An-Najah National University

Faculty of Graduate Studies

RISK BASED MANAGEMENT OF INDUSTRIAL WASTEWATER IN NABLUS CITY

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This Thesis is Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Engineering Management, Faculty of Graduate Studies, An-Najah National University, Nablus - Palestine.

2024

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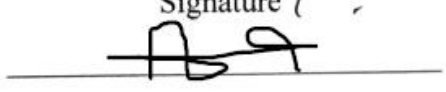
Dr. Ahmed Abu Scha'ban	
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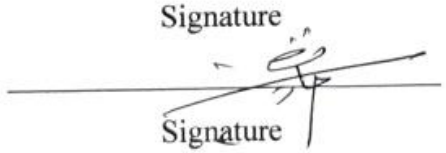
Dr. Hafez Shaheen	
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Dedication

To my daughters Alma & Sama

who give me the spirit every morning to do everything

Acknowledgments

First and before anything, I thank ALLAH Almighty for everything that I have and for completing this thesis.

My heartfelt thanks go to my parents for their endless support and encouragement. Their belief in me has been a constant source of motivation.

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Declaration

I, the undersigned, declare that I submitted the thesis entitled:

RISK BASED MANAGEMENT OF INDUSTRIAL WASTEWATER IN NABLUS CITY

I declare that the work provided in this thesis, unless otherwise referenced, is the researcher's own work, and has not been submitted elsewhere for any other degree or qualification.

Student's Name: Afeid Afaneh

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Date: 13/10/2024

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RISK BASED MANAGEMENT OF INDUSTRIAL WASTEWATER IN NABLUS CITY

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Abstract

Industrial wastewater is highly polluting the environment if not handled properly, also affect the wastewater infrastructure for both collection and treatment. Most of consumed water is converted to wastewater from residential, industrial, and commercial uses. Industrial wastewater is a critical concern for all industrial settings that lacks the infrastructure to handle such water.

Generally, industrial wastewater in Palestine represents a major challenge to the environment and municipal infrastructure, mainly in the industrial cities like Nablus city.

This thesis aims at concluding the most appropriate solutions which prevent or decrease the hazards resulted from industrial wastewater on the wastewater infrastructure and its operation. The research utilized the risk based management approach to propose proactive and reactive barriers for industrial wastewater hazards and impacts. Cost Benefit Analysis was used to estimate the costs and benefits for Nablus municipality for each identified barrier.

Risk analysis was carried out to explore the hazards and impacts of industrial wastewater on the infrastructure; Wastewater Network (WWN) in Nablus and Nablus-West Wastewater Treatment Plant (NW-WWTP). Risk evaluation was used to priories the hazards through the calculated risk priority number (or degree of severity) to quantify risk.

Results showed that industrial wastewater, which had risk priority number of 9 poses a significant threat to the municipal infrastructure. Infrastructure damage and operational inefficiencies were resulted.

To reach this thesis's goal, estimated proposed strategies to reduce negative impacts were discussed in risk control approach.

After conducting risk cost benefit analysis for Nablus municipality, it is found that awareness and WWN rehabilitation have to be excluded because their proportion Factor (d) is more than 1, but the other barriers should be executed by the municipality. Since equipment insurance barrier has the smallest d which is 0.0036, it has to be prioritized. Then, to execute the remaining barriers from smallest d in ascending order.

Finally, risk-based management approach and risk cost benefit analysis options are very useful tools to mitigate and adapt hazards to improve the preparedness and response for Local Governmental Units (LGUs), particularly in the field of wastewater management. The results of this thesis should guide the implementation of effective management practices that ensure environmental protection and infrastructure resilience.

Keywords: Industrial wastewater; municipal wastewater network; Risk Based Management (RBM; Wastewater Treatment Plant (WWTP; Risk Cost Benefit Analysis (RCBA).

Chapter One

Introduction

1.1 Background

Water is considered to be the basic element needed to assure the actual independence in socio-economic development. Water was central to society and still is today. Wastewater (WW) is mainly dependent on water use and its consumption.

Used water and effluent of WW are linked to the socio-economic status in any region, especially if the industrial sector in that region is pioneer. Overtime, more awareness has been gained of how the correlations between accelerated growth of industries, population and the increased effects of pollution.

According to (Davis, 2010), Most of used water is converted to WW especially in domestic WW, which consists of water and materials dissolved or suspended in the flow.

WW is known as sewage, originates from household, commercial, industrial, human and animal wastes, storm runoff and ground water infiltration. Most WW is disposed wrongly in West Bank since it is discharged to cesspits or through Wastewater Network (WWN) with minimal or no treatment. As for Palestine, WW is one of the most important issues that represent a threat to the environment and public health (Shaheen O. H., 2013).

As other cities in Palestine, Nablus city's industrial WW have hazardous effects on the surrounding environment and public health. Also, it is considered as the primary challenge to the Wastewater Treatment Plant (WWTP) in the western part of the city (Figure 1.1) and threat to the other municipal infrastructure such as the WWN itself and water network (WN).

The government, ministries, authorities and Local Government Units (LGUs) have to take serious actions regarding industrial WW in order to minimize the adverse effects of this event. These actions need a planned and comprehensive coordination between related responsible parties, in addition to implement the concept of local community

participation. This will contribute in raising the awareness of the public by spreading the needed knowledge into communities.

Figure 1.1

Western WWTP in Nablus

This research is about providing managerial solutions that can be applied to prevent or reduce the effect of industrial WW on WWN and WWTP in order to protect the environment by conducting Risk Based Management (RBM) of the industrial WW in Nablus city, taking into consideration its costs and benefits for Nablus Municipality (N.M.) using Risk Cost Benefit Analysis (RCBA).

These proposed solutions will represent the main key for N.M. and the stakeholders to do the needed coordination to protect the environment and public health to preserve the public interest.

1.2 Problem Statement

The industry sector is considered as main source of pollution on the environment since it affects the environment by its pollutant emissions or its effluent WW. It produces huge quantities of WW that is extremely harmful to the surrounding environment and to the municipal infrastructure. Adverse effects of industrial WW were manifested in several directions, especially in the environment and public health. Nablus city is a main aspect of this situation.

Municipal Nablus city's WWN suffers from the effects of industrial WW which is discharged to either the WWN without conducting the needed pre-treatments and so reaching NW-WWTP with high loaded of industrial pollution (Figure 1.2), especially the western part of the city and its surrounding villages which were mentioned in section 1.7.3.2, or directly to Zomer wadi.

Figure 1.2

WW influent in Nablus WWTP

The effect of this untreated industrial WW is highly on NW-WWTP since this facility receives the effluent WW that produced from the western part. Clogging, efficiency reduction and faults in equipment in WWTP are the primary effects. Also, it affects the municipal infrastructure by reaching the untreated industrial WW to the WWN, which hurts the network itself and then the WWTP.

Municipal WWTPs, such as NW-WWTP, are designed on certain hydraulic and organic loads. Design loads can be exceeded hydraulically due to severe weather conditions mainly intense rainfall resulted floods, and organically due to illegal discharges of industrial WW.

For example, (Shaheen & Karim, 2007)mentioned that Chemical Oxygen Demand (COD) that exists in the effluent of Olive Mill industry's WW in Palestine reaches approximately 100 g/L, but the COD limit for WWTP discharge standards should not exceed 0.12 g/L (Zhou et al., 2018).

As a result, 1 L of olive mill WW is higher than the WWTP standards by over than 800 times.

So, reducing the effects of this WW is a primary issue which should be improved. This research aims to study the industrial WW problems in the city of Nablus. In addition to mitigate the adverse effects of industrial WW in the coming years using the concept of RBM to recommend the needed barriers. Then, to estimate economically the cost and benefits for the results of RBM to priories the needed barriers for N.M.

1.3 Research Question

This research will try to answer the following key question:

- How to manage the industrial WW in Nablus city economically and environmentally?

Also, the following sub-questions will be considered to answer the key question:

- What are the hazards of industrial WW?
- What are the main causes of hazards?
- How can get fewer negative impacts?
- Is it possible to economically apply the solutions?

1.4 Research Objectives

The main goal of this research is to find applicable solutions for the industrial WW problem in Nablus city and analyse its costs and benefits to protect the WWTP and the municipal infrastructure through:

- Analysis of the industries in the city of Nablus.
- Proposing a comprehensive study about the hazardous events that result from the industrial WW and estimating the potential future risk.

- Evaluating the consequences of these hazardous events.
- Conducting RBM principle.
- Choosing the most appropriate barriers to reduce the effects of industrial WW on municipal infrastructure, especially WWN and WWTP.
- Using brainstorming session, expert opinion to enhance the results.
- Estimating the cost and benefits for each barrier.
- Prioritize implementation of proposed barriers.

This work will use different risk management tools such as Preliminary Hazard Analysis (PHA), risk matrix analysis, and Cost Benefit Analysis (CBA) for risk. Also, brainstorming session and expert opinion will be assisted to this research.

1.5 Research Importance

The significance of this study is to have a better understanding about the current status of industrial WW in Nablus city, taking into consideration its effects to the municipal WWN and WWTP, the needed reducing measures, the possibility of its application and estimating the needed cost and the resulted benefits.

