete, and because of its growing demand, the production of this material is escalating worldwide (Scrivener and Kirkpatrick, 2008). In fact, cement is the material most widely used in building activities across the globe. Therefore, the cement industry has started to expand in many regions of the world. However, on the downside, the cement industry is ranked as one of the high-energy industries, largely from a consumption perspective; but from an environmental point of view, the cement industry is one of those that directly impacts the environment to a high degree as it releases many gaseous emissions, noise, and hazardous materials (Devi et al., 2017; Manjula et al., 2014; Hesham et al., 2012). The cement plant emissions which greatly affect the environment and which require immediate attention include dust (particulate matter), sulfur dioxide (SO_2), nitrogen oxides (NOx) and carbon dioxide (CO_2) (Samadi et al., 2009; Stajanča and Eštokova, 2012). Generally, noise pollution from the cement industry, arises from the large machines employed, as well as from the manufacturing processes of grinding, packing, etc. (Kumar and Mishra, 2019). Also, much of the emissions, which contain the greenhouse and acidifying gases, (Council on Environmental Quality, 2010) originate from the cement industry, as discussed in this study in Chapter Four. The major cement production-related environmental issues encountered in Iraq are discussed in detail.

In the building and civil engineering construction industries, cement features as the basic component of concrete. In fact, around one ton of concrete, on average, is produced annually per human being, upon this earth. Therefore, concrete or cement is recognized as one of the most important manufactured materials in the world (Kumar and Mishra, 2019; Feridun, 2006). As it is abundant in the global market, it becomes very significant to gain a good understanding of the environmental implications because the manufacture of concrete and cement has gained great importance (Huntzinger and Eatmon, 2009).

As the cement demand continues to escalate, the numbers of cement factories too are annually increasing on a global scale, and cement consumption and production has correspondingly risen much, over the recent years. The cement industry has been identified as a crucial player which causes environmental imbalances and a significant producer of hazardous air pollutants. This industry emits large quantities of cement dust into the atmosphere, which forms a hard crust once it settles on the surroundings, and induces several adverse effects (Karstensen., 2007).

Cement is produced by using a variety of raw materials including sand, clay, limestone, chalk, and shale. These raw materials pass through several manufacturing processes from quarrying, crushing, fine grinding, and blending, until they achieve the right chemical composition (U.S. EPA, 2010). After the raw materials are mined, ground and homogenized, they are calcinated and finally after the resultant calcium oxide is burned together with silica, alumina and ferrous oxide at high temperatures, the clinker is formed; this clinker is then ground or milled along with other components like gypsum, slag etc., to produce cement (Stajanča and Eštokova, 2012).

Figure 2.3 reveals the diagrammatic representation of the process flow in cement manufacture.

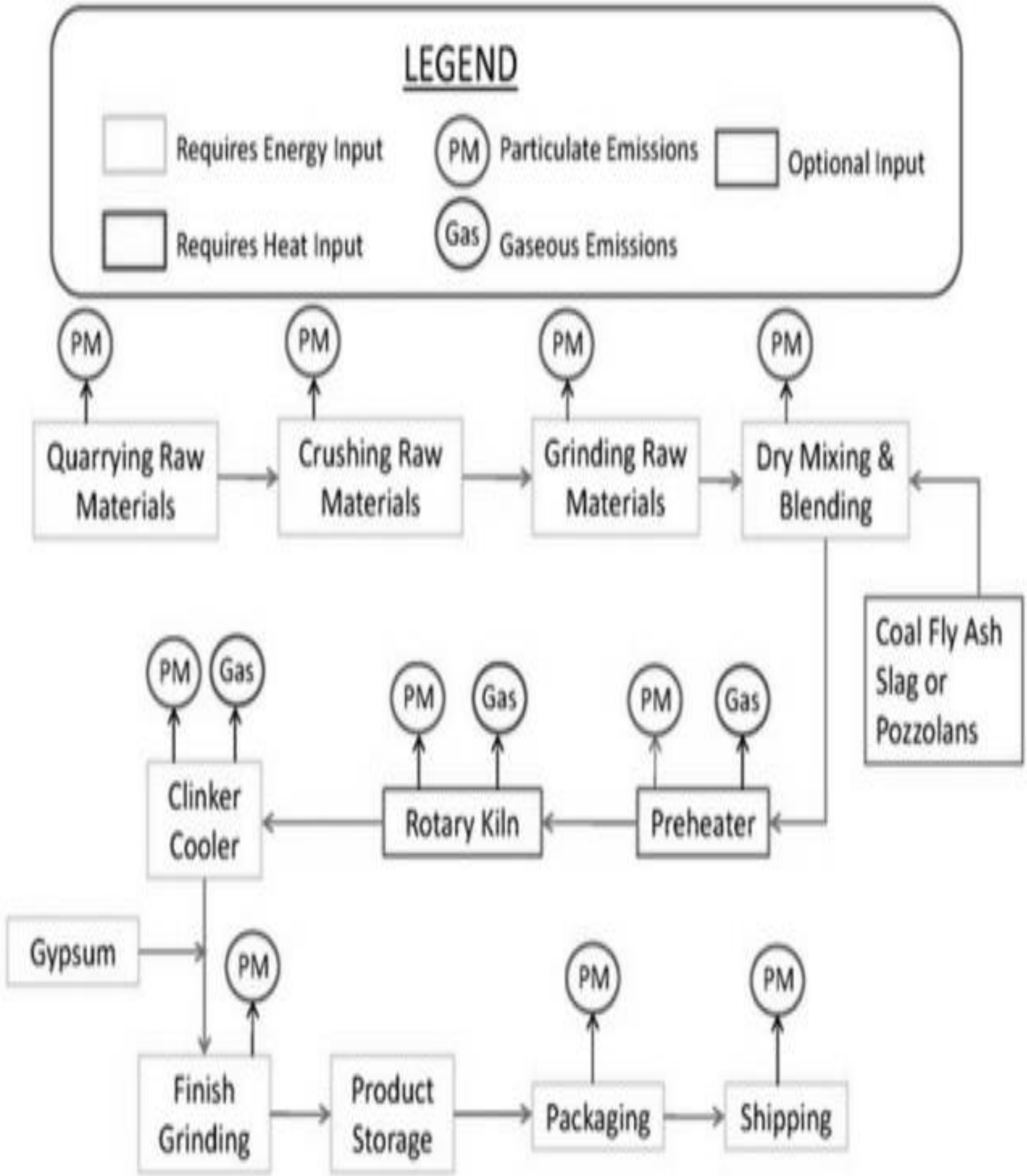

Figure 2.3. Diagrammatic representation of the process flow in the manufacture of cement

(Stajanča and Eštokova, 2012)

Cement manufacturing is a large-scale process involving the use of massive quantities of raw materials, as well as energy. Table 2.1 lists the raw materials consumed on average of the one utilized in cement production in the European Union (Chen et al., 2010).

Table 2.1: Raw materials consumed during cement production (tons) (Chen et al., 2010; Huntzinger and Eatmon, 2009)

Materials (dry basis)	Per ton clinker	Per ton Cement	Per year per Mt Clinker
Limestone, clay, shale, marl, other	1.57	1.27	1568000
Gypsm, anhydrite	-	0.05	61000
Mineral additions	-	0.14	172000

As a solution to the issue faced by the cement industry, of requiring large quantities of materials, a few recent studies have revealed that by utilizing waste as a raw material, this industry can substitute quite a large quantity of raw materials, without affecting the product quality. Most important, the waste employed should non-hazardous to the workers. Also, the incineration of this waste should not emit hazardous or toxic fumes into the environment, and thus affect humans. Therefore, in the cement industry, the use of waste as a substitute to raw materials is highly limited.

The spectra of environmental risks encountered in the cement industry are listed. The intensity of harm depends upon the type of cement factory in question. The most commonly recorded risks faced in this industry, are listed (Chen et al., 2010):

1) Dust exposure: Dust is released or emitted during the grinding process, and particularly from material transportation, as well as when storing and packing the cement. When this excess dust is inhaled, it leads to severe respiratory issues in the workers and those residing near the factory.

2) Electrical hazards: As electrical energy is a vital requirement in the cement industry, in all its processes and particularly in the burning stage, all the electrical parts like cables and control panels pose a grave risk to the workers.

3) Noise exposure: This type of pollution arises during the stage of heavy material transport in the final packaging and marketing stages; however, in the cement plant, the most significant operation that releases excessive noise is the one involving the crushing and grinding process of the raw materials. Besides, noise also occurs during the drilling process. During the drilling operations too, noise is produced.

4) Land and water pollution: This occur during the disposal of the various surplus and polluted materials into the surrounding environment.

Besides, there are other risks, to a secondary degree, when compared with the four risks listed thus far, which include:

5) Falling material: Materials falling from certain heights pose a problem.

6) Hurling of mill parts: Mill parts dropping from the mill platform pose high risk

7) Hazardous thermal load in kiln: Thermal disturbance which influences the surface property.

8) Manual work equipment used: Improper handling of material under poor operating conditions of the equipment pose a threat.

9) Working in confined spaces: The interior work performed based on the clinker production system.

10) Untrained drivers: Drivers with poor training are careless when in the driving position.

11) Inadequate brakes: The possibility of low maintenance levels.
12) Hit by flying rocks: Bodily injury due to flying rock pieces in the course of the blast operations.
13) Storage of explosive: Explosives being exposed to excess pressure.
14) Boulder accidents: Flying rocks and boulder accidents occurring during blasting operations.
15) Accidental fire: Sometimes fire accidents can happen during the process of materials transportation.
16) Conveyor hazards: Conveyor moving parts can cause injury when workers come in contact with them.
17) Mechanical hazards: Harm due to failure of mechanical equipment.
18) During lifting: Lifting equipment involves high risk in the course of material loading.

In fact, according to Carder and Rogan (2003), to overcome such risks in the cement factory, regular checkups and a plan of health safety policy statement are highly recommended. These authors suggest the following recommendations be considered while drawing up the safety policy plan.

i. Put in equipment to ensure personal protection, which is a requisite at every step of the production process.
ii. Prepare a training program to educate the employees, conduct periodic evaluations of the risks, gather the required information, as these are fundamental to the health and safety of the workers.
iii. Organize programs on occupational safety, with the aim of covering health, safety and environmental problems.

2.3 Cement processes and stages

Cement constitutes the basic material in the construction of buildings. The raw materials used in the cement industry include limestone, chalk, shale, clay, and sand. These raw materials are passed through a sequence of complex processes, such as quarrying, crushing, fine grinding, and blending to the correct chemical composition in order to manufacture cement (Devi et al., 2017; Al-Jalaby and Al-Taee, 2009). Once the raw materials are mined, ground and homogenized, they are calcinated and then the resulting calcium oxide is burned at high temperatures with silica, alumina and ferrous oxide to form a clinker; next, the clinker is ground or milled with other constituents like gypsum and slag etc., to produce cement (Karstensen, 2007).

The system under study has been divided into three major processes as seen in Figure 3.2. The first (S1) is the extraction and preparation process of the raw materials in the quarry. Most often, as the quarry is close to the cement plant, transportation of the raw materials is not considered. The second process (S2) involves the clinker production in the cement plant. Here a fine mixing of the raw materials takes place followed by the cement kiln process (Figure 3.2). This burning process has not been described in detail; however, a review of the different kinds of kilns and their relative environmental effects with respect to the energy used is available, for instance in Bastier, (2000); Worrell et al., (2000). In the course of this burning process, the impacts exerted by the fuel production have also been assessed with the exception of the alternative fuels (which have been excluded in the system because they are regarded as waste from the other industries. Transport is considered for both the alternative and primary fuels. The third process (S3) is the actual cement production, which includes grinding of the clinker and mixing it with gypsum (Figure 2.4). For all the processes, the materials required for the construction of the industrial installation are taken into account and divided by the expected lifetime of the cement plant (approximately 50 years, with 340,000 tons of production per year).

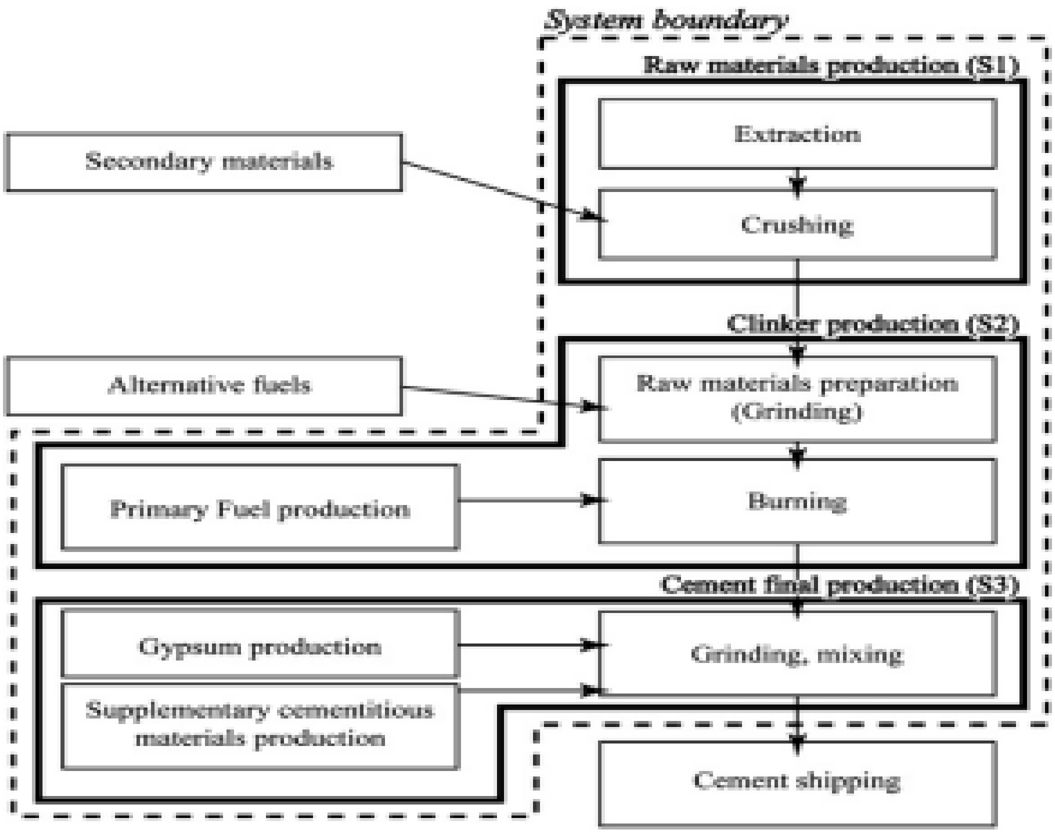

Figure 2.4: Cement production processes (Chen et al., 2010)

Thus, the cement manufacturing process can be distinguished into 10 secondary stages.

- Mining (raw material acquisition): Most of the raw materials utilized are mined and quarried from the earth and can be classified as mentioned: lime, silica, alumina, and iron (Albeanu et al., 2004). As limestone (calcium carbonate – $CaCO_3$) is the most important raw material, most cement plants are located close to a limestone quarry or they source this material using cheap transportation. It is vital for the cement factory to minimize the transportation expenditure because during the pyro-processing one-third of the limestone is converted to carbon dioxide (CO_2) and is subsequently lost. Mining operations include drilling, blasting, excavating, handling, loading, hauling, crushing, screening, stockpiling, and storing.