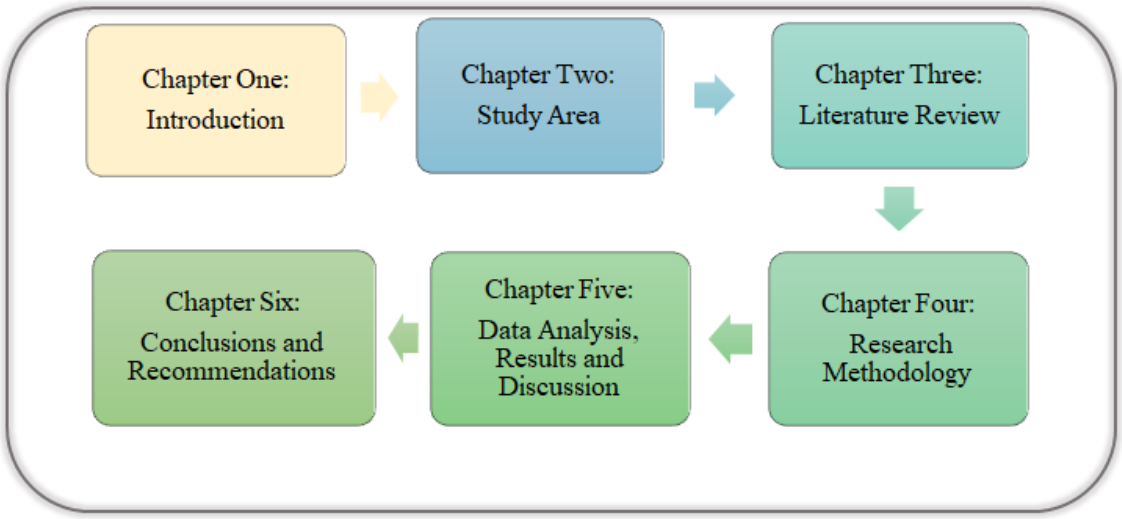
This will help to evaluate the hazardous events that happened due to discharging untreated WW to WWN. It is also important to choose the best management strategies and practices in minimizing and mitigating the negative consequences by conducting the most appropriate RBM to generate the needed results. This should guide the implementation of effective management practices that ensure environmental and infrastructure protection.

1.6 Research Structure

The thesis is organized in six chapters as shown in Figure (1.3).

Figure 1.3

Research structure



Chapter one presents the introduction of the thesis with a brief illustration of the research. It also covers the problems, importance and objectives to support this research.

Comprehensive study area for Nablus city was explained in chapter two.

In chapter three, an intensive literature review about industrial WW, risk management principles and RCBA were conducted. In addition, a broader view was taken to look into how industrial WW affects the environment and the municipal infrastructure.

The research methodology which consists of the data collection methods and data analysis techniques are outlined in the next chapter.

In Chapter five, the results of the data collected were presented using data display and analysis techniques that were described in chapter four. This chapter ends with the illustration of how to assess and manage the industrial WW hazards and its reducing measures including its costs and benefits.

Finally, chapter six abstracts the thesis results through conclusions. It indicates to the recommendations of the study, and includes suggestions for future studies.

1.7 Study Area

This chapter describes Nablus city starting with its history, religious and archaeological sites, location, area and population, topography, climate, socio-economic conditions, importance and ending with water, WW and WWTP status. This will help to understand the nature of the area.

1.7.1 History and Religious and Archaeological Sites

Nablus City is an old and historic city which was built by Arab Canaanites who named it "Shakim", which is originated from a Canaanite word meaning the High City. It includes more than eighty mosques and nine famous churches, including: the Orthodox Church (Old City), the Church of the Annunciation of Our Lady. The city also has several sites of archaeological interests, including the Old City, historical mosques like, As Satoon, Al-Baik, Al Hanbali and the khans, like Khan al Wakala (ARIJ, 2014).

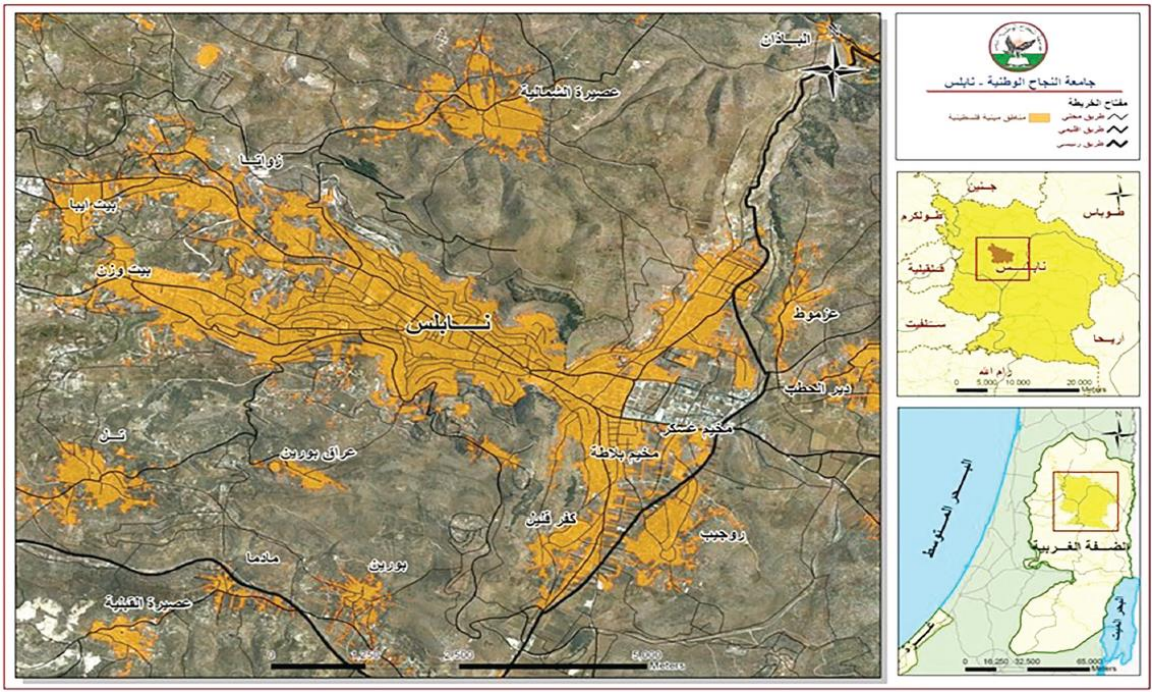
1.7.2 Location and Physical Characteristics

Nablus City is the only city in Nablus District. It is bordered by 'Azzmut and Deir al Hatab to the east, Kafr Qallil, Rujeib, ‘Iraq Burin and Tell to the south, Sarra and Beit Wazan to the west, and ‘Asira ash Shamaliya to the north. Figure (1.4) describes Nablus city location and its borders. It has an important, vital and strategic location linking its parts, since it is located at the main crossroads that extend from Jenin District in the north and Hebron District in the south, also from the Jaffa city in the west to the Jericho District in the east (ARIJ, 2014).

Nablus city is located in the northern part of West Bank in Palestine, about 114 Km west to Jordanian capital and 69 Km north to Jerusalem city. It is located about 42 Km to the east of the Mediterranean. It is located on 35:16 longitude and 32, 13 latitudes (NM, 2024).

Figure 1.4

Nablus City Location



(N.M., 2023)

1.7.3 Area and Population

This section includes two sub-sections which are area and population. The first one describes the area of Nablus city, its building area, borders and its municipality. The other one, indicates to the predicted population of the city and the projected people in this study.

1.7.3.1 Area

The total area of Nablus District is approximately 605 Km^2, 29 of them is the area of Nablus city. The urban area represents about 30% of the total area of the city since the building area is about 8,700 m^2 (NM, 2024).

This locality borders are defined by the Ministry of Local Government (MoLG) in Palestine according to the new local councils" borders. These borders were set by many parts in Palestine, including: Palestinian National Authority (PNA), MoLG, Ministry of Planning (MoP), Central Elections Commission and Palestinian Central Bureau of Statistics (PCBS) in the year 2011 (ARIJ, 2014).

Since 1869, the city has been governed by a Municipal Council, which is currently administrated by fifteen members including its mayor. These members are appointed by general elections every four years to take their responsibilities to provide the city and its people the needed services that include (ARIJ, 2014):

1. The establishment of the drinking WN and WWN.
2. Streets cleaning and solid waste collection and transfer to the final dumpsites.
3. Road rehabilitation, including: constructions and paving and Management of public parks.
4. Processing of the issuance of construction licenses and organizing the urban area.
5. Provision of offices for governmental institutions and protection of governmental properties.
6. Protection of historical sites and implementation of projects and studies for the city.

1.7.3.2 Population

According to PCBS, Nablus district has a population of 439,631 inhabitants at mid of 2024, 40.41% of them in Nablus city with annual growth rate around 1.019%. The predicted population in Nablus city at mid of 2024 relative to PCBS is 177,638 inhabitants (PCBS, 2021).

The projected people in this study include the western part of Nablus city. It is assumed that the half of Nablus city inhabitants live in this part relative to PCBS population projection as in table (1.1). In addition, many western regions and villages will be in the study, which are:

1. Ein Bet Elma' Camp.
2. Beit Iba.
3. Deir Sharaf.
4. Zawata.
5. Beit Wazan.
6. Qusin regions.

The projected people will be assumed about 110,000 as table (1.1).