- Milling in V.R.M.: Raw milling includes a careful mixing of the raw materials extracted to achieve the correct chemical configuration; these are then ground to produce the proper particle size. This will ensure that the cement kiln will have optimal fuel efficiency and the final concrete product will achieve the desired strength.
- Preheating in the pre-heater: Drying and preheating and a part of the calcination process are done outside the kiln, on the moving grates provided with hot kiln gases.
- Burning in the kiln: The raw mixture is then heated until the cement clinkers are formed. These clinkers are hard, grey, spherical nodules with diameters in the range of 0.32 - 5.0 cm and are formed by the chemical reactions (sintering) occurring between the raw materials.
- Cooling in the cooler: The mixed material is cooled before passing on to next steps of the manufacturing procedure.
- Grinding: This stage, also termed finish milling, is where the clinker is finely ground to a powder with other materials (which bestow the unique and desired features to the finished product). The addition of gypsum and/or natural anhydrite help to regulate the setting time of the cement.
- Packing in packers and Dispatch products: Using bucket elevators and conveyors, the finished product is transported to the storage silos. Most of the cement is transported in bags (usually 50 kg bags) to customers in bulk via railway and trucks. The cement is principally utilized in the construction industry, in mortar and concrete.

2.4 Risks from cement factories

The construction industry is recognized as the fastest growing engineering field and presents a platform as well as a challenge to the engineers seek new innovations for building construction. The challenge considers the application of technological advancements in terms of the energy sources with the focus on reducing all the environmental backlashes. It was Albogamy et al., (2013) who reported from the study they performed in the Kingdom of Saudi Arabia, that very shortly, through risk management, a clear plan will be drawn up to tackle the construction industry issues faced in this country. This will also enable the maintenance of the overall framework of the presently ill-managed building engineering system. From this step onwards, risk assessment becomes a very important process in all construction work.

The global boom of cement factories has led to severe environmental impacts and a clear deterioration in the quality of soil and water, and consequently, the occurrence of various diseases in humans and animals. For example, some studies have found harmful effects on the respiratory health of people exposed to cement dust (Al-Neaimi et al., 2001). Furthermore, the prevailing feature is that vegetation cover is almost non-existent near the cement factories (Al-Jalaby and Al-Taee, 2009; Adak et al., 2007).

Although cement industries provide economic benefits and financial returns, they inevitably cause environmental pollution. They rank high among the big environmental pollutants because they are responsible for high levels of air pollution, noise pollution, ground and surface water pollution, as well as vegetative cover loss, resulting from dust pollution. On comparison with other activities, environmental agencies have identified the construction industry including the cement industries as one of the largest producers of environmental pollution. Indeed, the cement industry directly and indirectly, exerts adverse impacts on human health and environmental systems. These impacts include solid and liquid wastes, dust and particulates, harmful gases, and noise. Hence, the reduction and control of these impacts is the critical, through the adoption of environmental impact assessment methodology.

- The assessment of the environmental influence exerted by cement factories reveals three principal impacts, namely: the impacts upon the ecosystems, on natural resources, and on public health (Gangolells et al., 2011; Li et al., 2010). A detailed report on these impacts is listed:
- Ecosystems Impact: Such impacts arise from an accumulation of adverse environmental backlashes like dust, solid and liquid wastes, noise, and hazardous emissions. These impacts largely arise from the construction process and are potential threats to the health and well-being of humans and the ecosystems (Chen et al., 2004). From another perspective, the boom in the rate of construction of new buildings, has had a huge impact on the ecosystems, which has now become a significant issue which cannot be ignored.
- Natural Resources: In the course of the construction process there is a huge consumption of several natural resources, such as energy, land, materials and water (Shen et al., 2005). Further, many operations of the construction-related equipment involve the use of natural resources, like electricity and/or diesel fuel. Generally, the cement industry is recognized as a user of vast quantities of natural resources, generating huge amounts of pollution resulting from the energy consumed in the extraction and transportation of raw materials, as well as during the manufacturing process (Li et al., 2010; Morel et al., 2001).
- Public Impact: As construction projects are frequently observed in thickly populated regions, workers who either live on or near the construction sites face very real risks of deteriorating health, caused by dust inhalation and noise exposure (Li et al., 2010).

Considering another viewpoint, in several studies the authors have discussed the outcomes identified from the relationship between the environmental impact and financial success of an activity. For instance, Horváthová (2010) gave a detailed report on the connection between environmental performance and financial success. This study highlighted the differences between the sectors, companies, and markets that interact within the cement industry. Also, in a survey done by Kiron et al., (2012) it was evident that 67% of the participating company directors agreed that the environment-economy facet is crucial to risk management studies to enable them to stay in the competition today. Besides, in this survey done in this study, 22% of the participating company directors agreed this will be only significant in the future when the environmental aspect tended to be of great importunate.

2.5 Environmental impacts of cement industry

Accurate prediction and thereafter managing the environmental risks encountered in the cement industry are crucial to the enhancement of the internal and external environments of the cement industry. In fact, this complex task is dependent on a variety of factors. Besides, an accurate identification of the environmental risks will result in an improvement of the performance of the processes involved in the manufacture of cement (Gangolells et al., 2011). It was Li et al., (2010) who listed the four major groups of risks in the cement industry, which include:

- Ecosystems Impact: The quantity of accumulated unfavorable environmental impacts such as waste, noise, dust, and hazardous emissions that are generated throughout the construction process severely damage both human beings and ecosystems. As the number of new building constructions escalates, the impact these constructions make is a critical issue.
- Natural Resources: A variety of natural resources like ‘energy’, ‘land', ‘materials’ and ‘water’ are normally employed in the course of a standard construction process. Further, many of the operations of the equipment used in construction consume natural resources, such as electricity and/or diesel fuel. The building industry actually utilizes

large quantities of natural resources and releases large outputs of pollution due to the energy consumed in the course of the raw material extraction and transportation processes.

- Public Impact: As construction projects are most often seen in thickly populated locations, the individuals who reside in or near these construction sites are likely to experience ill effects to their health due to the release of dust, vibrations and noise arising from construction activities, excavation being one of them.

Figure 3.4 reveals the ranking of the performance subcategories of the environment as the environmental impacts through the construction process. The best way to identify which of the environmental risks from among those listed in Figure 3.3 might be released from the factory under study is by applying the questionnaire technique, which is the focus of the current study.

2.6 Previous studies

Authors Kumar and Mishra (2019), have identified ten stages in the cement manufacturing. Generally, from the step of loading the limestone and up to the cement manufacture stage, many risks have taken place that have damaged the environment. Therefore, in this study some of the principal methods have been identified which can facilitate mitigation of the risks involved in the cement industry. First, the parameters related to human health and environmental safety are explained in detail. Besides, all the risks were identified, analyzed, estimated and assessed via qualitative and quantitative means. The findings revealed that the best methodology included proper documentation, recording, and periodic reviews which can ensure proper control of the processes involved in the cement manufacturing industry.

It was Von Bahr et al., (2003) who investigated the variability of the emissions from three kinds of cement factories, namely: dust, nitrogen oxide, and sulfur dioxide. Analysis of the data collected was done, using the monthly emissions from 1993 to 1999, over a 7-year period, from 30 different cement factories. Testing of the data was done against six hypotheses, taking into account the different aspects of the variations in the emission factors. Quality assurance was performed to remove those factors that reduced the comparability. From the results it was clear that the cement processes showed improvement with time. Besides, a wide variability was observed among the cement plants.

In fact, Tamošaitienė and Lapeikytė (2019) showed the that risk identification and its reduction were crucial to the good performance of the construction projects. The pivotal criteria in risk management were highlighted as vital to construction. For the construction industry, the factors of protection and value creation were thoroughly examined. Evaluation of the degree of risk was specifically highlighted and confirmed for the advancement of the enterprises, apart from the quality of the construction projects. Thus, for construction projects, the risk assessment model was confirmed to be effective in raising the profitability of the construction sector.

In fact, Devi et al., (2017) in their review, presented the latest findings of the effects of global warming caused by the cement industry. In their investigation of the cement industry (as it ranks high among the most commonly used building materials and its production is escalating worldwide) they focused on the effects of noise and emission of odors. The results revealed that the most vital parameters considered included, CO_2, NO_X, SO_X, VOCs, and particulate matter. Therefore, in the current study, the environmental risks of these parameters will also be emphasized.

In this study, Sereshki and Saffari (2016), utilized the Folchi method as a crucial tool to assess the environmental effect, to determine the environmental pollution generated by the Shahroud Cement Factory (Iran). Besides, this effective tool also enabled viable solutions to be found that could facilitate the mitigation of the unfavorable effects of environmental pollution produced via this plant. See these two references for further details regarding the Folchi method

(Folchi, 2003; Mirmohammadi et al., 2009). Based on the findings, the pollution generated by the plant, particularly affects the aspects of the air quality, soil, and landscape, and most of all, the environment surrounding the site area. From the findings in this study, the adoption of preventive activities is also indicated to decrease the degree of environmental deterioration.

In his thesis, Andersson (2014) investigated the environmental risks in different manufacturing activities from the perspective of environmental sustainability. The author presented a simulation system of manufacturing risks connected with the economic performance and the environment. The system suggested was subjected to simultaneous analyses from the perspectives of the environment and economics. The methodology developed in this study came from interviews with the practitioners, according to the results of the literature reviews of earlier studies. Besides, developed demonstration software was presented in this thesis, implementing the functionalities. In this thesis, details were discussed on how and when the simulation of manufacturing systems can be employed to evaluate the environmental impact of the manufacturing activities. These results illustrate that simulations of the manufacturing systems can be successful when the necessity arises to assess productivity and environmental assessment or both together.

In their research Ilalokhoin, et al., (2013) performed a crucial study dealing with the evaluation of the environmental impact of a construction cement plant proposed to be built, in a city in Nigeria. On principle, assessment studies on environmental impacts are done to acquire environmental approval, prior to the construction of a plant, wherever it may be. In Nigeria, studies on environmental impact are conducted in accordance to the rules and guidelines of the Federal Environmental Protection Agency. These facilitate a prediction the pollutants and their concentrations at ground level. Using the dispersion modeling technique, a mathematical model equation was developed to predict the gaseous pollutants that are generated when a plant is in operation. Process data were employed which had been monitored from a similar plant, where these data were entered into the developed model, after which the model was simulated to estimate the diffusion of the particulate materials and concentration levels of the carbon dioxide, from the proposed plant. The results thus calculated were compared with the ambient air quality standards of Nigeria and the maximum limits set by the World Health Organization (for 8 hours, on average). As the findings were observed to fall within the permissible limits, the proposed plant was recommended to be established and approval for this study of the cement factories was proposed, to reduce their risks to the environment.

In the study on the effects the cement industry caused to the air quality, Mikulcic et al., (2013) revealed that this industry is one of the greatest contributors of carbon emission in the industrial sector. In fact, this industry accounts for around 5% of the global anthropogenic CO_2 released. Therefore, it is relevant to introduce CO_2 emission regulation strategies for this industrial sector. Considering the significance of the cement industry in Croatia, and as this country will soon gain the status of an EU member state, the analyses of the current paper shows the potential of minimizing the CO_2 emission in the cement industry, in Croatia. Several measures that can be employed to decrease the CO_2 emissions from the cement manufacturing process include the employment of alternative energy sources like waste heat, technologies for the entrapment and storage of the CO_2, lowering the ratio of clinker to cement, usage of alternative and biomass fuels, utilization of alternative raw materials, and adopting an energy efficient combustion process. In the cement manufacturing industry, the best energy efficient technology at present is the combined use of a rotary kiln with a multi-stage preheater and calciner. As cement calciners are a relatively new technology in use today, greater improvement of their operating conditions is required. This paper also emphasizes the findings of the research in the arena of computational fluid dynamics (CFD) simulations being utilized to investigate the process and combustion emissions. The measures listed the influences exerted by the cement manufacturing industry on the environment in Croatia to make it more competitive with the other the EU cement manufacturers.

In their study, Albogamy et al., (2013) revealed seven major risk factors that may likely interfere with the construction activities right from the design stage to implementation and which include: Risk Factors related to the Project, Contractor, Owner, Consultant, Design and External Risk Factors, as depicted in the Figure given below.

Figure 2.5. The critical risk factors affecting the construction processes (Albogamy et al., 2013)

These factors are defined as given below:

- Material is representative of the base from which any project is commenced. Any issues regarding the material quality in a construction project are regarded as vital to its success. Any delay in the delivery or escalation in the prices would pose a grave difficulty to any company because this would imply a decrease in the predicted profit margins.
- Project simply indicates the variety of activities and tasks that are performed in a specific sequence to build or renovate a building, structure or infrastructure. Any productivity issues related to manpower or equipment will pose a huge problem to the companies, as these will have a direct effect on the profits obtained overall.
- Contractor is the term used to describe an individual or firm, who or which is responsible for giving independent and professional services, while supplying the required materials in certain cases. Any issues regarding the qualifications of the contractor engineers or technical staff is significant and could actually be responsible for a project to fail.
- Owner in construction refers to the individual or firm who or which takes the initiative for a project and is responsible for its financing. Generally, the services of third-parties are contracted to accomplish the design and construction of the project. Any delay by the owner in decision-making will be considered a lost opportunity and, therefore, a loss in profits.
- Consultant implies the individual or entity who or which is the mediator between the contractor and owner, and whose role is to settle any differences of conflicts. Besides, it facilitates the proper planning by the owner for the projects coming up, always being conscious of staying within the budget. Any issues regarding the qualifications of the consultant staff will end up in disastrous consequences that will adversely affect the project and lower its success.

- Design includes the process of metamorphosing a small idea into reality. Here the design team applies its professional skills to bring the company's desires to fruition, all the while being careful not to overstep any budget limits.
- Apart from the risk factors mentioned above, External involves all the other factors that could hamper the construction project. Any unfavorable conditions prevailing in the environment (weather or regulations) surrounding a project are expected to exert a negative impact and have huge implications for the project, with respect to its financial success and profitability.

In the study done by Zolfagharian et al., (2012) on risk management in the construction industry in Malaysia, a structured interview was performed using an expert panel group. The experience of these many experts enabled the assessment of the intensity the environmental impacts exerted upon the environment, due to the various processes in construction. This study highlighted their findings listing the principal risks from the construction industry, namely, noise pollution and dust production. The source of both these risks is transportation. Besides, machinery is also responsible for causing environmental risks. The findings from this study enable the construction managers and other participants in construction sites to have a heightened awareness of the construction processes and their harmful influences upon the environmental systems.

In their study, Chen et al., (2010) explored the degree of impact the cement production had upon the environment and the variations of this impact among the different cement manufacturing units within the same factory. Therefore, the authors performed a Life-Cycle Impact Assessment (LCA) study. First, the processes involved in the cement manufacture are examined in detail, to record the respective preparation process of the raw materials and clinker yield. Besides, using the LCA method, the impacts each unit exerted upon the environment were identified. On analyzing this study, it was evident that global warming, abiotic depletion, marine eco-toxicity, and acidification are the main impacts that arise due to the whole cement processing. Finally, from the results it was clear that for the LCA method which are under the control of the kiln emissions, only two parameters, namely, photochemical oxidation and global warming, reveal 20-30% variations among the cement units. For the parameters of terrestrial ecotoxicity, acidification and eutrophication, around 40% variation was observed. This was possibly caused by the paucity of accurate measurements of the annual flow and pollutant content.

The study by Al Smadi et al., (2009), was conducted to predict the air pollutant emissions (dust, NOx, SO_2, and CO) released from a cement factory that is yet to be constructed in the Wadi Al Abyad area, around 100 km south of Amman, Jordan. Using the Gaussian air pollution model, the levels of the air pollutants predicted are compared with the air quality standards of Jordan (JS 1140/2006). An annual data analysis was conducted to assess the effects of the metrological cases. The findings showed that September appears to have experienced the worst situation, where the stability of the atmospheric condition is categorized as A with wind speed on average being 1.7 m/s. The hourly predictions of SO_2 and the 24-hour levels - when fuel oil is utilized - achieved concentrations of 0.8 ppm and 0.42 ppm, at about 750 m distance from the plant. However, this value crosses the standard values of 0.3 ppm and 0.14 ppm. When natural gas is the energy source, the predicted SO_2 concentration is to be insignificant. While the hourly NOx concentration is 0.32 ppm, at 750 m distance from the plant, once again it is in excess of 0.21 ppm, which is the standard limit. It was expected that the maximum TSP 24-hour concentration would touch 359.61 μg/m3, going beyond the standard value of 260 μg/m3. Thus, the TSP, PM10 and PM2.5 levels were above the standard values set for the area surrounding the cement plant, at a distance below 300 m. The steps proposed to mitigate these levels, should restrict the ambient air pollutant concentrations so as to comply with the standard values.

Ayad and Taee (2009) studied the problem of pollution has become one of the global issues that should be encountered. The economic activity in certain sector as industrial sector may produce certain goods and services against supplying and providing certain kinds of pollution. Pollution can be looked at as productive goods as well as producing other sorts of goods. But, these kinds of goods differ from producing other goods as they yield other negative internal and external effects. One of these productive industries is cement industry. The study has been conducted on Kirkuk Cement Factory that the dust and sand sprayed over and the aggravation of solid debris have become a large scale threat of the current generation, the waste quantities product exceed their standards particularly with production decreases. It is expected that the future production while the decrease with an increasing of dust sprays and solid debris. Additionally, the lack of studies and researches in the field of the environmental pollution of industry in general and cement industry in specific had led to the effects environment and the inefficiency in applying environmental standards. The study concluded a group ignorance economic and environmental pollution.

2.7 Summary of chapter two

1. As has been discussed in this chapter, environmental risk management study is an essential process that should be applied in order to assess the possible impacts of cement factories.

2. Despite risk management being applied in different industrial sectors in Iraq, the environmental risks management study for cement factories in this country have not been adequately investigated.
3. In the field of risk management, a gap has found between many studies involved this topic in the construction industry in the world and in Iraq.
4. However, the researcher think that this work will be the first in the studying of risk management of cement factories in Iraq

Chapter Three: Methodology and Case Study

3.1 Introduction

As mentioned earlier in Chapter Two, the detrimental effects must be identified to control and minimize the effects of pollution caused by the cement industries. This chapter, therefore, presents a comprehensive overview and describes stepwise the methodology used in this thesis. It is also graphically represented as a flow chart, as depicted in Figure (3.1). Besides, the principal risks arising from the cement industry are also discussed, and finally the management of the potential environmental risk is explained. Several studies were cited and generally the environmental risks from the cement industry are listed based on their case studies. From another perspective, a large percentage of the environmental impacts coming from the cement industry are linked to human health and climate change or air quality. In the current study, the focus will be trained on the effects exerted by the cement industry on both humans and the environment around it. Other parameters including the physical and aquatic environments too will be investigated depending on the data collected.

3.2 Methodology stages

The methodology of this research was achieved by directing the research through the phases listed:

- Phase one: Review the literature pertinent to the subject of this study in terms of the management and assessment of environmental risks.
- Phase Two: Identify the possible risks encountered in cement industries.
- Phase Three: Propose a methodology relevant to cement industry management to minimize the risks in such an industry.
- Phase Four: Present the major findings from the data analyzed, inferring conclusions from these results and suggesting recommendations for related studies in the future.

In order to achieve these four stages the following steps are done (Figure 3.1):

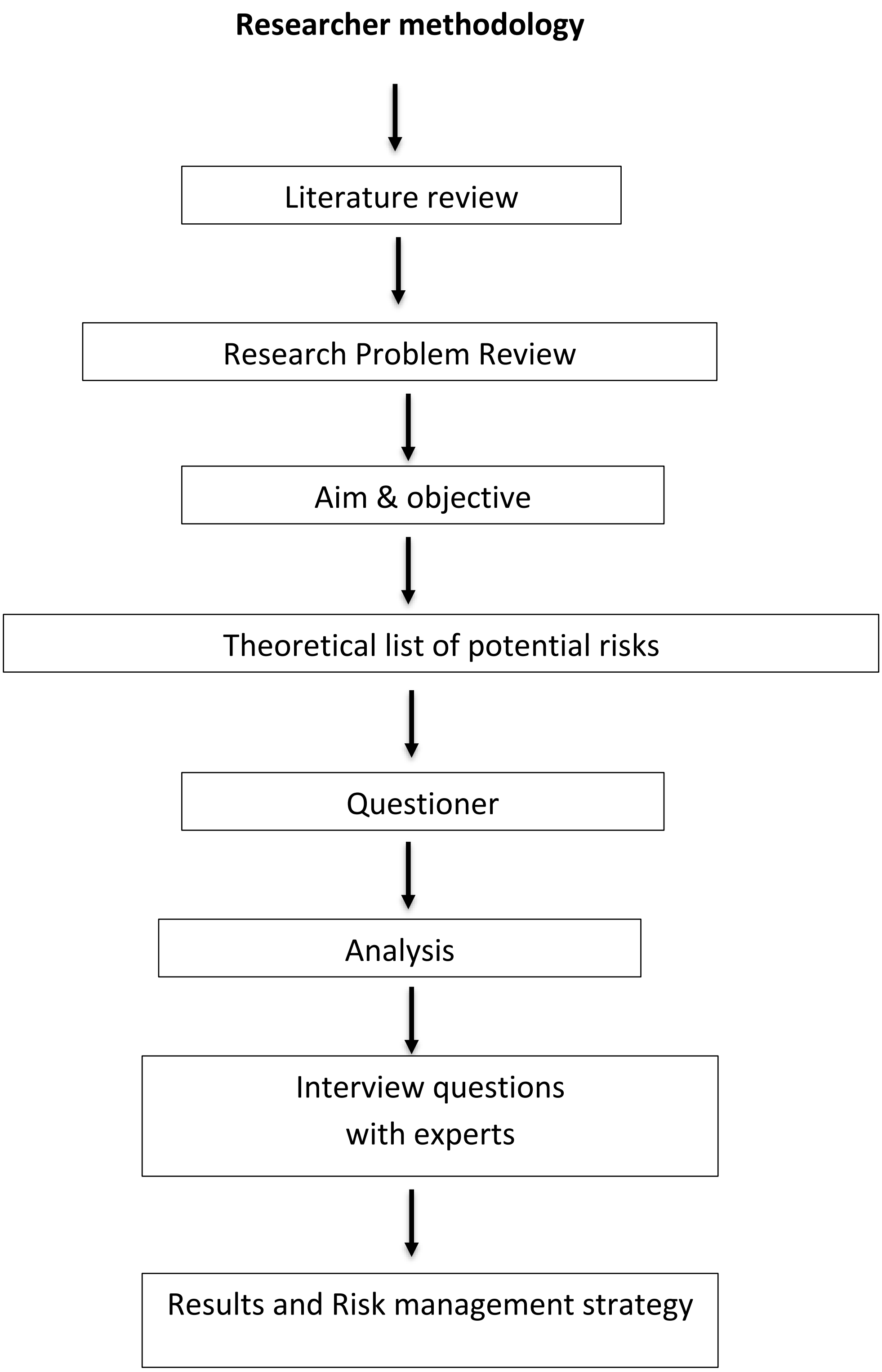

Figure 3.1: A flow chart of the methodology of this study (by researcher)

3.3 Investigation the risks in cement factories

Several risks and hazards are encountered right from the mining of the raw material to the dispatching of the cement products, which harm the environment. Such environmental risks may fall under two classes, namely the external and internal factors (see Figure 3.2).

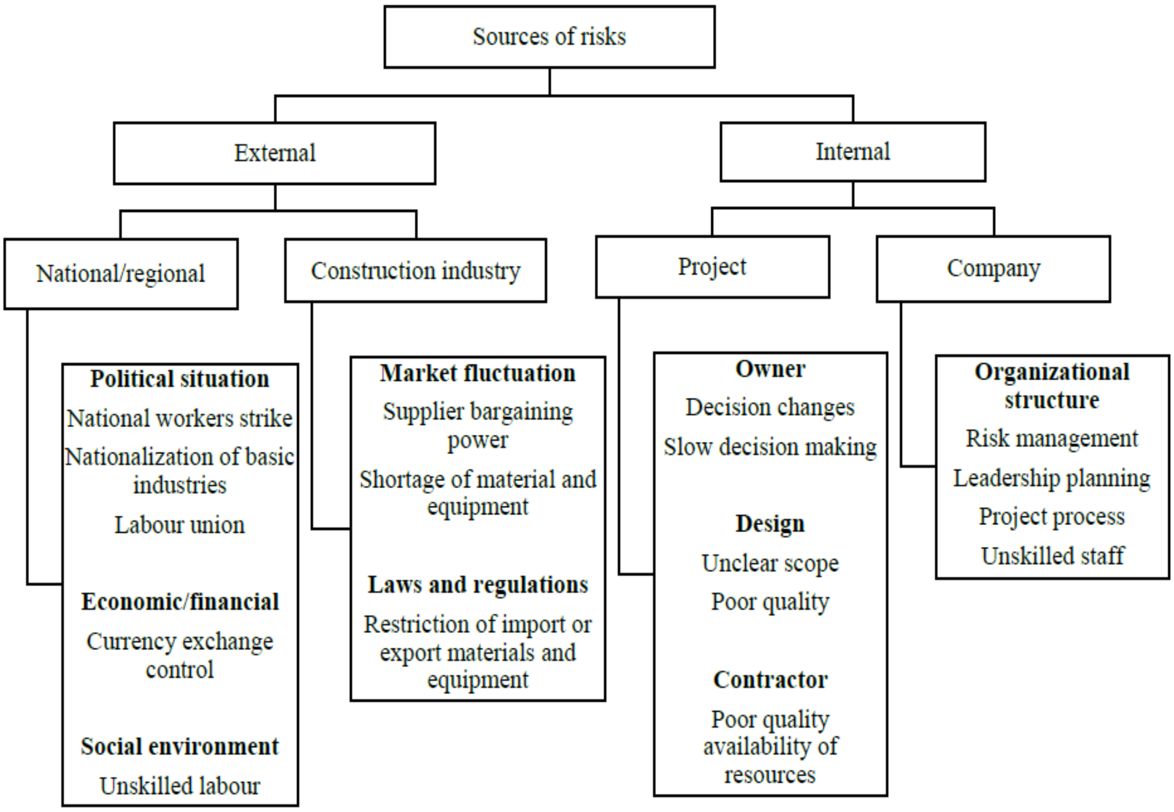

Figure 3.2. Sources of risks and their possible effects (Chen et al., 2010)

From this perspective, the assessment of the environmental impacts caused by the cement factory is crucial to a clear understanding of the total risks that could be generated from the cement industry. Indeed, the cement industry is so energy intensive that around 40 % of operational costs account for energy i.e., while this excludes the capital costs, it includes the electricity costs. Normally, in Iraq, crude oil as well as waste fuels are the primary fuels used. The use of such fuel types caused the emissions of a variety of gases detrimental to both human health and the environment. Chen et al., (2010) demonstrated that at present close scrutiny is being done of the cement manufacturing industry, as huge volumes of CO_2 emissions are being released. According to these researchers, the cement industry sector is responsible for the release of approximately 5 to 7% of the total anthropogenic CO_2.

Another perspective highlights the rather large quantities of liquid and solid wastes released during different processes in the cement industry. This occurs because cement production involves the use of raw materials, energy, and heat in huge amounts. Cement manufacturing is a very complex process, which uses a large variety of materials (of different material properties), processing methods (e.g., wet and dry kilns, preheating, recirculation), and fuel sources (e.g., coal, fuel oil, natural gas, tires, hazardous wastes, petroleum coke), and gas and oil (heavy, medium or light fuel oil). Besides using the traditional types of fossil fuels, large volumes of waste fuels are also used in the cement industry. Frequently, these wastes which are rejected release harmful emissions into the surrounding environment, causing innumerable unfavorable effects.

It was Mahendra et al., (2013) who identified four major risks generally arising from the construction industries, which include:

i) Technical risks - these include incomplete design, insufficient specification, infrequent site investigation, alterations in the scope, construction processes and inadequate availability of resources.

ii) Construction risks - these include labor productivity, labor disputes, conditions at the site, equipment breakdowns, design alterations, high standards of quality and slower technology.

iii) Physical risks - these include structural damages, equipment damage, labor-related injury, material, fire and theft.

iv) Organizational risks - these include issues with contractual relations, contractor experience, participant attitudes, inexperienced work force and low degree of communication.

All of these risks are encountered in any construction project; therefore, they need to be reduced right from their sources to avoid expenditure and time overrun.

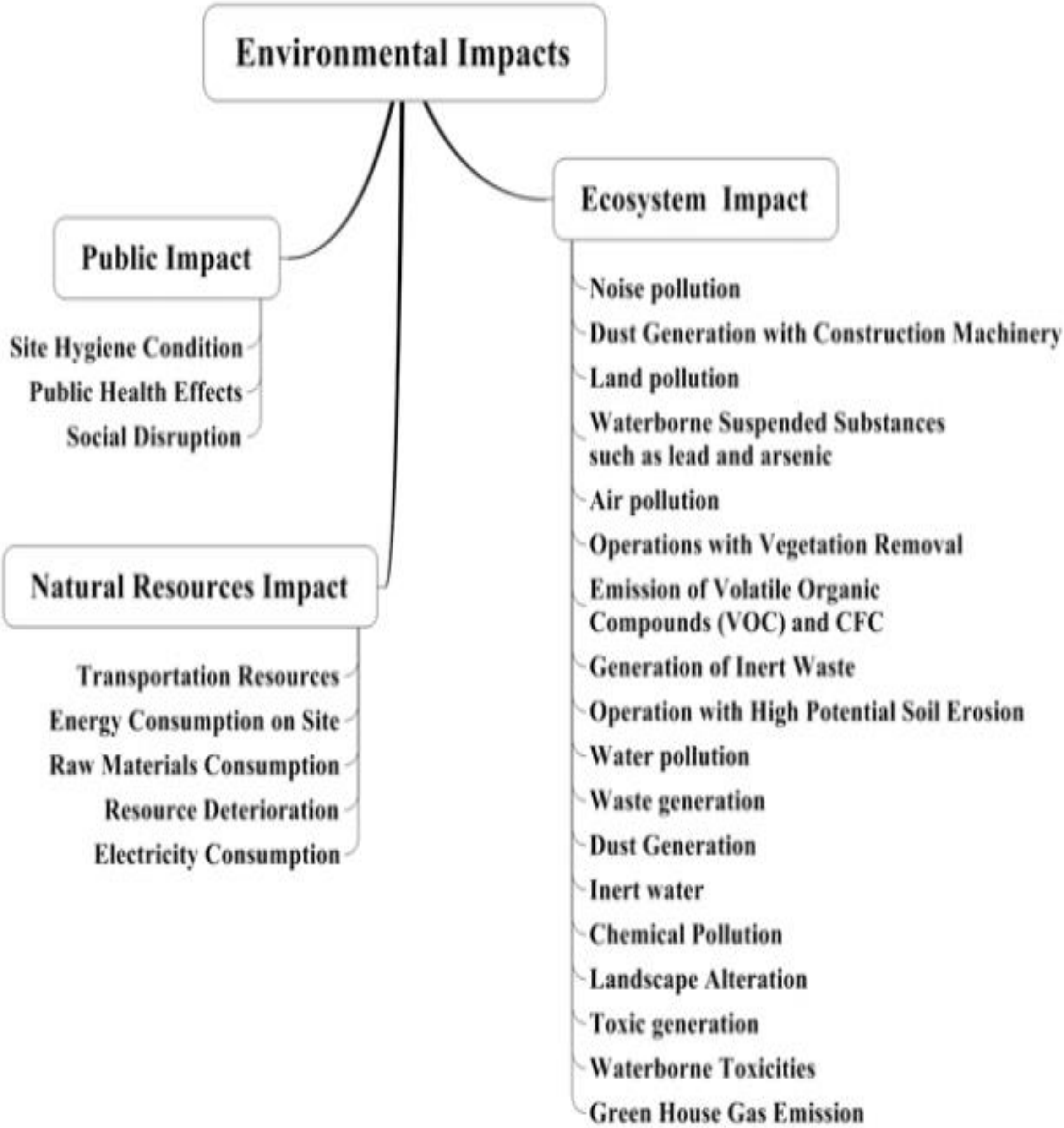

Figure 3.3. Environmental impacts of cement industry (Devi et al., 2017; Dosumu, 2018)

3.4 Questionnaire

Construction industries, the cement industry, in particular, are categorized as hazardous, complex, and a huge source of pollution (Huang et al., 2017). Therefore, the risks due to this process are dependent upon the uncertainties and their potential results, for which several studies have principally sought to reduce both these parameters (DALL, 2010; Bednekoff, 1996). This implies, that any estimation of the rate of environmental impact is dependent upon the likelihood of an event taking place and the severity of its effect on the environment. In fact, probability/likelihood or frequency is explained as the possibility of the potential of the activities involved in construction being realized, and triggering a series of effects that could end up causing environmental damage. The intensity of the results is expressed as the degree of damage that could be a consequence arising from an environmental impact.