Table 1.1

Projected Population

#	LGU	Population in 2024 (inhabitants)
1	Western part of Nablus City	177,638 / 2 = 88,819
2	Ein Bet Elma' Camp	4,062
3	Zawata	2,872
4	Beit Iba	4,618
5	Deir Sharaf	3,339
6	Qusin	2,548
7	Beit Wazan	1,485
Total Projected population		**107,743**

1.7.4 Topography and Geotechnical Characteristics

The old Nablus city is a long and open valley originated between the mountains of Ebal in the north, and Jerzim in the south, but the modern Nablus city was built on these two mountains. The city's valleys descend from the Nablus region to the west and east, like Wadi Al-Tuffah and Wadi Al-Bathan. Wadi al-Tuffah, which starts from Nablus city and connects to the Zoumr Valley in the Tulkarm District to the west. Also, Wadi Al-Bathan, which starts from the north mountains of Nablus city and flows into Wadi Al-Far'a in Tubas District. The topographic elevation varies from 550 m.a.s.l. at old Nablus city to 940 m.a.s.l. at the northern edge of the city which is the height of Mount Ebal. The height of Mount Jerzim is 881 m.a.s.l. at the south of the city (Jardaneh, 2007).

1.7.5 Climate

In general, the climate is largely dependent on the geographical position of the earth. Climate has primary factors such as: temperature, humidity, evaporation, wind speed, atmospheric pressure and precipitation. The previous factors are considered as follows:

1.7.5.1 Temperature

The climate of this region is Mediterranean with dry summers and short and cold winters (NM, 2024).

The mean annual of air temperature is 19.5°C and the mean annual minimum temperature is 15.3°C. The mean of maximum air temperature is 25.2°C.

1.7.5.2 Humidity, Evaporation and Sunshine Duration

Due to the location of Nablus city which is not far from the Mediterranean, the humidity is relatively high with a range from 71% to 77% (PCBS, 2024). The average evaporation quantity is about 1,863 mm which depends on humidity and sunshine duration (PCBS, 2024).

The average Sunshine duration in West Bank is 8 hours/day (PCBS, Mean Sunshine Duration in the West Bank (hour\day) by Station Location and Year, 2010-2018, 2020). In Nablus city, the sunshine duration ranges from 4.5 hours/day in December to 10.9 hours/day in August. The average sunshine duration in Nablus city is 7.78 hours/day (NM, 2024).

1.7.5.3 Wind Speed and Atmospheric Pressure

In general, the wind speed in Palestine affected by the environment of the Mediterranean. In Nablus city, the northwest winds are the prevailing winds in the Nablus region (NM, 2024). The mean annual wind speed is 4.6 Km/hr with direction lies between the southwest and the northwest.

In general, the atmospheric pressure depends on two factors which are existing water vapour and temperature. The relation between it and its factors is reverse proportional. So, the city has an annual mean of atmospheric pressure about 949.8 mbar.

1.7.5.4 Precipitation

Precipitation is the main factor that affects the climate of the Mediterranean environment. In general, the rainy seasons in Nablus city are winter and spring. It usually starts in late October and continues through May. Between December and March, almost 80% of the annual rainfall occur, while 20% of the annual rainfall occurs usually in October and November (NM, 2024).

December and January are normally the wettest months in Nablus city. The amount of the mean annual rainfall in Nablus city varies from year to year and may reach 873mm (PCBS, 2024). According to the year 2018, the number of rainfall days in the city were 71 days. Figures A1 and A2 show the mean annual rainfall and the number of rainfall days Nablus city (PCBS, 2024).

1.7.6 Socio-Economic Conditions

As Nablus City, the Majority of this area's economy is dependent mainly on the trade sector. This sector represents 41.6% of the city's workforce. The industrial sector in the city is a vital sector too, and represents 24% of the cities' activities, which includes many industries, such as: Tahina, Stone-Cutting, Aluminium, Soap and Olive mill. Also, Skilled and unskilled labours work in it in a situation has minimum job opportunities (ARIJ, 2014).

This case resulted from that Nablus city is surrounded by different Israel Occupation barriers and checkpoints. It is surrounded by 13 Israeli settlements that prevent the city from its urban expansion. Also, the case contributes in separating Nablus city from the rest of the district (Aqel, 2019).

1.7.7 Importance of the Area

Nablus city one of the most important areas in Palestine, also it is considered as the largest commercial and cultural centre in Palestine (NNU, 2024a). It is a regional, vital and administrative centre. Also, it is a junction of industry and commerce with big and important educational facilities. The city embraces three main religions which are: Islamic, Christian and Jewish that represented in the Samaritan community which lives in Mountain Jerzim. Also, it is considered the first medically city in the middle and north of Palestine since it contains many advanced hospitals and medical centres, especially: Specialized Arab Hospital (SAH) and NNU Hospital which was built in 2013 (NNU, 2024b).

1.7.8 Water recourses

Nablus City is mainly fed with water from ground water by its wells and springs. There are five springs are feeding the city which are: Ra's Al-Ein, Ein Beit Al-Ma', Al-Qaryoun, Ein Dafnah and Ein Al-A'asal springs (Hudhud, 2006). N.M. is providing water by its public WN which was established in 1934. In 2021, approximately 14.4 million m^3 was the consumed water with estimated consumption equal 94 L/d/c (PCBS, 2021).

1.7.9 Sewage collection

The municipal WWN in Nablus city serves about 96% of inhabitants with a length about 230 Km. the western part of this network suffers from many problems like, illegal connections which lead to send the untreated WW to the WWTP especially the industrial WW (Abu Zant, 2024).

To conclude, a quick study such the current one in order to find an appropriate solution relate to industrial WW problems is needed to be submitted by identifying the problems and predicting the consequences in the future. Also, suggesting reducing measures that affecting the resulted risk to be less. Different methods will be implemented in this study rather than the risk assessment.

1.7.10 WWTP

Wastewater Treatment Plant (WWTP) in the west of Nablus represents the most vital project for Nablus Municipality. Nablus Wastewater Treatment Plant (NWWTP) located near Deir Sharaf and operated in June, 2013. This project is the second most expensive project in Palestine. It is funded by the Federal Republic of Germany through the German Development Bank - Kreditanstalt für Wiederaufbau (KfW) with total cost approximately equal 40 million euros.

Daily treated WW was estimated from 10,000 m^3 to 14,000 m^3. However, phase one of this project is continuing to 2020 which has a daily design flow capacity about 14,000 m^3 in the same year to serve about 150,000 inhabitants in the west of Nablus. The project consists of (NWWTP, 2016):

1. WWTP serving people who are living in the western part of Nablus city, Beit Wazan, Zawata, Beit Iba, Qusin and Deir Sharaf.
2. Main sewer line of 12 Km from Nablus City to the WWTP.
3. Storm water tank located in Beit Iba village.
4. Conducting WWNs for Beit Wazan, Beit Eba, Qusin and Deir Sharaf villages.
5. Implementation of Pre-treatment units for industries like Tahini, stone cutting factories, jeans factories etc.

6. Treated WW will be used for irrigation purposes for more than 3000 donums; includes reuse scheme inside and outside WWTP.

The main goal of establishment of WWTP is to contain the influent WW and using it in irrigation purposes after the needed treatment by achieving the following objectives (NWWTP, 2016):

1. Elimination of odours and epidemic diseases caused by WW flow in Nablus.
2. Protecting surface water and groundwater from pollution.
3. Preventing farmers from using untreated WW in their irrigation to protect environment and public health.

1.8 Literature Review

1.8.1 Overview

Literature reviews are a collection of the most relevant and significant publications regarding this study, such as: scientific papers, reports, past theses, past graduation projects, academic researches, websites, books and journals. This chapter is written in order to provide a comprehensive look at what has been said or done on this topic and by whom to get the needed depth knowledge.

This chapter discusses basically previous data and information in the field of risk management and industrial WW.

1.8.2 Risk Management

This section will give a summary about risk and its tools. Also, its multiple definitions, divisions and types from different sources will be mentioned.

1.8.2.1 Risk Definition

The success of any organization or institution depends on many things, from continually assessing, producing their offers and updating their data to optimize their processes and system. As this wasn’t enough of a challenge, they also need to study the unexpected events and its consequences in managing risk (ISO, 2018).

Different types of organizations and institutions may expose different internal and external factors and uncertainty conditions to achieve their scopes. This uncertainty effects on the organization's goal are called "risk" (ISO, 2009).

The word risk can be replaced by many words such as: chance, possibility, likelihood. In other cases, it could be synonymous with hazard, threat and danger. So, risk is always related to what can happen in the future (Rausand, 2013).

Definitions of risk can be found from many references and sources since there is no unique and universal definition. For example: The Institute of Internal Auditors (IIA) defined it as the uncertainty of an event occurring that could have effects and impacts on the achievement of objectives and it is measured in terms of consequences and likelihood. In order for assessing risk, an event must occur. So, it is generally accepted that risk is best defined by concentrating on risks as events.

Risk was defined by (Hopkin, 2018) that event with that ability to impact the mission, strategy, projects, operations and processes.

1.8.2.2 Risk Analysis

Risk can be analysed and managed in rational ways; the first tool is "risk analysis". Risk Analysis (RA) is very important to identify the causes of any harm events such as events caused by natural forces, to evaluate the possible consequences of the harmful events, to identify barriers, and finally to decide if the risk related to a system is tolerable (Rausand, 2013).

RA is an efficient method to predict and reduce the risks of occurrence of any accident in any system. RA techniques share in a common main goal, which is to provide an assurance that a system is designed and operated under an acceptable risk (Ferdous et al., 2012).

Munier (2014) mentioned that it is performed in order to provide answers to the following three main questions:

1. What can happen?

The possible hazardous events that may affect properties and assets such as people and the environment.