For risk identification, a structured interview with an expert panel group in three cement factories in Iraq was conducted, in the present study. Experts connected with the cement industry and the environmental impacts were called upon to reveal the effects the cement industry had upon the environment, in terms of frequency and severity. The interview thus included two major divisions; Section A included the background and general information of the respondents, while Section B was open to the respondents to estimate the frequency and severity of the environmental impacts on a five-point Likert Scale (Figure 3.4).

Scale	Severity	Description	Frequency
1	Insignificant	Minimal impact	Never
2	Minor	Short-term impact	Unlikely
3	Moderate	Significant impact	Possible
4	Major	Major short-term impact	Likely
5	Catastrophic	Major long-term impact	Always

Figure 3.4. Likert Scale used to Determine the Levels of Frequency and Severity (Kumar and Mishra, 2019)

This study therefore, performed a structured interview on an expert panel group which included 15 working professionals to examine the frequency and severity of the environmental impacts across the cement factory constructions, in Iraq. The two principal sections in the interview were Section A which dealt with the background and general knowledge of the respondents, while Section B included the rate of the frequency and severity of the environmental impacts estimated by the respondents on a five-point Likert Scale (Figure 3.5).

Therefore, cement industry-induced risks can be evaluated and shown, through matrices, by either qualitatively assessing the probabilities and consequences or by using quantitative values (Ayyub, 2003). A risk matrix is utilized to list the various risks, ranked in order of significance (Jeong et al., 2010). A risk matrix is a Table showing many categories of probability, frequency or likelihood in the rows (or columns) and other categories of severity, consequences, or impact in the columns (or rows) as depicted in Figure 3.5 (Cox, 2008).

Level of Consequence	Description
1	Insignificant
2	Minor
3	Moderate
4	Major
5	Catastrophic

×

Level of Frequency	Description
1	Never
2	Unlikely
3	Possible
4	Likely
5	Always

=

Probability					
5	5	10	15	20	25
4	4	8	12	16	20
3	3	6	9	12	15
2	2	4	6	8	10
1	1	2	3	4	5
Consequence	1	2	3	4	5

Figure 3.5. Shows the matrix of risk that is used to rank the various risks in the order of importance (Jeong et al., 2010; Kumar and Mishra (2019)).

In Figure 3.6, the outcome matrix is shown to identify the likely degree of environmental impact for each common environmental effect in the cement industry examined in the case study. The significant rating of a risk (expected loss) is calculated as given (Modarres, 2006):

$$R = F \times S \qquad (3.1)$$

where R is the significance rating of the degree of environmental risk for a specific activity; F refers to the frequency of occurrence, in the range of 1 to 5, where '1' implies the least frequency and '5' is the greatest frequency; and S represents the severity of the impacts on the environment, in the 1 to 5 range, where '1' indicates not severe and '5' denotes extremely severe.

The design of the questionnaire was aimed at abiding by decisions. The style of answering the questionnaire or how the respondents were expected to answer the questionnaire was a big point of debate, which is normal when designing it. One of the objectives to the questionnaire used in this study was it needed be fast and easy to complete. This was an essential prerequisite because there were several questions, and also the fact that the field of risk management is very broad. The objective, therefore, was to enable the respondents to respond efficiently, as well as quickly to all the questions. The questionnaire applied is shown in Appendix (A).

3.5 Sampling

There were around 71 engineers and workers, in the three cement factories (refer case study Section 3.6). Thus, the equation given below was used to calculate the sample size (McClave et al., 2014):

$$n = \frac{N \times p \times (1-p)}{(N-1) \times \frac{d^2}{z^2} + p \times (1-p)} \qquad (3.2)$$

Where: n is the sample size; N is the population size; Z is the standard score corresponding to confidence level; d is the standard error of the sample distribution; p is the estimated value of the population proportion.

The estimated value of population proportion, based on McClave et al., (2014) in case of unknown value, p will be = 0.5. the confidence level was chosen to be 95%, thus Z = 1.96. In this context, the standard error (d) has a value of 0.05, where this parameter is estimated with an acceptable sampling error range from 5 to 10%. In addition, the population taken in this study =71. By substituting values in the above equation, the acceptable sample number will be ≈ 60 as shown below.

$$\mathrm{n} = \frac{71\times0.5\times0.5}{70\times\frac{0.05^2}{1.96^2}+0.5\times0.5} = 60.056 \approx 60 \text{ Minimum Samples Required}$$

In this study, the random sampling method was used to select the samples and the data required were gathered via a questionnaire template given to the participants either through direct contact or electronically sent as email. The scope of our sample included different cement industries, of the first class, second class and third class, in Iraq. This gave a practical environment in which a systematic evaluation of the degree of risk management implementation could be done. Individuals possessing different levels of knowledge were given the questionnaire, in all the three cement factories, in Iraq. Samples were drawn from Chief Executive Officers, consultants, engineers, and workers (see Figure 3.6). Normally, around 60 samples were collected from these experts (20 samples from each factory). Besides, 30 random samples (10 samples for each factory) were gathered from those residing in the areas surrounding each factory being considered in the current study. Hence, the number of samples collected in total were 90. However, several samples (<3%) were rejected as the questionnaire either had not been answered or had not been properly filled in. Once the answered questionnaires were gathered, the data collected were analyzed. The analysis of the questionnaire responses was done by employing a Microsoft Excel template developed by the researcher to quantify the weights of the risk factors under consideration, based on expert opinion using the matrix of risk as shown in Figure 3.6.

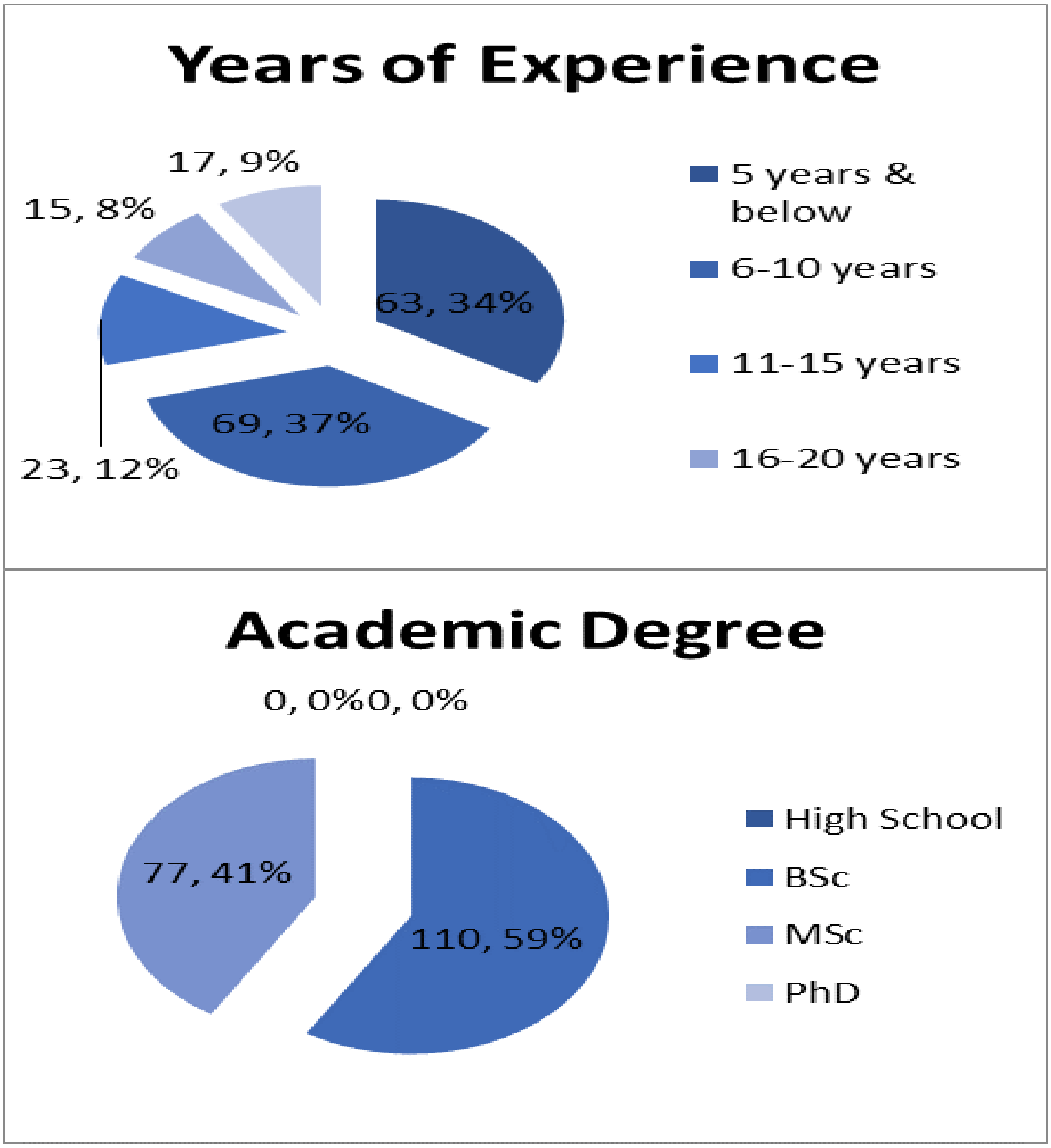

Figure 3.6. Sample by Years of Experience and academic degree (by researcher)

3.6 Summary of chapter three

From what was presented above, Chapter Three explains the methodology for this study, which can be summarized in Figure (3.7).

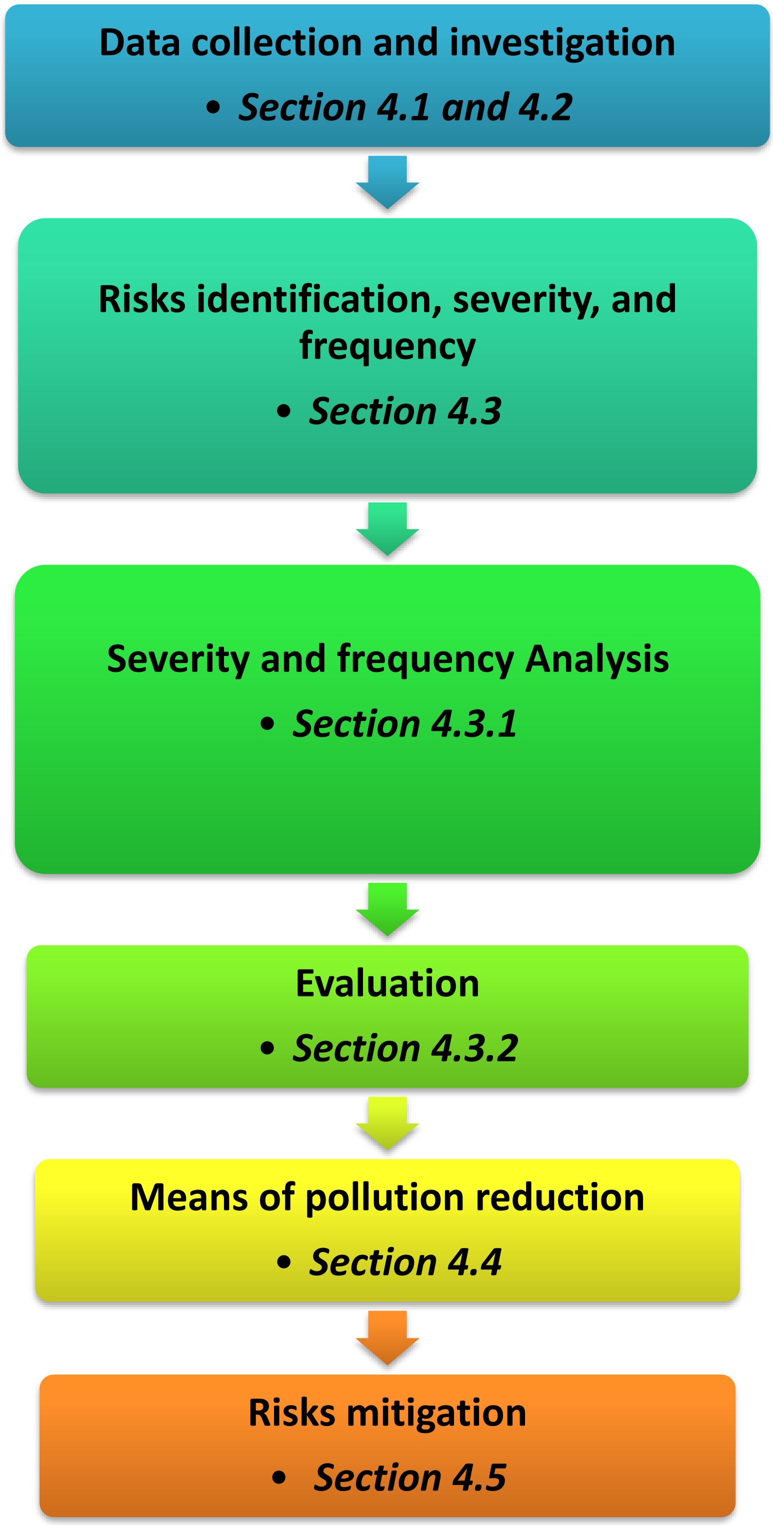

Figure 3.7. Road map of risks analysis and mitigation adopted in this study

Chapter Four: Results and Discussion

4.1 Risks highlighted from cement factories

In this chapter the findings presented were acquired through the questionnaire method on risk assessment in cement factories. In Iraq, the principal risks observed in the cement factories were underscored according to the data gathered (preliminary interviews with experts). The degree to which these risks affected the factory were studied using the questionnaire technique. Then, employing the excel software, an analysis was done of the data collected. Besides, the crucial techniques or procedures which can be implemented to lower the level of risk are also described here.

The first step taken in this research was to identify the environmental risks likely to arise from the process of cement production. To accomplish this, the researcher conducted an preliminary analysis to collect the necessary data regarding the dominant and prevailing risks. This information was gathered from sources like personal contacts, earlier reports, and visual observation. In the initial step, widespread environmental risks were identified. In fact, one environmental risk was recognized as noteworthy for a specific cement factory if overall, there was a repetition of its significance rating by a minimum of 5 experts. Therefore, a few environmental risks have been discussed in this study based on the response of the experts, while the other risks were ignored. The environmental risks thus related to each cement factory in the study were then noted, as shown in Table 4.1. Indeed, the data given in Table 4.1 is very significant in assessing the overall risks collected from the cement factories in Iraq. It is noteworthy that the part played by each risk in its effect on the environment was investigated based on a survey of the literature.

Table 4.1: Major risks types identified from three cement factories

	Type of risk	Effects	Reference
1	Air Pollution	Some of the most crucial impacts caused by the cement manufacturing processes are dust, SO_X, NO_X, and CO gases which are released into the atmosphere as well as due to transport, storage, milling, packing and other related activities.	Al Smadi et al., (2009)
2	Exposure to Noise	When drilling is in process, noise and vibrating surfaces affect the production operations	Kumar and Mishra (2019)
3	Electrical Hazards and consumption	Electrical parts like cables, and at times the possibility of shocks and vibrations	Kumar and Mishra (2019)
4	Land Pollution	Erosion is an important issue in the construction stage as well as during the operational one, where the safety of the slopes necessitates attention. Suitable preventive and protection steps must be provided during the course of construction.	Dosumu (2018)
5	Generation of solid and hazardous wastes	• Suitable materials for the hazardous waste fuel/waste-derived fuels program. • The principal source of pollution produced by the cement industry	El Haggar (2005)

		is cement by-pass dust, the solid waste which collected from the dust filter bottom.	
6	Water Resources pollution	High levels of pH, nitrate, phosphate, total solid, total suspended solids, total dissolved solids, turbidity and biological oxygen demand were found downstream, due to the cement effluent influx.	Ipeaiyeda and Baje, (2017)
7	Greenhouse gas emission	The cement industry accounts for roughly 5% of the anthropogenic carbon dioxide emissions, on a global scale.	Mahasenan et al., (2003)
8	Public health effect	From this perspective, human health plays a vital part in the investigations of cement production because the cement industry exerts direct and indirect effects on human health, particularly in the industrial cities, as they release huge quantities of respiratory organic and inorganic pollutants through the overall course of the cement production.	Morsali, (2017)

4.2 Data analysis, validity and reliability study

In the present study, before starting the process of analyzing the results a validity and reliability study was applied on the obtained questionnaire data. In this context, Cronbach's alpha and Pearson correlation coefficient was used as an efficient tool for measuring validity of questionnaire data (Saunders, 2011). Tables (4.2) and (4.3) show the validity and reliability of the questionnaire related to this thesis, by calculating Pearson correlation and Cronbach's alpha Coefficients using SPSS. Pearson correlation represents the validity of each type of risk that has been adopted in this thesis. Obtained value from SPSS must be greater than the critical value that equals to (0.3061) in Pearson correlation coefficients (Table 4.4).

Table 4.2: Cronbach's alpha and Pearson correlation coefficients (Severity) (Saunders, 2011)

#	Type of Risk	Pearson Correlation	Cronbach's Alpha
1	Air Pollution	0.571	0.852
2	Exposure to Noise	0.718	0.808
3	Electrical Hazard and Consumption	0.546	0.850
4	Land Pollution	0.374	0.865
5	Generation of solid and hazardous wastes	0.388	0.877
6	Water Resources pollution	0.161	0.880
7	Greenhouse gas emission	0.344	0.863
8	Public health effect	0.355	0.800

Table 4.3: Cronbach's Alpha and Pearson Correlation Coefficients (Frequency) (Saunders, 2011)

#	Type of Risk	Pearson Correlation	Cronbach's Alpha
1	Air Pollution	0.532	0.842
2	Exposure to Noise	0.683	0.831
3	Electrical Hazard and Consumption	0.600	0.800
4	Land Pollution	0.367	0.871
5	Generation of solid and hazardous wastes	0.451	0.886
6	Water Resources pollution	0.321	0.890
7	Greenhouse gas emission	0.358	0.810
8	Public health effect	0.377	0.809

Critical value calculation will be shown below:

- Degree of freedom (d.f) = Sample size – 2
- Population Proportion = 0.05
- One tail

By matching all numbers that have been mentioned, the critical value has been obtained. The results were found all types of risk are valid except (water resource pollution) in severity case. Also, the Cronbach's alpha coefficients represent the reliability that obtained must be in the range of values. By calculating the average of each case, severity was found (0.849), and frequency was found (0.842). Thus, the reliability level is determined to be in a good range.

Table 4.4: Cronbach's Alpha Limits

Cronbach's Alpha Limits	Status
0.00 – 0.69	Poor
0.70 – 0.79	Acceptable
0.80 – 0.89	Good
0.90 – 0.99	Excellent

After the risks were identified, data on their frequency and severity were drawn from the analysis of the findings from the questionnaire, as depicted in the section on methodology in Chapter 3. In Tables 4.5–4.7 the list of the mean and standard deviation values of the data were collected for each factory.

Table 4.5: Values of the mean and standard deviations of the data on the severity and frequency of risks in the Al-Faluja factory (sample size = 20)

Type of risk	Minimum level	Maximum level	Severity		Frequency	
			Mean	Standard Deviation	Mean	Standard Deviation
Air Pollution	1	5	4.200	0.748	4.10	0.70
Exposure to Noise	1	5	3.200	1.470	3.20	1.40
Electrical Hazards and consumption	1	5	2.400	0.663	2.70	1.00
Land Pollution	1	5	2.200	0.872	1.90	0.83
Generation of solid and hazardous wastes	1	5	2.100	0.943	2.20	0.87
Water Resources pollution	1	5	1.300	0.458	2.20	1.08
Greenhouse gas emission	1	5	2.300	1.005	2.60	1.20
Public health effect	1	5	1.800	0.600	1.80	0.40

Table 4.6: Values of the mean and standard deviations of the data on severity and frequency of risks in the Al-Kubaisa factory (sample size = 20)

Type of risk			Severity	Frequency

	Minimum level	Maximum level	Mean	Standard Deviation	Mean	Standard Deviation
Air Pollution	1	5	3.800	0.600	4.000	0.632
Exposure to Noise	1	5	3.700	1.269	3.800	1.166
Electrical Hazards and consumption	1	5	2.900	0.943	3.300	0.900
Land Pollution	1	5	2.600	1.200	2.800	1.327
Generation of solid and hazardous wastes	1	5	2.200	0.748	2.700	0.781
Water Resources pollution	1	5	2.100	1.136	2.600	1.114
Greenhouse gas emission	1	5	2.300	0.900	2.200	0.872
Public health effect	1	5	2.000	0.894	1.800	0.872

Table 4.7: Values of mean and standard deviation of severity and frequency data of Al-Qaim factory (sample size = 20)

Type of risk	Minimum level	Maximum level	Severity		Frequency	
			Mean	Standard Deviation	Mean	Standard Deviation
Air Pollution	1	5	3.900	0.700	3.300	1.269
Exposure to Noise	1	5	3.700	1.269	3.100	1.300
Electrical Hazards and consumption	1	5	2.900	0.943	3.000	0.894
Land Pollution	1	5	2.600	1.200	2.900	1.044
Generation of solid and hazardous wastes	1	5	2.200	0.748	2.000	0.447
Water Resources pollution	1	5	2.100	1.136	2.100	1.136
Greenhouse gas emission	1	5	2.200	0.980	2.400	0.917
Public health effect	1	5	2.000	0.894	2.200	1.327

4.3 Results

4.3.1 Severity and frequency

Figures 4.1-4.6 list the average values of the data collected regarding the severity and frequency of risks for each cement factory.

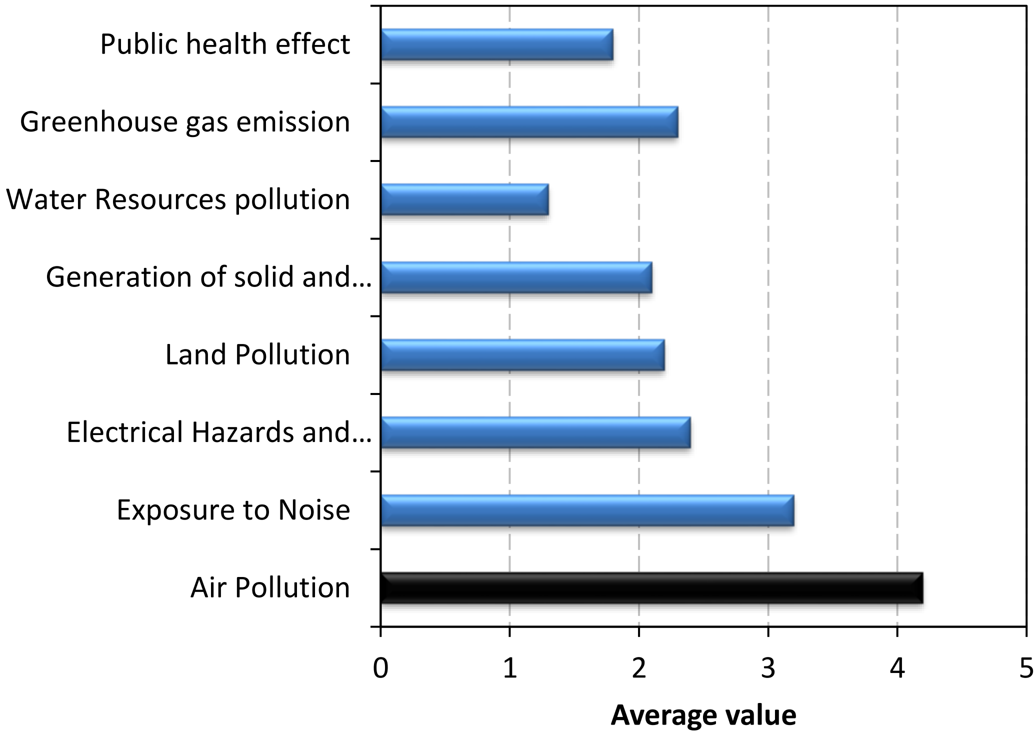

Figure 4.1: Average values of the collected data of the risk severity in the Al-Faluja factory

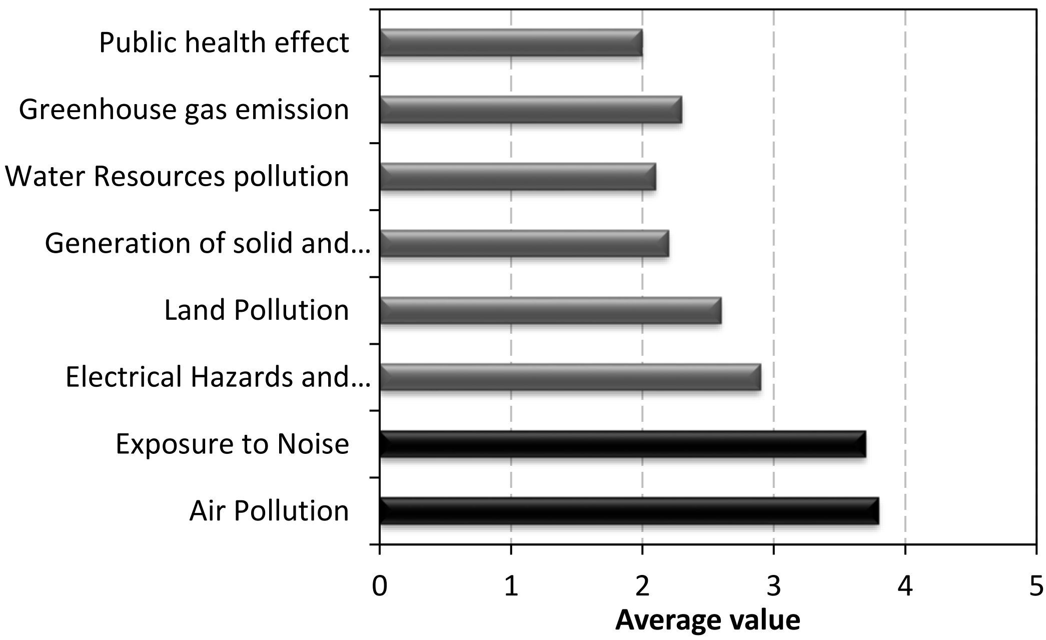

Figure 4.2: Average values of the collected data of the risk severity in the Al-Kubaisa factory

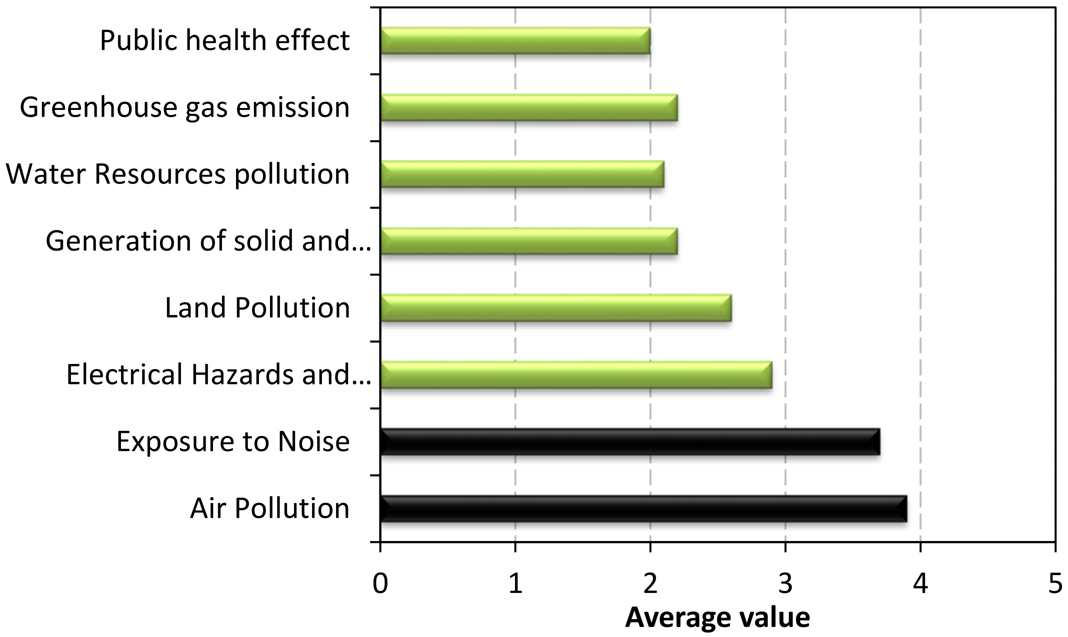

Figure 4.3: Average values of the collected data of the risk severity of the Al-Qaim factory