2. What is the probability?

It means that the probability of its occurrence of an accident. This question can be answered as probabilities or frequencies. By answering this question, the likelihood of the hazardous events that have to be identified in first question will be determined.

3. What are the consequences?

Consequence is the potential harm for each hazardous event. Answering this question will identify it. Then, every consequence or harm has to be managed by choosing the most appropriate barriers to the system.

Finally, by answering the mentioned three questions, risk will be clearly identified.

1.8.2.2.1 Hazard Identification

Hazard Identification (HI) is the first step to conduct RA. It is used to answer the first question for RA which is what can happen? So, all of predicted dangers and hazards that may cause harm or any consequence to assets and properties should be identified. It includes environment, people, proprieties, reputation or other types (Rausand, 2013).

HI is the process of finding, recognizing and describing risks that could affect the needed achievements (ISO, 2018).

According to (Rausand, 2013), the objectives of HI process are:

1. Identify all the hazards and hazardous events that are relevant to the system.
2. Describe the forms and quantity for each hazard.
3. Describe when and where in the system the hazard occurs.
4. Select the conditions that affect hazards to lead to a hazardous event.
5. Describe which pathways the hazard may follow.
6. Increase awareness for hazards and potential hazardous events.

There are different methods to conduct HI process. The most famous one is Preliminary Hazard Analysis (PHA). PHA is a simple method commonly used to identify hazards in the design phase of a system. Since its results are often updated, the analysis is called

"preliminary". The main technique used to update the results is conducting brainstorming sessions. Teamwork and brainstorming session used to come up with details about the events after choosing a list of generic hazards.

1.8.2.2.2 Casual and Frequency Analysis

To deal with the second question which is what is the probability of its occurrence and how will the hazardous event occur? It is important to identify and analyze the possible causes of the hazardous event. Fault Tree Analysis (FTA) method can be used to identify and analyze the causes of the current risk (Samaro et al., 2016).

Causal Analysis (CA) means analyzing and identifying the possible causes of the hazardous events. FTA is an efficient and commonly used tool for CA. It is suitable for quantitative and qualitative analysis of systems, as well as estimate the probability and corresponding consequence of each risk (Wu & Zhang, 2014).

1.8.2.2.3 Consequences of Hazardous Events

In this step, the predicted and possible consequences resulted from each hazardous event are identified and assessed. The assessment should consider both immediate and future harms. Several approaches can be used to assess:

1. The most probable case.
2. The worst conceivable case.
3. The worst credible case (the worst case that may reasonably occur).

The selected approach will mainly depend on the objectives of the PHA because it is the first step and it introduces the comprehensive RA study. The consequences include various categories, such as: people (inhabitants or employees), environment, facilities, equipment, reputation, and so on (Rausand, 2013).

Related to Samaro (2016) research, analyzing the third question which is "what are the consequences?" have to be performed by answering "How can the possible consequences of a hazardous event be determined?"

Event Tree Analysis (ETA) tool determines and analyzes the possible event sequences that may possibly happen after the occurrence of a hazardous event. It is used for modeling and analyzing the possible accident scenarios (Rausand, 2013).

Additionally, the Bow Tie Model can be used to illustrate the overall RA. It includes the hazardous events and threats and the barriers controls.

1.8.2.3 Risk Evaluation

Risk Evaluation (RE) is different from RA but they are correlated. RE is a process used for comparing risk analyses' results with risk criteria to determine a specified level of risk (ISO, 2018).

Another similar definition for RE introduced by (Refsdal et al., 2015), which is the process of comparing the results of the RA with the risk evaluation criteria which have to be defined during the context establishment to determine whether the risks are acceptable.

The main goal of RE is to help in taking decisions which are based on the outcomes of RA by prioritizing risks and its need for treatment and control barriers. It involves the process of comparing the level of risks found during the analysis process with risk criterion reference. In some situations, RE can lead to a decision to conduct further analysis or to a decision not to treat the risk in any way. Finally, it is the final step to conducting a comprehensive risk assessment (Munier, 2014).

1.8.2.4 Risk Assessment

Once the threats are illustrated, they have to be assessed. So, risk assessment is done after RA and RE are carried out in one joint process (Munier, 2014). Risk assessment is defined as the overall process that resulted from three separated processes which are: risk identification, RA and RE (Samaro, 2016).

(Munier, 2014) said that risk assessment is the process of analyzing and evaluating risks to find out the most appropriate methods and control barriers to reduce the effects and impacts of the hazards. RA used to identify and understand the causes and sources of the risk. Then, RE results are used to determine the level of risk and the risk is can be accepted or not.

Risk assessment strategy depends mainly on the nature of the event or hazard. So, it may be classified in many different ways (Rausand, 2013).

- **Qualitative Risk Analysis**

A qualitative risk analysis way uses words and qualitative descriptive scales to describe the severity of the potential harms that may result from the events and the frequency of the identified hazardous events. The scales can be adapted or modified and different descriptions can be used.

- **Quantitative Risk Analysis**

A quantitative risk analysis way uses numerical values for frequencies, consequences, and severities. These values depend mainly on the event itself and it may come from many different sources.

- **Semi-quantitative Risk Analysis**

In this way, values are given to the qualitative scales. These values and numbers do not have any accurate relation to the actual magnitude of the severity and frequency and it can be combined in many ways to present a risk picture.

The objective of this way is to illustrate more detailed prioritization than may be achieved in a qualitative analysis and not to suggest any realistic values for the risk as in a quantitative analysis.

After that, the trends in system improvement to get less risks should be directed toward the eliminating or minimizing the potential threats of the events by applying different methods of risk management after choosing the control barriers or reducing measures (Karkoszka, 2015).

1.8.2.5 Risk Management

Risk management has many origins and is practiced by a wide range of people. One of the early developments in risk management has been correlated with insurance sector in the United States. Then, risk management practice and use became more widespread and better coordinated. It has a continuously relationship with finance, commercial, marketplace and reputational issues. Different approaches of risk management are existed (Hopkin, 2018).

Conrow (2003) defined risk management as the act or practice of dealing with risks to document overall risk picture for the system by conducting the following steps:

1. Planning for risk.
2. Risk assessment (identifying and analyzing) risk issues.
3. Developing risk handling options.
4. Risks Monitoring.

After finalizing RA by identifying and analyzing the current situation, choosing a suitable and adaption plans and developing mitigation approaches for the critical risks should be done. This process means Risk Control (RC). After conducting RC regarding to RA, risk management will be achieved. Also, brainstorming sessions are very important during this process to get several additional options (Samaro et al., 2016).

1.8.2.5.1 Risk Management Process

Regardless of sector, type and impact, different steps have to be followed and analyzed to ensure comprehensive, efficient and effective risk management process. These steps allow to risk management process to be credible to make the needed improvement and reach the long-term goal (Rausand, 2013).

1.8.2.5.2 Risk Control

To make well-designed system, it must have safety or protection equipment to protect people, environment, properties and other assets against harms that could occur in the systems. This equipment has several terms such as: barriers, safety barriers, safety critical junctions, mitigation options, defense measures and layers of protection. All of the previous names are correlated because they are physical or nonphysical planned tools to prevent, control and mitigate undesired events (Rausand, 2013).

RC means the process of finding the most appropriate mitigation options and barriers for the hazards. Barriers can be classified into two main types which are (Rausand, 2013):

- Proactive barrier: A barrier that is installed to prevent occurring the accident or reducing the probability of a hazardous event. It is also called frequency-reducing barrier.

- Reactive barrier: A barrier that is installed after occurring the accident to avoid, or reduce the consequences of a hazardous event. It is also called consequence-reducing barrier or mitigating barrier.

Hopkin (2018) said that conducting the previous barriers effectively lead the system to prevent or reduce the losses and damages. This process called Loss Prevention and it represents the main goal for RC because it contributes in both:

1. Damage limitation: which is concerned with reducing the amount of harms that occurs by the hazardous event.

2. Cost containment: which is concerned with minimizing the impact of the loss on the system by reducing the resulted cost to the minimum.

Loss prevention has different techniques and it will vary according to the type of hazards that is being considered. For example, for health and safety risks, loss prevention is related to ensure the hazardous event will not be used in the system or eliminate the activity completely. But for risks in buildings, the techniques involve some controls like restrictions on smoking.

1.8.2.5.3 Risk Cost Benefits Analysis

All results from risk analyses have to be used as input to decision-making process. General argument happened in this step to select the choice concerned with whether the risk has to be reduced or it should be unnecessary to make this decision to avoid risk. It refers to cost or practical reasons which should be related with quantitative or qualitative risk acceptance criteria. Within using the quantitative approach, level of risk has to be weighted according to the corresponding benefits to pose minimal potential for adverse effects. Making a trade-off between the risk reduction's cost and benefits must done before spending money to reduce the risk. It can be expressed as dollars per

impact and taking into consideration main three elements which are: equity, utility and technology.

Also Jones-Lee & Aven (2011) added that ALARP principle may assists in this step which means As Low as low as Reasonably Practicable to regulate the risk management for a hazard by considering the need for reducing the risk and the cost of risk reduction. ALARP divides the risk into three regions, which are:

1. Unacceptable region: risk is intolerable, and risk reduction measures are mandatory.

2. Middle region: Also named ALARP region, where risk reduction measures are desirable depending on cost and the benefit gained.