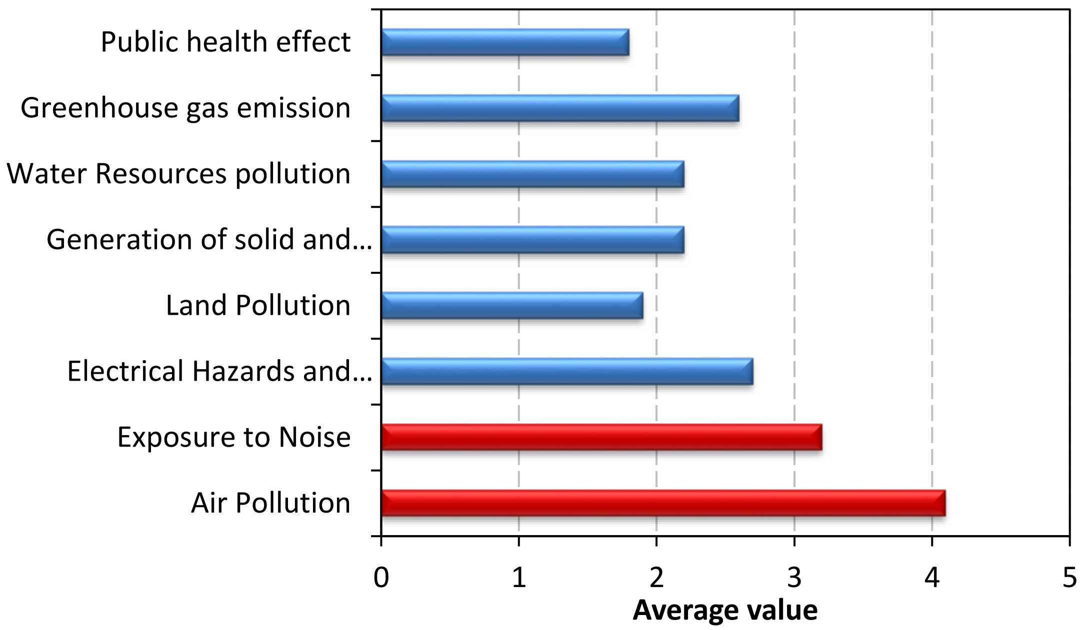

Figure 4.4: Average values of the collected data of the risk frequency of the Al-Faluja factory

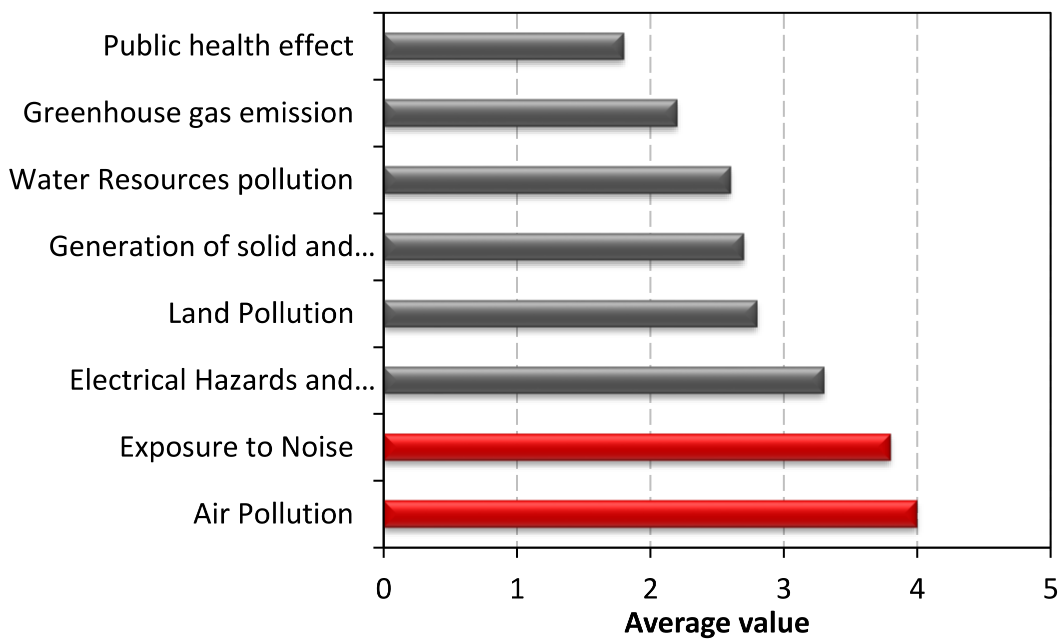

Figure 4.5: Average values of the collected data of the risk frequency of the Al-Kubaisa factory

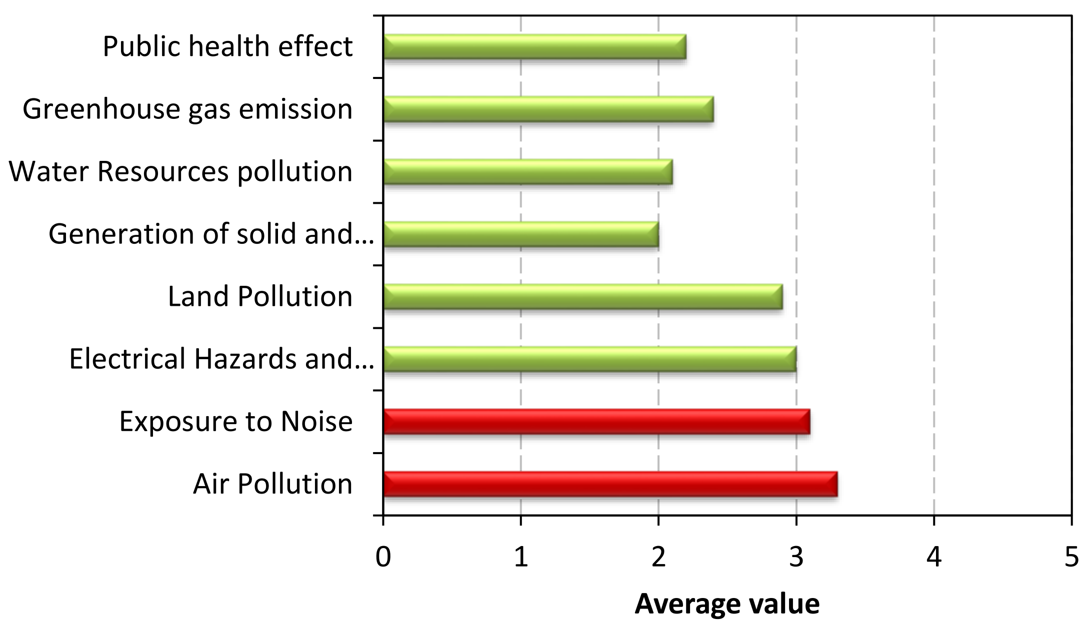

Figure 4.6: Average values of the collected data of the risk frequency of the Al-Qaim factory

4.3.2 Estimation of risk

This section aims at developing the risk matrix, by which the severity of each risk is multiplied by its frequency value, according to each respondent. Later, all the risks are categorized, based on Figure 1.1 'Estimation of Risks'. In Table 4.8, the values of the risk ranges adopted in this study are listed.

Table 4.8: The values of the risk ranges adopted in this study (Gangolells et al., 2009; Gangolells et al., 2011)

Range of determined risks' values	Strength	Identification color
From 1 to ≤8	Low (L)	Green
From >8 to ≤16	Medium (M)	Yellow
From <16 to ≤25	High (H)	Red

In Table 4.9-4.11, the results of the risks have been calculated according to the methodology shown. However, in these Tables the resultant risk values for each type of risk produced in the three cement factories under investigation, are shown.

Table 4.9: Risks values and strength revealed from the Al-Faluja factory

Type of risk	Risk value	Classification
Air Pollution	17.22	H
Exposure to Noise	10.24	M
Electrical Hazards and consumption	9.48	M
Land Pollution	8.18	M
Generation of solid and hazardous wastes	8.62	M
Water Resources pollution	2.86	L
Greenhouse gas emission	9.98	M
Public health effect	3.24	L

Table 4.10: Risks values and strength that presented from Al-Kubaisa factory

Type of risk	Risk value	Classification
Air Pollution	17.29	H
Exposure to Noise	16.96	H
Electrical Hazards and consumption	9.57	M
Land Pollution	8.98	M
Generation of solid and hazardous wastes	8.44	M
Water Resources pollution	8.26	M
Greenhouse gas emission	9.06	M
Public health effect	3.6	L

Table 4.11: Risks values and strength revealed from Al-Qaim factory

Type of risk	Risk value	Classification
Air Pollution	12.87	H
Exposure to Noise	11.47	H
Electrical Hazards and consumption	10.97	M
Land Pollution	8.14	M
Generation of solid and hazardous wastes	9.01	M
Water Resources pollution	8.41	M
Greenhouse gas emission	7.08	L
Public health effect	4.4	L

In addition, Figures 4.7-4.9 present the risk estimation according to the questionnaire data of the severity and frequency levels for each cement factory.