3. Broadly acceptable region: risk reduction measures in uneconomical and no need for risk reduction measures.

To decide if the risk is acceptable or not, cost benefit approach can be implemented depending mainly on grossly disproportionate concept between the cost of the risk and the benefit gained (Adler & Posner, 2001).

It can be done by estimating Proportion Factor (d) as the following equation (Achille et al., 2017):

$$d = \frac{\text{cost of the risk reduction measure}}{\text{benefit of the risk reduction}} \quad (1.1)$$

Cost of the risk reduction measure is an estimation of the total cost which taking purchase, installation, training and the operation of the system into consideration.

Before estimating the actual proportion factor (d), disproportionality limit (do) must be defined. Then, if the d is less than do, the risk reduction measure should be implemented, and if d larger than do, it should not be implemented. All estimations have to be concerned with societal risk criteria.

The main problem in this method that the costs are deterministic, whereas the benefits are probabilistic (Rausand, 2013).

The essence of a CBA is weighing up different system alternatives by comparing cost and benefits on society and economy. Generally, it is used in the final stages of the

decision-making process, but it is advisable to involve all stakeholders in the early stage in conducting CBA process.

In the beginning, it includes preparatory phase that describes the problems and alternatives. Since the core of the CBA is the determination of the costs and benefits, analysis and handling of variants and risks have to be conducted.

During the previous steps, effectiveness and efficiency have to be taken into consideration. Effectiveness refers to how useful something is, which concerned here to policy or choice contribution to solving the problem. Efficiency refers to how well something is done, expressed here to magnitude of the expected costs and benefits and choosing the aspects or components (Romijn & Renes, 2013).

According to (CDEMA, 2014), risk reduction has to study many angles; economic, social, cultural, environmental and political. Different tools can be used to estimate the best scenarios for risk reduction, such as: CBA, Cost Effectiveness Analysis (CEA), Multi Criteria Analysis (MCA), Environmental Impact Assessment (EIA) and Social Impact Assessment (SIM).

- CBA method is used to compare costs and benefits monetarily over a period of time.
- CEA is similar to CBA but it doesn't show whether the benefits outweigh the costs or not, but shows which alternative has the lowest costs with the same level of benefits.
- MCA considers many criteria treatments and in contrast to CBA, it doesn't require the monetization of all the impacts.
- The output of EIA and SIM could be linked to the outcome of a CBA.

To assess the economic and financial acceptance of risk reduction measures, CBA is preferred to be used by doing the following steps:

1. Selecting the hazards and risk identification.
2. Risk analysis and potential impacts.
3. Analysis of risk reduction.

4. Calculating the net benefits of the reduction.

5. Estimating the cost of risk management.

In this case, costs are the needed expenditures to set the barriers to reduce or prevent the risk, and benefits are the avoided or reduced potential damages and losses. The reduced or avoided damages can be direct or indirect damages.

No clear relation between direct or indirect damages. Direct damages are related with damageable property. It can be expresses as the magnitude of the cost that may be paid for property restoration to its conditions before the event or the loss in its market value. Indirect damages are resulted for economy disruption like stopping of traffic flow.

Also, damages can be monetary (tangible) that can be expressed in terms of monetary value or non-monetary (intangible) that can't be expressed in terms of monetary because it is related with high emotional, cultural, environmental and religious values.

CBA should be guided by the principle of proportionality. It means that the conducted effort to do CBA should be commensurate with the level and need of expected impact. The objective of CBA is to estimate the net impact of a policy (GOC, 2023).

A fundamental tool may be considered which is the Willingness to Pay (WTP). It means that the amount (demand price) that an individuals or company are willing to pay for a unit of a good or service which related generally to its economic benefit for the economy and especially to its economic value for the demander.

GOC (2023) mentioned that the evaluation of benefits is more challenging for many sectors because of the absence of markets, but there are different methods to measure the benefits by primary guiding principle which is WTP with many techniques such as:

1. Correcting Market Prices for Distortions: it concerns to market prices which are competitive and not distorted by taxes and other effects.

2. Revealed Preference Methods: it uses data obtained by observing the individuals' actual choices.

3. Stated Reference Methods: it depends on information obtained through direct survey approach on value placed on goods or services.

4. Benefit Transfer Methods: it relies on information from past existing studies.

Benefits measuring in a quantitative approach assists in understanding the magnitude of the effects of alternative policies, while some benefits can't be measured in monetary terms.

In CBA, costs are simply the costs of the resources used to implement a policy. It may be direct and indirect. Indirect costs associated with some particular cases, but direct costs can be divided to:

a. Administrative costs incurred by government. These costs can be either capital or operating costs, such as: administration, monitoring and execution costs.

b. Compliance costs related to the private sector to operate within the policy rules, such as: capital costs, operating, maintenance, administrative and environment protection costs.

1.8.2.5.4 Benefits of Risk Management Process

According to Rausand (2013), there is no zero risk. So, risk management process has to be taken into consideration in any system which is anything has boundary regardless if it is physical or imaginary. It has to be conducted for both chronic accidents which are occurring at a long time at a reduced magnitude or acute which are occurring at very short time with large magnitude.

The primary reason for doing risk management is finalizing decision making process to achieve successfully the desired goal which is the long-term objective for any system. It is applied to all types of the decision making which are:

1. Deterministic: decision regardless consequence and it is generally top management approach.

2. Risk Based Decision Making (RBDM): decision taken according to risk management process only.

3. Risk Informed Decision Making (RIDM): decision taken according to risk management process and past experience.

Moreover, the general benefits of risk management can be explained as a reduction of the different hazards and accidents threatening a system

The following points summarize the major benefits of using risk management process (Mok et al., 1997):

1. It allows taking systematic, logical, judgemental and intuitional decisions, especially the complex decision problems.

2. It easily contributes in interpreting the cost estimates.

3. It discusses the uncertainty in a realistic manner.

4. It provides a different guideline to aid problems and finding alternative options.

1.8.2.6 Risk Benefits Analysis Estimation

Generally, risk benefits are qualitative, but sometimes it has to be converted to quantitative terms. For example, the resulted benefits from awareness campaigns depend mainly on: duration, target people, campaigns' expenditures and dose of intervention (Cavill & Bauman, 2004).

The result of implementation of laws in industries is considered as the major motivation to enter to the international market. Many benefits are resulted from the industries' commitment in local laws and legal instructions, such as: enhancing environmental awareness of suppliers, saving resources and improving corporate image (Zeng et al., 2005).

1.8.3 Industrial Wastewater

1.8.3.1 Wastewater Definition and Contents

Warwick et al. (2013) defined WW as a wide range mix containing water with significant concentrations of solids (total solids 350–1200 mg/L), dissolved and particulate matter (chemical oxygen demand 250–1000 mg/L), and microorganisms (up to 109 number/ml). Also, it contains nutrients, heavy metals, micro-pollutants, phosphate compounds and other anions found in wastewater include chloride, nitrate and sulphate.

As Nablus city, the approximated quantity of generated WW is 12,528 m^3 daily, or 4.6 million cubic meters annually. At the individual level, WW generation is approximately 89 L/d (ARIJ, 2014).

1.8.3.2 Wastewater Network (WWN)

WWN represented by sewer pipes, manholes and pumps. Sewers collect WW from houses, industries and other different facilities to deliver it to manholes then to WW treatment facilities before it is discharged to water bodies or land, or reused (EPA, 2024).

As mentioned in section (1.7.9), the municipal WWN in Nablus city serves about 96% of people who lives in the city with a length of 230 Km. The western part of this network suffers from many problems like, illegal connections which lead to send the untreated WW to the WWTP especially the industrial WW.

The responsible of WWN management in N.M. is Water and Wastewater Directorate in the municipality. It provides water to the city and the surrounding region, in addition to execute and maintain WWN and pipes. Furthermore, this directorate has actual contribution for improving environmental situation in the city (NM, 2024).

1.8.3.3 Industrial Wastewater Situation

WW discharges from industrial sources may contains different pollutants at levels that could affect two main issues (EPA, 2024):

1. Quality of receiving waters.

2. Publicly owned treatment works that receive those discharges.

W.A.L (2023) defines industrial waste as being the liquid, solid or gaseous generated by any business, industry, and manufacturing premises other than domestic sewage, storm water, or unpolluted water.

Industrial wastes contain 60% of all contaminants in seas and rivers. Most of the pollutants are mainly sourced from factories such as tanning, lead, paint, glass, detergents, dairy factories, slaughterhouses, sugar refineries and pollution of hydrocarbons which resulted from oil pollution (Younis & Al-Sa'ed, 2019).

EQA (2022) pointed out that the industrial sector in Palestine is known as a major source of various forms of environmental pollution because it producing hazardous chemical pollutants and solid, liquid and gaseous waste.

As for industrial WW, 59.9% of Palestinian factories dispose of their WW in the municipal WWN, which leads to put these networks under a risk of damage by the chemicals which found in industrial effluents. In addition, 29.9% of the factories discharge their WW into cesspits, putting groundwater under the risk of pollution.

Industrial WW discharges form about 7% of municipal WW stream in Palestine. This percentage is produced by different types of industries such as: slaughterhouses, stone cutting, leather, tanneries, and olive oil mills industries. These industries' WW has high loads of organic and inorganic pollution, which have diversified hazards represented by costs, quality of treatment, environment pollution and public health. This lead to make industrial WW treatment and management as a priority of the municipalities and governmental related parties, but treating this industrial WW faces many challenges in Palestine as the following (Diab, 2020):

1. High pollution loads because the lacking or absence of the needed pre-treatment.
2. Not enough WWNs to all factories because the random spreading of factories and industrial businesses.
3. Absence of the ability to separate the domestic WW form industrial WW due to the lack of industrial zones.
4. Inapplicable laws and regulations for discharged WW.