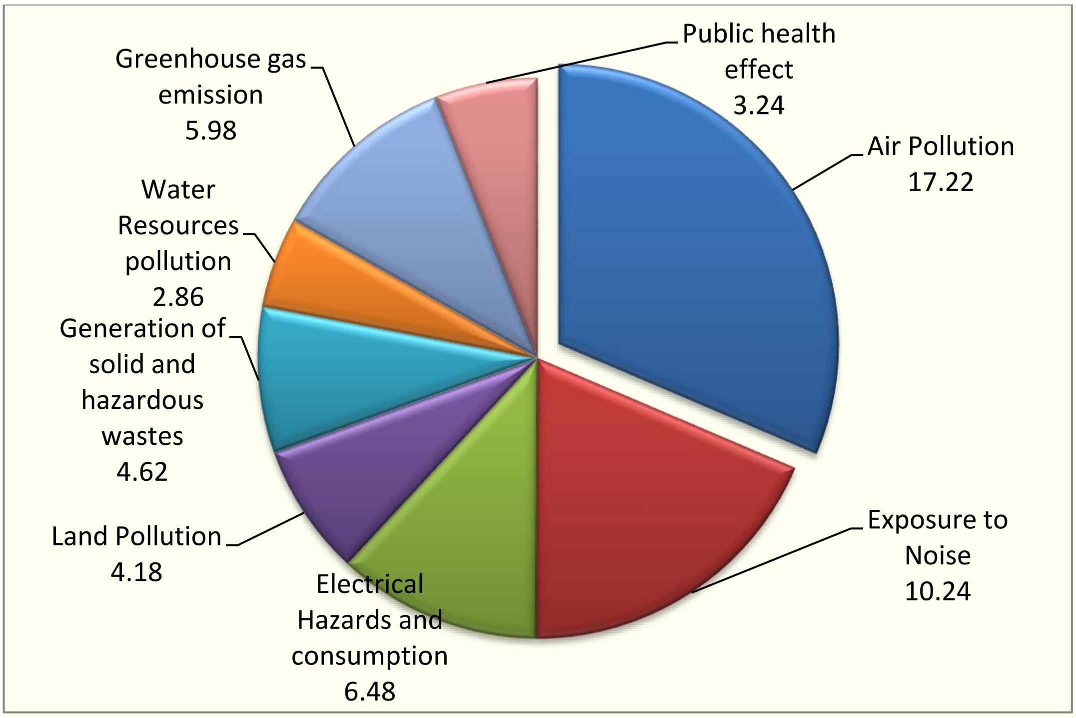

Figure 4.7: Total risks generated from the Al-Faluja factory

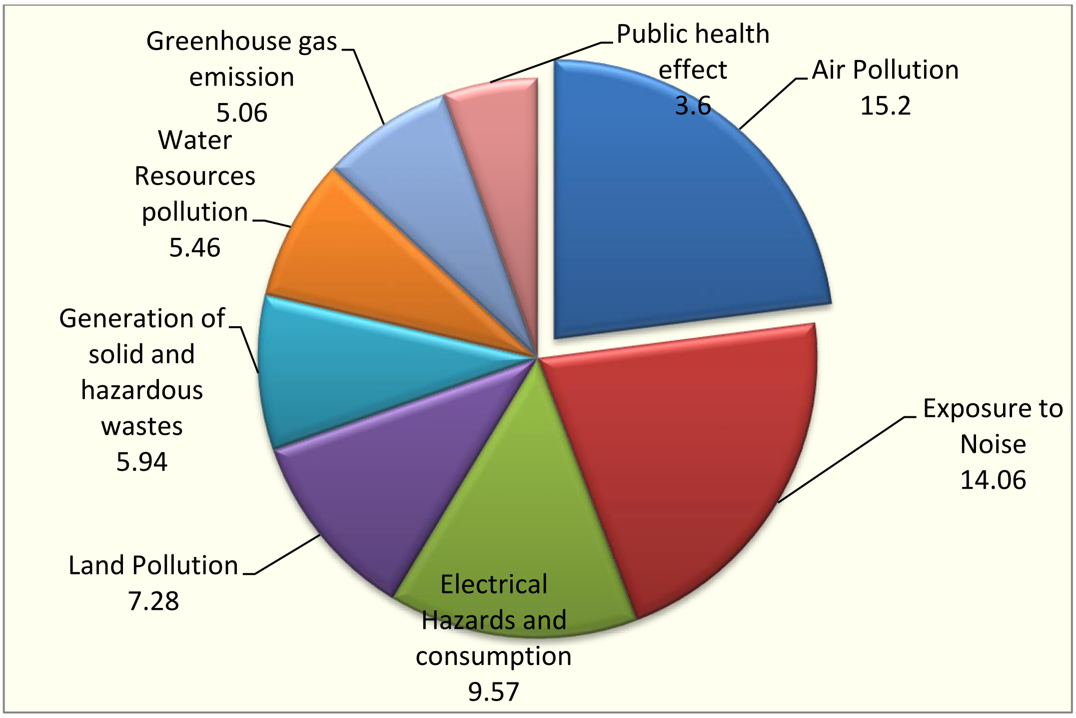

Figure 4.8: Total risks generated from the Al-Kubaisa factory

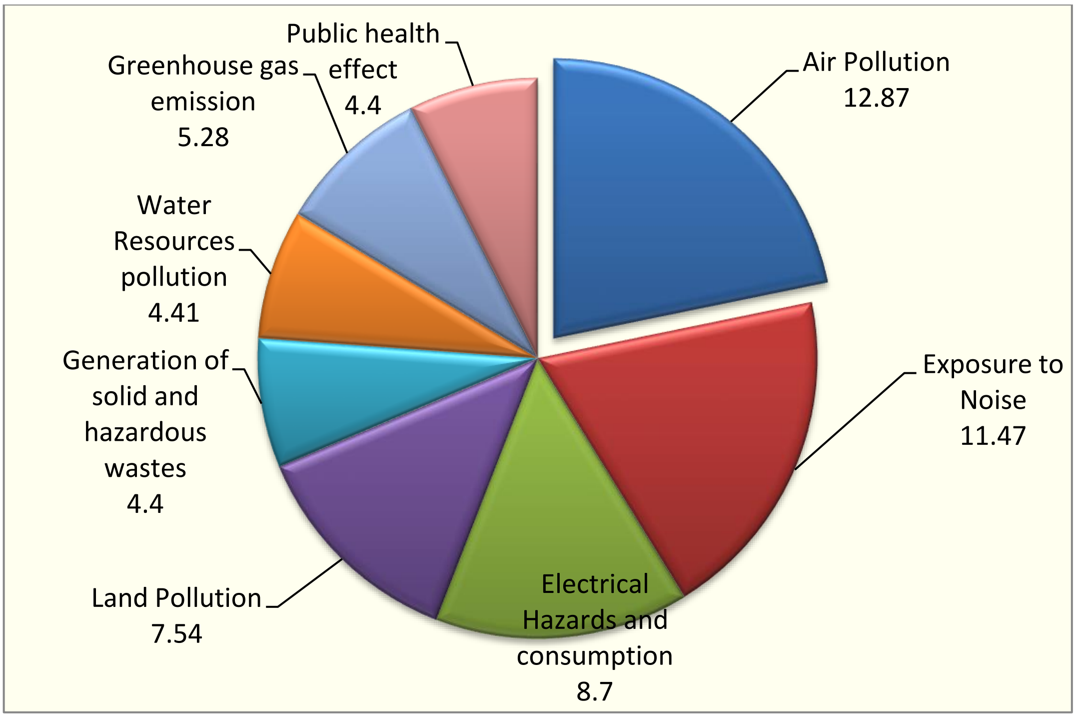

Figure 4.9: Total risks generated from the Al-Qaim factory

From Figures 4.7-4.9 it is evident that the greatest risks, according to the levels of severity, frequency and total risk came from air pollution in the first degree, with noise following in the second degree. Based on these results, and with the use of modern tools and update of the manufacturing process may lead to a notable decrease in the impact of the cement factory-generated air pollutant and noise on the environment. The findings collected through the questionnaire method in terms of air pollution produced by the cement factories was based on (1) meteorological data specifically with respect to the prevailing wind direction and speed, rainfall, and temperature; (2) presence of extreme weather conditions, like storms and droughts, and their locations and duration; (3) data on the current ambient air quality, including the source(s) and degrees of pollutants in the local and extended regions (the services of a specialist company with capabilities of monitoring and modeling air emissions may be required to perform the analyses); and (4) risks connected with inversion conditions. In fact, the suggestion of employing processes to improve the existing air quality cannot be accurately determined unless sampling is done over an extended time period. However, as this may prove impracticable, a descriptive approach considering the prevalent weather conditions and pin-pointing the principal sources of local emission which impair the air quality such as, traffic and heavy industries having several stacks, is frequently a more effective method. A common approach employed to reduce the atmospheric impacts is to decrease or avert emissions right at their source. Apart from that, improving the fuel employed may also go a long way in minimizing the air pollutants emitted into the atmosphere. During certain construction activities, workers get exposed to dust that is hazardous to their health. For example, sandblasting, grinding, concrete and brick-cutting release silica, which can lead to silicosis and lung cancer in workers suffering exposure to such activities (Bergdahl et al., 2004; Dement et al., 2010; Peters et al., 2009). Some common methods employed to reduce the dust exposure in the cement industry include the use of exhaust ventilation systems, wet dust suppression, and personal protective equipment (Nij et al., 2003). In light of this, Figure 4.10 shows the EU and World Health Organization guidelines for ambient air quality for several common air pollutants frequently released from cement factories.

EU Air Quality Directive				WHO Guidelines	
Pollutant	Averaging Period	Objective and legal nature and concentration	Comments	Concentration	Comments
$PM_{2.5}$	Hourly			25 µg/m³	99th percentile (3 days/year)
$PM_{2.5}$	Annual	Limit value, 25 µg/m³		10 µg/m³	
PM_{10}	Hourly	Limit value, 50 µg/m³	Not to be exceeded on more than 35 days per year	50 µg/m³	99th percentile (3 days/year)
PM_{10}	Annual	Limit value, 40 µg/m³		20 µg/m³	
O_3	Maximum daily 8-hour mean	Target value, 120 µg/m³	Not to be exceeded on more than 25 days per year, averaged over three years	100 µg/m³	
NO_2	Hourly	Limit value, 200 µg/m³	Not to be exceeded on more than 18 times a calendar year	200 µg/m³	
NO_2	Annual	Limit value, 40 µg/m³		40 µg/m³	

Figure 4.10: WHO air quality guidelines for four common pollutants (Adak et al., 2007; Zimwar et al., 2012)

Noise from the factory may cause disturbance to individuals at their homes, schools or other areas of sensitive land use. However, it is possible to perform noise control right at the noise source, noise path, or noise receiver. To accomplish noise control at the source, less noisy equipment need to be selected (e.g. opting for bored piles over driven piles) (Pelton, 1993). To reduce the noise along the path, the noise source needs to be moved to a greater distance from the receiver. This can be done by constructing a barrier (e.g. wall) between the noise source and receiver (Barron, 2003). Noise control can be performed at the receiver by the mandatory use of protective tools like ear plugs or canal cap. Generally, variations are noticed in the levels of noise and its influence produced during construction, based on the kind of activities, the nature and status of the equipment in use, the characteristics of the surrounding environment, and an understanding of the regulations related to the environment and health.

Electrical hazards and land pollution were considered moderate risk levels. Land pollution occurred principally due to the land uses surrounding the factory, in the cases of both urban and rural milieu, for the purposes of housing, industrial activities, agriculture, fishing, and recreation. The risk levels of the land around the cement factories must be decreased at the stage of the site plan itself, at which point the characteristics of the land and its usage (i.e., topography, soil features, stability and susceptibility of the terrain to erosion or land slip, present use of the land around the site, and current characteristics of the surface of the surrounding region) must be clearly noted. Further, the current land uses of the surrounding areas must be addressed; especially the ones which would be affected by industrial development or various other uses. Furthermore, it must indicate the maximum land area that would be influenced by the proposal, for port facilities, quarries, pits (sand, chalk, limestone, clay, pyrite, and gypsum etc.), sand extraction regions, storage areas (e.g. raw materials and fuels), and the actual site of the cement factory etc.

From the findings it is evident that the risks caused by solid waste, greenhouse emission, and public health effects dropped to a little under the moderate level. While this was discussed with the experts, the author focused upon solid waste disposal from the cement factories, specifically the waste which contains toxic or other detrimental compounds resulting in injurious effects on the amenities, quality of water and land, and potentially unfavorable effects on agricultural tracts and human health. However, several experts who answered the questionnaire were indifferent to the risks arising from solid wastes. Besides, due to the poor degree of the awareness culture in society to the emissions of greenhouse gases, a low level of risk was assigned for this significant factor, despite the fact that there were many studies which reported its occurrence and significance. Therefore, the risks discerned from these parameters was comparatively lower than those of other parameters. To reduce the risks the greenhouse gases emitted from the cement plants (primarily CO2 gas) on the environment, and to minimize such emissions, it was advised to adopt eco-friendly fuels as an alternative, carbon capture and storage, and other such means (U.S.EPA, 2009). The reduction of these emissions will go a long way towards the mitigation of climate change and its consequent effects on the natural resources, while also improving sustainable development (Chennoufi et al., 2010).

From another perspective, these Figures indicate that the cement factories pose a low risk for water resource pollution. This was because generally the sites of the factories investigated in this study are quite distant from water sources. Thus, the effect exerted by these factories on the river- or lake-water quality is limited, considering that the groundwater pollution caused by cement factories is not to be ignored. Besides, to avoid the discharge of untreated or poorly treated wastewater effluents from cement factories flowing into canals and drains in the vicinity (and thus affecting the water quality and posing a threat to crops and human health) the installation of an efficient sewer system for these factories is crucial. Thus, the risks induced by cement factories on the surface and ground water can be reduced (Bates et al., 2008).

4.4 Means of pollution reduction

From the findings of the present study, cement manufacture has impacted the environment in the area, at every single stage of the process. These impacts involve the airborne emissions (which carry the pollutants as dust, gases and noise), vibrations that occur during machinery operations and quarry blasting in quarries, as well as quarrying-related damage to the countryside. Equipment to minimize dust emissions during the quarrying and cement manufacturing process should have been extensively utilized, as well as equipment to trap and separate the gases emitted.

Therefore, the environmental risks investigated in the current study can be listed in the order of having suitable methods to mitigate them, as evident in Table 4.12. As shown, the ranking is done based on the summation results of the risks for three factories. As observed, in the present study, the environmental risks are ranked in terms of priority as: Air Pollution> Noise Exposure> Electrical Hazards and consumption> Land Pollution> Emissions of greenhouse gases > Generation of solid and hazardous wastes> Water Resources pollution> Public health effect.

Table 4.12: Total risks and priority of each environmental risk caused by the cement factories

Type of risk	Risk from Al-Faluja factory	Risk from Al-Kubaisa factory	Risk from Al-Qaim factory	Σ risk	Priority
Air Pollution	12.87	15.2	12.87	45.29	Priority 1
Exposure to Noise	11.47	14.06	11.47	35.77	Priority 2
Electrical Hazards and consumption	8.7	9.57	8.7	24.75	Priority 3

Land Pollution	7.54	7.28	7.54	19	Priority 4
Generation of solid and hazardous wastes	4.4	5.94	4.4	14.96	Priority 6
Water Resources pollution	4.41	5.46	4.41	12.73	Priority 7
Greenhouse gas emission	5.28	5.06	5.28	16.32	Priority 5
Public health effect	4.4	3.6	4.4	11.24	Priority 8

From the results shown in Table 4.12, the procedures and technologies that can be included in the cement factories to mitigate the environmental risks are listed; however, only the first two priorities were investigated.

4.4.1 Consequence and reduction of air pollutant emissions

As the cement particles are of aerodynamic diameter, they become a potential health hazard, because they are easily breathed in. Once they reach the internal organs, especially the lungs, they cause occupational lung diseases. This size distribution causes the trachea-bronchial respiratory region to be the primary target site where the cement gets deposited. The cement dust particles mainly enter the body via the respiratory route (via inhalation) and/or the gastrointestinal route (via swallowing), respectively (Green, 1970). Both pathways, the respiratory tract in particular, face exposure to several potentially injurious substances in the surroundings of the cement mill. Apart from cement dust, several other gaseous pollutants are also released by the cement factories which are pollutants and which finally affect human health. The two commonest technologies, filter and electrostatic precipitators, are utilized to minimize the air pollutants released from cement factories.

The filtration method involves the entry of raw gas through the filter via inlet ducts that have guides which equitably route the gas into the filter bags. This facilitates the gas to flow downward due to gravity, through the filter bags, thus directing the dust into a hopper underneath. This design averts the creation of an upward flow of the gas. The high velocity gas blocks the minute particles from settling onto the hoppers at the time of the online cleaning cycle (Zimwara et al., 2012). The fabric filters the raw gas coming in from the outside, while the clean gas exits via the top of the bag, with a fan positioned at the clean gas outlet part of the filter. (See Figure 4.11).

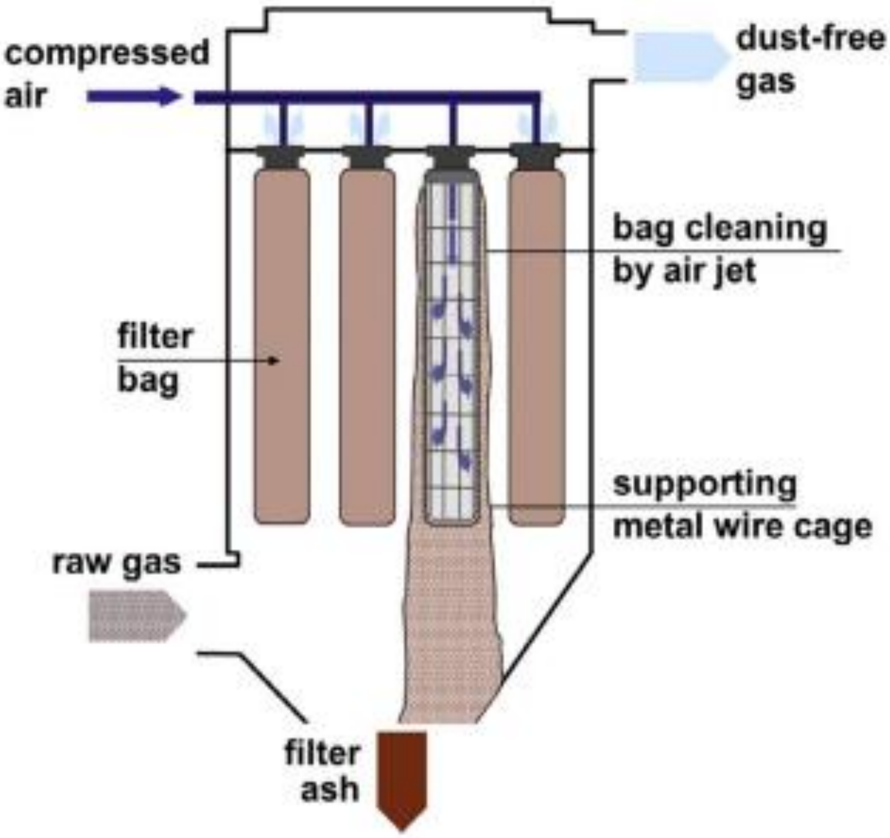

Figure 4.11: Filtration of polluted air (Zimwara et al., 2012)

As the electrostatic precipitators are efficient, simple in design and operate at low pressure drops, they are generally used to remove the dust (Zainudeen and Jeyamathn, 2004). The electrostatic force is the dust removal mechanism. This device is composed of metal plates of parallel and negatively charged wires. As the raw gas flows via the channels between the plates and at low velocity, the fine particles get ionized at the wires by the corona effect and moves along the electromagnetic field to the earthed metal. In Figure 1, Scheme of fabric filter, the cleaning plates where they exert the negative effect are shown (Vehlow, 2015). The particles are then removed from the collector plates and passed through the hopper just beneath the device by rapping at specific time intervals. Generally, the efficiency exceeds 99% and because of the low-pressure loss, the ESP is considered for de-dusting, where minute particles, as small as 10 µm, can be trapped (Vehlow, 2015). See Fig 2.

Advantages:

- Nominal maintenance, presence of unwanted, corrosive and adhesive materials in the flue gases.
- Only few moving parts are present.
- Operable at high temperatures from 300^{o} C to 450^{o} C.

Disadvantages:

- Higher initial cost.
- Sensitive to fluctuating dust loading and flow rates.
- Usage of high voltage which could pose risk to the personal safety of staff.
- Collection efficiency decreases with time.

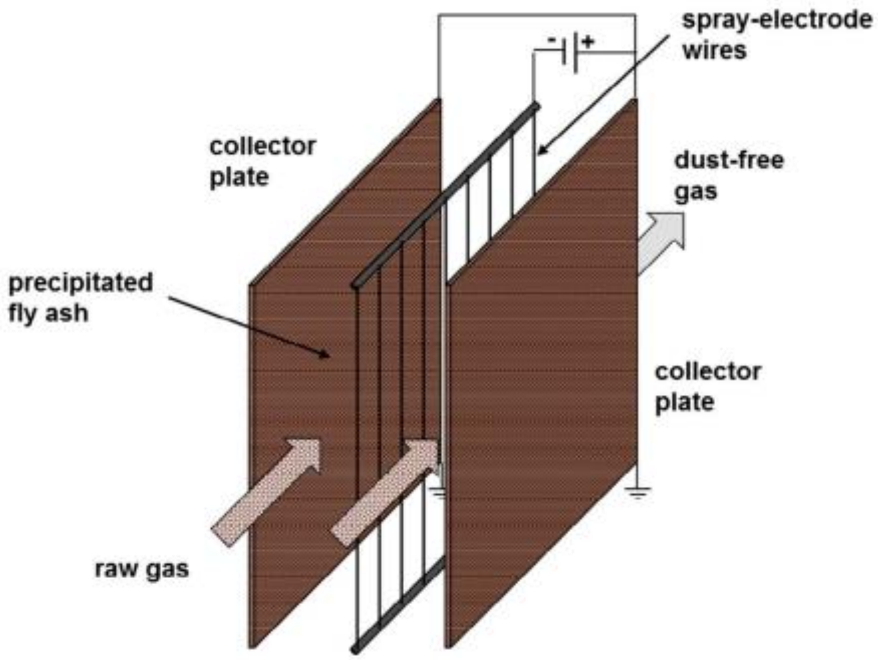

Figure 4.12: Electrostatic precipitator (Zimwara et al., 2012)

4.4.2 Noise

This study demonstrated a high level of noise pollution during the cement production process in the factory, which ranks among the principal occupational disease-inducing factors in the cement industry. The nature of the noise source is known to be complex, particularly in the cement industry (Jun, 2005; Huiqun, 2006; Guangfeng, 2003). In the cement factory the noise pollution and the injury it causes to human health must be determined at the field location, and correctly analyzed. Noise pollution can have an extensive range of impacts on the activities of the workers, which causes hearing loss, and at times even precipitates diseases related to the nervous, digestive, and cardiovascular systems. In light of this, several studies were done to measure the level of noise pollution in the cement manufacturing plants (Canfeng et al., 2012; Hongwu, 2003). From the studies done in the main manufacturing units, several conclusions were drawn regarding the noise levels detected, as summarized in Table 4.13. Based on the noise control theory, comprehensive noise control measures and systems were proposed, including those related to management and technology. It was recommended that noise can be controlled by comprehensive methods from the perspectives of the noise source, means of noise propagation and noise recipients. From an engineering point of view, noise needs to be controlled using comprehensive measures, like noise attenuation, absorption and insulation, to ensure the achievement of successful and economic results of noise reduction (Canfeng et al., 2012).

Table 4.13. Noise level detected in cement manufacturing units (Canfeng et al., 2012)

Workplace	Test numbers	The highest noise level /dB (A)
Casher room	3	106
Ball mill room	3	101
Packaging machine room	3	85
Air compressor room	3	95
Raw material mill	3	103
Rotary kiln end	3	93
Coal mill room	3	102
Pump room	4	97

In the cement factory, noise control should be perceived as a noise control system, which involves two subsystems: management control system and technical control system, as evident from Figure 4.13. The Management Control System encompasses both the administrative and technical managements. Administrative management is specifically linked to the noise control regulations. Technology management, on the other hand, is performed from four points of view, including reduced work hours and a changing work system, with greater attention being paid to equipment maintenance and management, machinery, equipment and technology update, and equipment installation in a reasonable layout or with necessary adjustments. Technical control enables the following: control of the noise from the perspective of the source of the noise, propagation paths and recipients, such as vibration absorption, vibration isolation, damping, noise absorption, noise insulation, noise attenuation, and anti-noise.

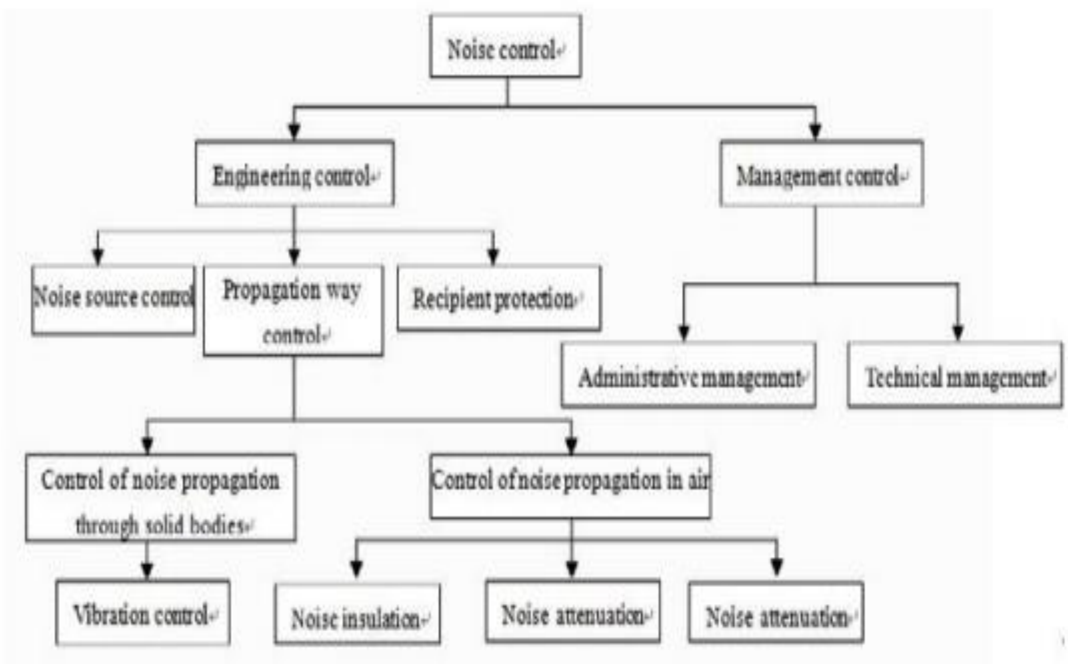

Figure 4.13: Noise control system in cement factories (Jun, 2005; Huiqun, 2006; Guangfeng, 2003)

4.5 Risk mitigation strategy

This section clarifies the mitigation strategy including the studying of alternatives & extent of important impacts that these procedures can avoid, reduce and the mitigation procedures evaluation must take the following aspects into consideration (Awad et al., 2010):

- Continuity.
- Integration.
- Feasibility.
- Compatibility with the legislative requirements in accordance with clearances & other licenses.

Mitigation procedures must clarify the principles of environmental management that have to be followed through the stages of planning, designing, constructing, and operating the proposed facility. And they must include the characters specified for the site, dividing it, the design, used technology, and clarifying the current plans for management & monitoring.

4.5.1 The specified Mitigation Procedures

The mitigation procedures & management proposed to control the implications include each of the following (the examples mentioned here are some of the procedures that can be taken).

- The type of lands includes the procedures:
    - The works of soil stabilization in case of digging, constructing bridges, and opening tunnels.
    - Establishing facilities to control corrosion & sedimentation (like windbreaks)
    - Presenting the suggestions of natural views & land replantation.
    - Controlling & getting rid of solid waste (Re-using it as fuel or as inputs in other industries).
- Type of water, the procedures include:

- Controlling industrial drainage liquids & treating them (like recycling cooling water & cooling towers, separating oils, sand traps & ponds, and tanks of sedimentation & elutriation).
- The facilities of controlling pollution & substance restoration.
- The procedures of dealing with all kinds of dangerous substances & residues, and saving, transferring, and getting rid of them [like recycling residues & using them as raw materials (sands) and providing closed stores for protecting them from flood water].

• Air type includes the procedures:

- Controlling chimney emissions [like using heat exchange systems, cloth filters, and dredging devices].
- Controlling the used fuel (via replacing the fuel of high phosphate content or ash content in other types).
- Controlling the best combustion process in furnaces (via controlling its supply with sold heavy fuel, and reducing the flame & combustion temperature).
- Controlling the produced emissions (by using packaging by conveyor pipes or water spray, and using ventilation systems supplied with centrifugal fans in the closed storing places).
- Treating the sands of the side exits (Bypass sands) resulting via using the pelleting system for sands connected with the side exits of clinker production line by dry process. And by which we can get rid of the surplus sands resulting through the process of their loading in lorries which leads to saving space in landfills. And sand treatment can be done via using a rotary roasting system on a water layer includes preparing the sands for the floating layer.

• Noise, the procedures include:

- Controlling the noise resulting from the factory & machines to guarantee meeting the standards.
- Applying the procedures of lowering sound like establishing walls & rubble (like the works of maintenance causing noise & using rubber curtains at the hatches of mills and crushers, and using lining & soundproof packaging).

- Habitats (plants & animals), the procedures include:
    - Planting plants or breeding animals to compensate the endangered species.
    - Providing new suitable habitats.
    - Studying the opportunities of establishing settlements.
    - Elaborate timing for the activities causing confusion & annoyance.
    - The procedures which control problems in the site, and controlling its spread in the sites close to the proposed project.
- Historical & cultural features, the proposed procedures must alleviate effects & preserve monuments & sites of historical & cultural attraction through the stages of this project.

And all these procedures must follow all the rules & legislations issued by competent authorities.

4.5.2 Environmental Management Plan

Environmental management plan is a document made to guarantee executing of commitments mentioned in the environmental report of effect assessment & the approvals and clearances. And the environmental management plan must clarify the following of the new environmental practices through the stages of establishing the facility & operating, substituting, and renewing it after using. And the environmental management plan must cover the following points:

- Managing the establishing effects (like the management line of natural views).

- Managing the operating effects (like hazardous substances, fuel management, transferring management, loading, maintenance, site security, and emergency plans).
- Work procedures & plans for turning the following-up & monitoring data into management practices.
- General awareness program & training for the operating employees.
- Compatibility indicators with the requirements of clearance & approvals.

The environmental management plan must include a plan of good designing for follow-up & monitoring where the predictions mentioned in assessing the environmental effect & main environmental indicators are considered. And the environmental management plan must clarify the extent of need for monitoring & its period, and the procedures of making its reports.

The standards & indicators related to the environmental management plan:

- Performance indicators of the operating core issues which include:
    - Type of water (salt & fresh).
    - The general form of beach line & deposition patterns.
    - Sand & depositions.
    - Noise & air type.
    - General health indicators.
    - The land's surface & hydrology.
    - Plants & animals.
- The indicators of waste management performance of recycling & re-using.
- Following-up complaints received.

The procedures of follow-up & monitoring must cover the following:

- The main information that will be monitored, its standards, and the reasons of its monitoring (like noise {low frequencies – and sounds and high frequencies} and substances emitted up in the air {the rates of nitrogen oxide & sulfur oxide, carbon monoxide, water, metals, etc.…}, and wastewater {its size, suspended solids, PH, and substances, etc.…} and waste {solid & hazardous} and smell).

- Monitoring sites, their classification & the reasons of their monitoring (like the exits of air emissions: heavy particles, nitrogen oxide, sulfur oxide – Borders: noise, smell, minute particles, nitrogen oxide, sulfur oxide, and other related substances – external storing sites for raw materials: sands fall, periods between monitoring processes & their periods.
- The procedures to be taken if monitoring shows non-commitment or gives abnormal results.
- Internal reports for the results & connection with management practices and work plans according to them.
- Notifying the relevant authorities, and if necessary, notifying the competent managerial authorities for clearances & community about information like work cease, daily workflow, used raw materials lists, reports about sands fallen from the areas of raw materials storing, and reports of monitoring noise levels & reports about smell emission & air pollutants, emission concentration, the rate of carbon dioxide, and reports about documentation, power consumption, wastewater, etc.

Notably, after assessing the alleviation procedures, there can be some remaining or accumulated effects that putting them in a table clarifies the degree of importance of each one of them would be useful.

Chapter Five: Conclusions and Recommendations

5.1 Conclusions

- This study investigated the environmental risks generated from three cement factories, in Iraq. Further, it offered a general perspective for the possible methods that can be used to minimize the environmental risks detected. The conclusions drawn are as follows:
- The methodology of the proposed questionnaire was found to be an effective method of assessing the environmental risks in cement factories.
- The high risk were observed to arise from air pollution and exposure to noise.
- A few other risks parameters were noted, namely, electrical hazards and consumption, land pollution, generation of solid and hazardous wastes, and pollution of water resources to a moderate degree.
- Based on the results determined from the questionnaire, the environmental risks considered in the present work, ranked in the order of priority, are: Air Pollution>

Exposure to Noise> Electrical Hazards and consumption> Land Pollution> Greenhouse gas emissions> Generation of solid and hazardous wastes> Water Resources pollution> Public health effect.

- From another perspective, as several environmental risks were revealed to be 'low risk', there is no necessity to apply risk management strategies to the cement industries. These 'low risks' include, Electrical Hazards and consumption, Land Pollution, Greenhouse gas emissions, Generation of solid and hazardous wastes, Water Resources pollution, and Public Health effects.

5.2 Recommendations

Risk management strategies must be applied as they are vital to the mitigation of the impacts of many risk sources in the cement plants. Therefore, the recommendations of the present study suggest initiating a comprehensive study that considers the methods that can ensure a significant degree of risk mitigation. Another recommendation is to have a study that outlines the risk criteria for cement factories.

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جامعة الإسراء
Isra University

Environmental Risk Management of Cement Factories

إدارة المخاطر البيئية في معامل الاسمنت

نموذج استبيان

Questionnaire Form

M.Sc. Student: **Ahmed Jassim**

Supervisor: **Dr. Tariq J. Al-Musawi**

Year: 2020

This questionnaire is an essential part to complete a Master's degree in Engineering Projects Management

هذا الاستبيان هو جزء من معلومات ضروريّة لإنجاز رسالة ماجستير في تخصص إدارة المشاريع الهندسيّة

المشاركون الأعزّاء .. تحية طيبة، وبعد:

أرجو منكم تخصيص دقائق من وقتِكُم، والتفضل بالإجابة عن الأسئلة المطروحة في هذه الاستبانة المغلقة التي تهدف إلى تحديد المخاطر البيئية المحتملة من مصانع الإسمنت. إن آراءكم ذات اهمية كبرى من أجل إعتمادها في تحديد المخاطر والنقاط الواجب اتباعها في تقليل الأضرار البيئية الناتجة عن فعاليات صناعة الإسمنت.

إن هذا الاستبيان مبنيٌّ في الأساس على مقياس ليكرت وهو أسلوب لقياس السلوكات و التفضيلات حيث يستعمل في الاستبيانات وبخاصة في مجال الإحصاءات. ويعتمد المقياس على ردود تدل على درجة الموافقة أو الاعتراض على صيغة ما.

في دراستنا الحالية ستكون الإجابات لكل نوع من أنواع المخاطر محددة من 1 الى 5 ولكل من درجة الخطورة والتردد وحسب الجدول أدناه:

Scale	**Severity (S)** **الخطورة**	**Description** **وصف الخطورة**	**Scale**	**Frequency (F)** **التكرار**
1	Insignificant:	Minimal impact	1	Never
2	Minor:	Short-Term impact	2	Unlikely
3	Moderate:	Significant impact	3	Possible
4	Major:	Major short-term impact	4	Likely
5	Catastrophic:	Major long-term impact	5	Always

Personal Information			المعلومات الشخصية
Qualification			**المستوى التعليمي** (دكتوراه ، ماجستير،بكلوريوس, اخرى)
Occupation			**الوظيفة**
Years of Experience in the cement industry			**عدد سنوات الخدمة في مصانع الإسمنت**
Years of Experience in the Field Environment			**عدد سنوات الخدمة في مجال البيئة**

	Risk	**Severity (1-5)**	**Frequency (1-5)**
1	Air Pollution مدى مساهمة مصانع الإسمنت في تلوث الهواء		
2	Noise Exposure التعرض للضوضاء من قبل العاملين و السكان		
3	Electrical Hazards and consumption مدى استهلاك الطاقة من قبل مصانع الإسمنت		
4	Land Pollution تلويث الأرض المجاورة		
5	Generation of solid and hazardous wastes المساهمة في توليد نفايات عادية أو خطرة		
6	Water Resources pollution تلويث مصادر المياه		
7	Greenhouse gas emissions المساهمة في انبعاث الغازات الدفيئة		
8	Public health effect		

	التأثير على الصحة والجمالية العامة		