There are many different laws and regulations regarding industrial WW in Palestine such as (Ahmada et al., 2022):

1. Public Health Law No. 20 of 2004.
2. Law No. 7 of 1999 on the environment.
3. Decree-Law No. 14 of 2014 on water.
4. Decree Law No. 10 of 2011 on Industry.

5. Local Authorities Law No. 1 of 1997.

6. Presidential Decree No. 22 of 2003 on the Competence of Governors.

7. By- law governing house and facilities connection system to the public sewerage network 2013.

Chapter Two

Methods

2.1 Overview

In this study, a RBM Approach will be used in order to analyze the current situation of industrial WW in Nablus District, find out ‘what is happening’ and then seek for new economical solutions and conducting the needed calculations.

2.2 Research Approach

This section includes two parts that will give a brief summary about RBM concept, definition and steps.

2.2.1 Risk Based Management Concept

Risk is basically related to what can happen in the future, so it can be managed and analysed in different rational ways. To conduct Risk Management, three questions have to be answered for any system or event. These questions are:

1. What can go wrong?
2. What are the consequences?
3. At what frequency?

The first tool used in risk management is the RA. It is an efficient way to predict the occurrence of an accident by conducting needed brainstorming sessions. So, the question of what can go wrong can be answered by applying PHA. After applying PHA, RE will be used to select the priorities. Then, the needed barriers have to be considered in both proactive and reactive situations. Finally, cost and benefit for each barrier have to be estimated by RCBA.

After the analysis and management steps, and before giving the last conclusion and recommendations, a brainstorming session was held at Qalqilya Municipality. Different engineers and accountants attended the session and suggested additional insights for achieving best risk management practices. List of attendance are attached in Appendix (A).

2.2.2 Proposed Steps

The main point in risk management method is risk analysis for the industrial WW in the city of Nablus. By implementing the risk management approach, the analysis helps giving insights for a successful mitigation plan for the current risks.

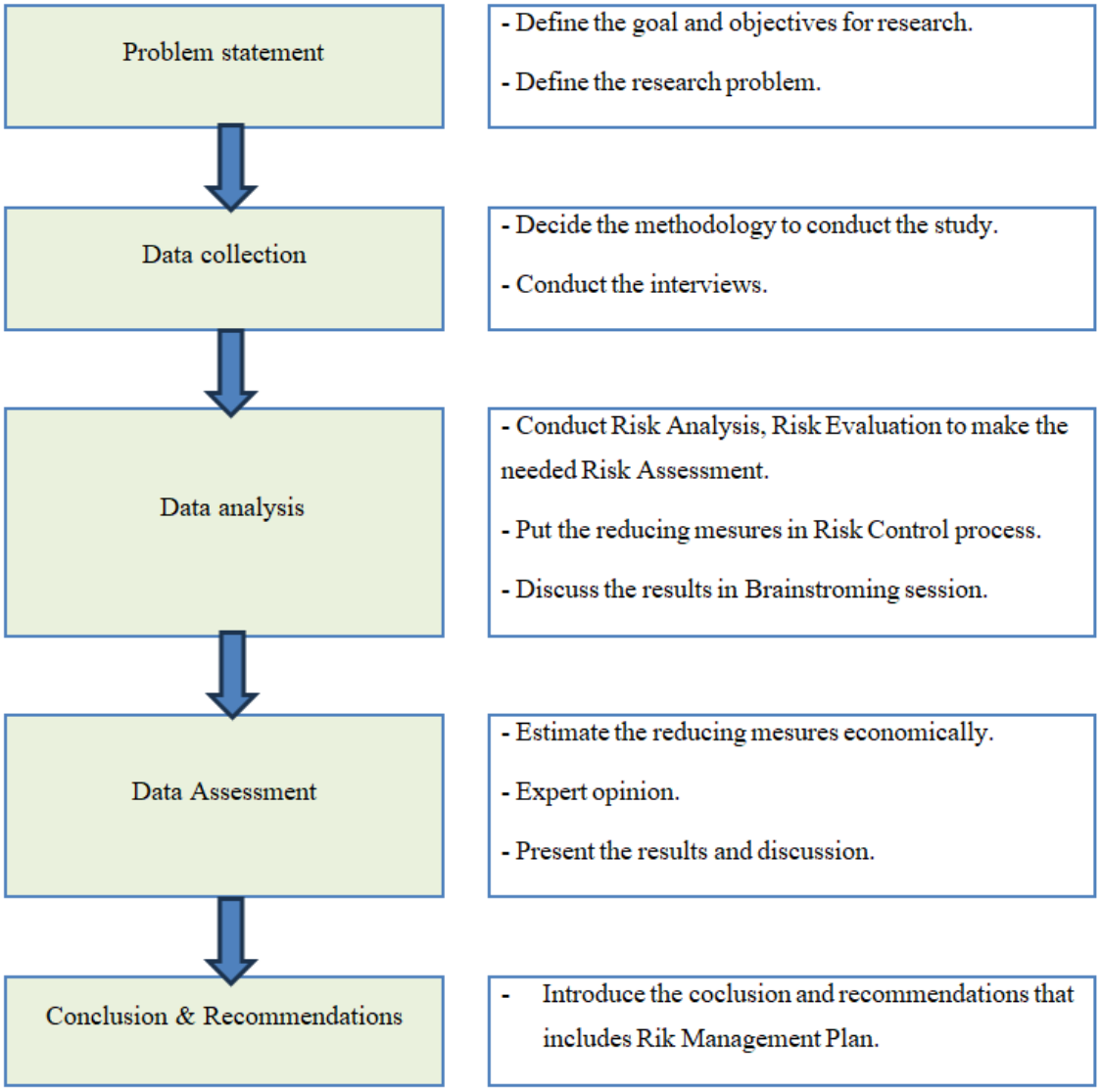
In order to achieve the objectives of this study, a proposed steps to conduct Risk Management Plan are summarized as follows:

- Data will be collected by reviewing existing literatures and publications.
- Interviews and communications with different related parties will be conducted in order to collect more data about the current situation and improve the risk analysis.
- After analysing the collected data, the causes of the current risk will be identified by using PHA.
- Risk will be evaluated, and control measurements will be recommended, in addition to introducing mitigation options.
- The best management strategies will be selected to reduce the effects of industrial WW on WWTP and the municipal infrastructure after making a brainstorming session, and expert opinion will be considered.
- RCBA will be applied for the selected barriers.
- A conclusion will abstract the results of the study. Also, recommendations to reach the best solutions will be mentioned.

Figure (2.1) summarizes the methodology flowchart of this research.

Figure 2.1

Methodology flowchart



Chapter Three

Results

In this chapter, the data collected through literature, studies and other tools were analyzed and explained.

This analysis contains types of the industries in the city after collecting the needed data about WWN situation and industrial WW in Nablus city that was conducted in chapter two and three.

3.1 Data Collection

This section includes the collected data about the industries in Nablus city which are represented by numbers and the types of industries in the city.

According to (Kharraz, 2024), Nablus city has 224 main factories within its area and adjacent villages distributed in two parts; east and west. Comparing to its area, it has a huge number of factories within its boundaries and its surrounding regions. Industrial sectors in Nablus can be divided in this study into eight main types as follows:

1. Stone – cutting and marble industry.
2. Tahina industry.
3. Slaughterhouses.
4. Olive oil mill industry.
5. Jeans washing industry.
6. Dairy industry.
7. Other heavy industries: tannery and aluminium industry.
8. Light industries: soap, shoes, chemical detergents, sewing, shoes, juice, food, sweets, construction products, glass and ice cream.

Since the western part contains over than 61.61% form the factories that represented in 138 main factories and the other 86 in the eastern part, it is considered as a primary vital industrial region and it was chosen as a projected area as mentioned in section 1.7.3.2.

According to ECU in N.M., the last update for number and types of factories in Nablus city was in 2023.

Table (3.1) shows the number of factories for each type in the year of 2023 (Kharraz, 2024).

Table 3.1

Nablus's factories number and types

#	Industry Sector	Location		No. of Factories
		East	West	
1	Stone – Cutting and Marble	24	41	65
2	Tahina	12	11	22
3	Olive Oil Mill	3	4	7
4	Jeans Washing	1	2	3
5	Slaughterhouses	1	6	7
6	Dairy	1	0	1
7	Others	0	2	2
	1 Tannery	0	1	1
	2 Aluminium	0	1	1
8	Light industries	44	72	116
#	Total	86	138	224

(Kharraz, 2024)

3.2 Heavy Industries' WW and its hazards

As mentioned in the previous section, the city has eight main types of industries. This section summarizes the effluent WW from factories and its effects on WWN and WWTP.

3.2.1 Description of the Main Heavy Industries' WW

This subsection describes the WW which results from the main six heavy industries in Nablus city (Stone – Cutting and marble, Tahina, Olive Oil Mill, Jeans Washing, Slaughterhouses and Dairy industries). Also, it shows the need for pre-treatment for the various industries as the following points:

1. Stone – Cutting and Marble Industry

This industry produces huge amount of WW which has no organic content. Therefore, it is not suitable for discharge into municipal WWN even after pre-treatment to remove the solids.

2. Tahina Industry

This WW has high content of organic and salts. Table (3.2) shows these contents in Tahina WW.

Table 3.2

Tahina WW contents

#	Parameter	Average Actual Content (mg/L)	2013 By-Law limit (mg/L)	Acceptable (Yes/ No)
1	COD	4,000 – 12,000	2,000	No
2	Chloride content	30,000 – 35,000	500	No

The organic content is easily biodegradable. So, it can be discharged into the municipal WWN, but the COD is about 2-6 times higher than the acceptable limitations in 2013 By-Law limit.

The chloride content is about 65 times the 2013 By-Law limit. Also, excessive sodium can cause decreased soil permeability when the effluent is reused for irrigation as planned.

3. Olive Oil Mill Industry

Olive juice that extracted from the olives represents the main polluting agent in olive oil mill industry since it contains the Black Water or Zibar. It is produced by the decanting process used to extract oil from the olives. This black water has very high COD, phenols and other toxic substance. Table (3.3) shows the COD content in olive oil industry's WW.

Table 3.3

Olive Oil Mill WW contents

#	Parameter	Actual Content (mg/L)	2013 By-Law limit (mg/L)	Acceptable (Yes/ No)
1	COD	100,000 – 120,000	2,000	No

4. Jeans Washing Industry

WW resulting from this type of industry is basically interfering with the WWTP ultraviolet light disinfection process. It contains very high concentrations of dye resulting from the washing of the jeans.

5. Slaughterhouses Industry

This industry produces blood of the animals with its high COD concentration make it enormous pollution source (see table 3.4). Also, bones and other carcass debris lead to high hazard to the WWN and WWTP.

Table 3.4

Slaughterhouses WW contents

#	Parameter	Actual Content (mg/L)	2013 By-Law limit (mg/L)	Acceptable (Yes/ No)
1	COD	400,000	2,000	No

6. Dairy Industry

The main polluting agents in this industry are whey and wash down water since this water containing small quantities of milk. Both previous components are biodegradable in the aerobic treatment process, but the problem that it requires high oxygen demand on the municipal treatment process. The grease and fat content also can enhance foaming aggravating in the treatment process.

3.2.2 Risks to WWN, WWTP and Environment

There are many risks to the proper functioning of both WWN and WWTP without conducting the needed pre-treatment of the discharged industrial WW resulting different threats to the public health and environment, particularly if this WW is being reused. In addition to that, increasing the operational costs to the municipality and WWTP.

- **Stone Cutting and Marble Industry**

Stone cutting and marble industry has high risk on WWN, which is represented in the solids resulted from the stone-cutter factories. Theses solids will clog the sewer pipes thus, the WWN system, leading to raw sewage overflows into manholes and streets.

This material will also overload both the grit removal and primary settling equipment. This will contribute greatly in shortening the useful life of the equipment and WWTP. Therefore, increasing the operational cost by increasing the financial cost process on the municipality or the WWTP budget.

- **Tahina Industry**

During Tahina production process, the resulted salty waste contributes directly in the corrosion and failure of concrete sewer pipes in the municipal WWN when receiving the WW discharge from these factories.

Also, plants and crops that can be irrigated with resulted reuse water are affected harmfully by the excessive salt concentrations in the WW. This will also lead to reduce the permeability of the soil since the salts will accumulate in the top soil layers.

- **Olive Oil Mill Industry**

The resulted Black Water or Zibar from extracting oil from the olives process in olive oil mill industry has very high COD which is about 50-60 times higher than the acceptable limits. Resulted phenols and the other toxic substances will increase the toxicity of WW. Therefore, increasing the operational cost to treat this WW in WWTP.

- **Jeans Washing Industry**

The effectiveness of the disinfection process at WWTP will decrease if the waste dye discharged in great quantities, particularly if ultraviolet light is used.

- **Dairy Industry**

The high COD concentrations cause odour problems and create hydrogen sulphide and explosive methane formation in WWN during WW discharge.

At headworks and primary settling processes of the WWTP, odours problems happen. Also, overload the aeration equipment and dramatically increase the volume of waste solids to be digested, dewatered and disposed of. This will lead to reduce the effectiveness of the WW treatment process and increasing the operational costs of the WWTP.

- **Slaughterhouse Industry**

In this type of industry, similar effects as the dairy industry WW will happen if the blood is not separated since it has a high concentration of COD. Also, a very high odours concentration will be existed.

The solids from this WW will affect the sewer pipes and clog the WWN system by creating different handling issues. Therefore, damages in the headworks equipment and WWTP equipment could possibly exist.

Table (3.5) summaries the main effects of industrial WW on WWN and WWTP.

Table 3.5

Main effects of industrial WW

#	Industry	Effects on	
		WWN	WWTP
1	Stone-Cutting and Marble	Clog the sewer system which resulting in raw sewage overflows into the streets.	Overload the grit removal and primary settling equipment, greatly shortening the useful life of the equipment and increasing the financial burden and the maintenance cost on the municipality.
2	Tahina	Corrosion and failure of concrete sewers.	Increasing the operational cost of treatment process.
3	Olive Oil	Increasing the toxicity of WW because WW contains Zibar with very high COD, phenols and other toxic substances.	Increase the toxicity of WW and the treatment process operational cost.
4	Jeans Washing	Hazards to environment and public health due to pathogenic organisms passing into WWN.	Decrease the effectiveness of the disinfection process and basically interfering with the WWTP ultraviolet light disinfection process.
5	Slaughterhouses	Clogging, corrosion and failure of the sewer system which resulting in overflows into the streets. Also, same effects as the dairy industry WW especially odours problem.	Damage the headworks equipment and increasing the maintenance cost.
6	Dairy	Odour problems and create hydrogen sulphide and explosive methane formation.	Overload the aeration equipment, increase the volume of waste solids to be digested, dewatered and disposed of, reducing the effectiveness of WW treatment process and increasing the operational costs. Requires high oxygen demands and enhance foaming aggravating for treatment process.

3.3 Risk Based Management

This section includes the main tools to assess the conducting of the Risk Management process of industrial WW in the city of Nablus. PHA is the main tool. A risk assessment will be conducted by PHA and RE. RC by selecting the most suitable barriers to prevent the hazardous event from happening will be added to risk assessment to Preparer a comprehensive Risk Management study as shown in figure (3.1).

Figure 3.1

Risk management

3.3.1 Risk Definition

Risk is a primary process for achieving the success of any organization, institution, company and systems, but there is no unique and worldwide definition for risk. In general, it is a synonym for the word "uncertainty" and it is correlated directly with events, future, probability and decision making. The objective of risk is to prevent damage on four main parameters which are:

1. Human or public health.
2. Property as assets or financed.
3. Environment.

4. Reputation.

So, risk can be defined as the uncertainty of occurring any hazardous event in a system. Risk analysis is conducted by using different analytical approaches and tools for the best decision making to face what can happen in future.

3.3.2 Risk Analysis (RA)

Any hazardous event has different harms, hazards and side effects on any system. So, these hazards have to be identified in detail to analyse the possible risk. The definition of RA is a systematic approach which is considered as the first tool in risk management process used to analyse and identify the possible hazards and consequences. To conduct RA, three main questions regarding industrial WW have to be answered which are:

1. What can go wrong?

2. What is the probability or at what frequency?

3. What are the consequences?

To answer the first question, HI process has to be carried out. it considers different issues to define any hazardous event that can happen by the industrial WW. This tool introduces any past, existing or future risk that can be resulted from the effects of the industrial WW. In this study, risks to WWN itself and WWTP and its consequences to people, assets, environment and reputation will be considered. Brainstorming sessions are an effective approach in this stage since it considering hazards, its forms and pathways, conditions, how can happen and when and where it can be happened.

PHA is the most efficient tool for conducting HI. It is represented as table correlated with the main three questions' answers which illustrates the possible hazardous events for the industrial WW, its causes, its consequences, its reducing measures and its priority.

The second question can be answered by analysing how and when the hazard will occur. After the conducting HI, the likelihood of occurrence for every hazardous event has to be discussed in order to arrange these hazards in terms of its consequences. It includes the minor accidents which are happening not very often and the major accidents.

In this study, two systems were selected as affected directly by industrial WW which are:

- Wastewater Network (WWN).
- Wastewater Treatment Plant (WWTP).

The first question was answered by identifying the main hazardous events that could result from these previous systems regardless the source or causes of these events as follows:

A. Hazardous events from WWN system:

1. Floods in WWN.
2. Pipes breaking.
3. Incorrect practices.
4. Industrial WW effluent.
5. Rising of WWNs material price
6. Loss of expertise.

B. Hazardous events from WWTP system:

1. Shortening the useful life of the equipment.
2. Increasing the operational cost.
3. Industrial WW effluent.

Then, all of the hazardous events were analysed in terms of hazards, which are: human, properties, environment and reputation to explore its causes.

Table B1 shows the correlation between the WWN hazardous events and human, assets, environment and reputation before conducting PHA.

PHA table will be divided into four parts in WWN System. Then, every part will include the hazardous events that have the correlation according to the previous figure. The same process will be applied on WWTP system.

Table B2 shows the correlation between the WWTP hazardous events and human, assets, environment and reputation before conducting PHA.

Finally, to find all possible causes, consequences and side effects which may result from each system. PHA will be conducted.

Table B3 represents PHA approach to complete RA process.

3.3.3 Risk Evaluation (RE)

This process concept is the judgmental tolerability of the risk process to decide if the risk is accepted for our willingness to live with it or not. In this process, all hazards have to be evaluated considering different factors and clear criteria called risk acceptance criteria which are considered as basis to choose the acceptable risk. So, it means comparing the results of RA with risk acceptance criteria. RE indicates to the hazards needs for the barriers and reducing measure. So, it is the main link bridge between the processes of RA and RC.

Every hazardous event was given a Risk Priority Number (RPN) which is an indicator of the degree of severity of a hazardous event. It results from the frequency plus consequence degrees for the hazardous event. Frequency and consequence degrees for the hazardous event were put as a criterion to get the RPN from the risk matrix.

Risk matrix is a table including five rows that represent the consequence degrees for the hazardous events starting from degree 1 to 5 in ascending order in terms of its consequences intensity. These degrees were added mathematically to another five degrees of probabilities which are exist in the five columns in ascending order. The mathematical results indicate to the rank of the hazardous event which is RPN.

Then, to complete the needed RE, three scenarios were put and examined, light risk, medium risk and high risk according to the resulted RPN, which is an indictor to degree of severity. According to judgmental approach, every scenario will represent the resulted RPNs.

The risk matrix which will be followed and the Scenarios' of RPN are shown in table B4.

For each scenario, the consequences and the probability have been listed in terms of four elements: people, assets, environment and reputation. So, four risk matrices were conducted separately.

All of the hazardous events that affect WWN and WWTP were got a symbol to indicate to it in the matrix as in table B5.

Then, hazardous events will be tested in four matrices which are people, assets, environment and reputation risk matrices. Every hazardous event that may result for WWN and WWTP has been tested separately by estimating its consequences and frequency. The hazardous event’s frequency is constant for the four matrices since the frequency depends on its probability and time. All of these estimations have taken into consideration a judgmental approach. The four matrices were conducted as follows:

A. Human Risk Matrix

In human or people risk matrix, the consequences were estimated by using judgment approach to measure its effects on people and inhabitants. These consequences may lead to different types of injuries and hits people in streets. Also, it can lead to fatality or more. Table B6 shows People Risk Matrix.

WWN:

As shown in table B6, rising of WWNs material price and loss of expertise will not result any injury and fatality for people and its occurrence is not permanent, thus it took a small RPNs which are 3 and 4. So, it is located in the light and medium risk regions.

Floods in WWN and pipes breaking are likely and very likely happening, but its effect is minor since this flood can cause simple vehicles accidents or people toboggans in the streets. These hazardous events locate in the medium risk region.

Incorrect practices and industrial WW effluent are happing very likely in Nablus and its effect are high since they may result in major injury or a fatality. It got a RBNs 8 and 9 and they located in the high-risk region.

WWTP:

Increasing the operational cost was getting RPN 5 because the operational cost doesn't correlate with human health, but shortening the useful life of equipment may lead to crew injuries, but its effects are minor to people and were located in the medium risk region.

Industrial WW effluent is happening very likely in Nablus WWTP and it may result in major injuries in WWTP labours and crew. So, it located in the high-risk region with RPN.

B. Assets Risk Matrix

Assets risk matrix taking into consideration the consequences on people properties and municipality infrastructure. The effects of the hazardous events could result an extensive damage as shown in table B7.

WWN:

As shown in table B7, rising of WWNs material price and loss of expertise will not result any damages for assets and properties and its happening is not permanent, thus it took a small RPNs 3 and 4 and it is located in the light risk region.

The medium risk region included Floods in WWN, pipes breaking and incorrect practices hazardous events because they are always happening, but its effects are minor or less on assets since this flood can cause simple vehicles accidents or closing shops and streets.

Industrial WW effluent is located in the high-risk region because they are happing very likely in Nablus and its effect are high since they may result in minor damages and faults in WWN pipes and WWN system generally.

WWTP:

Shortening the useful life of equipment and increasing the operational cost were getting RPN 7 and located in the medium risk region because they may result in simple or main faults in equipment.

Industrial WW effluent is very dangerous. It is happening very likely in Nablus WWTP and it causes extensive damages in WWTP equipment. So, it took the highest RPN.

C. Environment Risk Matrix

In this type of matrix, the consequences were estimated due to its effects on the surrounding environment. Some of them have slight to minor effects, but the others may have a massive impact on the environment as shown in table B8.

WWN:

Table B8 showed that rising of WWNs material price took the smallest RPN in this case because it will not result any effects on the environment and its happening is rare.

Loss of expertise and pipes breaking are likely happening, but its effect is slight on the environment since they can cause simple leakage to the streets and light odours concentration. These hazardous events located in the medium risk region.

Three of WWN hazardous events were located in the high-risk region, which are: Floods in WWN, Incorrect practises and industrial WW effluent. Their frequencies are very high in Nablus and its effects are noticed very well to the environment since they may result in stopping the WWN system work and spreading a high odours concentration.

WWTP:

Shortening the useful life of equipment and increasing the operational cost were got RPN 4 and 5 located in the light and medium risk regions.

Industrial WW effluent took an RPN 9 because it is happening always in Nablus WWTP and leads to major effect on the surrounding environment of WWTP.

D. Reputation Risk Matrix

This risk matrix is mainly dependent on Nablus Municipality reputation. The impact of the hazardous events could be local or national, but the main problem if it affected internationally.

Table B9 shows reputation Risk Matrix.

WWN:

As shown in table B9, rising of WWNs material price and loss of expertise will result minor impact or no impact on reputation because it leads to higher fees on people, thus it took a small RPN 4 and it is located in the light risk region.

Pipes breakings are likely happening in Nablus, but its effect is limited on reputation because they concerned with inhabitants' opinions on the N.M. These hazardous events are located in the medium risk region.

Floods in WWN and Incorrect practices are happing very likely in Nablus and its effects are limited to reputation since they may result in absence of inhabitants' confidence to N.M., but industrial WW effluent has a national impact.

WWTP:

Shortening the useful life of equipment and increasing the operational cost were got RPN 4 and 5 they located in the light and medium risk region. There are no effects on reputation.

Industrial WW effluent leads to national impact on N.M. reputation in Palestine. It is contract with all existing regulations and laws, especially EQA laws. Also, this hazardous event causes decreasing the confidence in N.M. from the funding parties. So, it leads to international impact. It got RPN 9 because it is happening always in Nablus WWTP.

3.3.4 Risk Assessment

This process is merging the RA and RE processes for decision taking to put the most suitable barriers within both proactive and reactive reducing measures. It includes the one event risks that happened in the past, predicted risks and truncate events reference to experts' opinions. The deterministic or top management decision which is taken regardless of consequences is not accurate. So, RBDM approach is used for industrial WW in Nablus city as a decision that taken according to the consequences and risk study.

As shown in table B10, RPN is estimated for human, assets, environmental and reputation. Then an average for the four RPNs for all hazardous events will be calculated.

3.3.5 Risk Based Management (RBM)

After defining and analysing the possible threats in RA using HI approach and evaluating it in the RE process to establish the risk assessment study, barriers have to be put in RC process. So, the step of conducting RBM for industrial WW is gathering and finalizing the results of risk assessment and RC processes. This process has to take into consideration the adaption plans and its monitoring and improvement.

3.3.5.1 Risk Control (RC)

For each threat, reducing measures and mitigation options have to be installed to prevent the hazard before occurring which are called proactive barriers, or avoid and reduce its consequences which are called reactive barriers. The resulted barriers depended on personal judgmental approach and the results of brainstorming session which is mentioned in figure A3 and table B11.

Table B12 summarizes all barriers for WWN system. Then, the needed barriers for WWTP system are illustrated in table B13.

3.4 Risk Cost Benefit Analysis

Many scientific methods' effects must be inferred before they are experienced. If those inferences are good, then informed decisions are possible. But if not, these decisions may incur risks and costs far greater than the expected benefits.

This section illustrates CBA for the conducted risk management process. It mainly taking into consideration both proactive and reactive barriers that put by brainstorming session which mainly depended on judgment. This process will be looking for the potential advantages from a barrier and the total estimation costs associated with this barrier. This process called (RCBA). It is very likely the single most used economic method for options' assessment.

RCBA can be simply defined as data tool that supports decision-making. It provides an overview of the hazards, uncertainties, resulting costs and benefits. It is focusing on effects' expression in monetary terms to reach easily understandable form for measurement to explain whether the economic and social costs of a measure outweigh the economic and social benefits. It resolves the controversy of the presence of doubts about whether if economic efficiency is of little or no importance without neglecting the effectiveness in general.

As known, effects of any system have many different advantages and disadvantages. Therefore, these effects have to be weighed up before a decision taken.

Risk reduction may be costly. So, stakeholders must carefully discuss the investment and how much they are willing to pay.

Assessment to all benefits and costs associated with this risk reduction are needed to justify the investments in risk reduction for a certain hazard. The answer for the question of "how large the damage of the current risk per time?" should be known without negating the social connection.

Benefits here can be defined as the possible damages and consequences which can be reduced or avoided, and the costs are the estimated money that have to be paid to make both the reactive and proactive barriers taking into consideration training, depreciation, efforts, time and other secondary expenses.

Damages can be discussed as property damages which called direct or as general effect on the economy which called indirect. It can be taken in terms of money as a tangible loss or can be related with intangible losses like human life and emotional issues.

3.4.1 Risk Cost Benefit Analysis Process

To conduct RCBA process, it is best to consult an environmental expert to ensure that the previous work is being done correctly and takes his opinion. This work was discussed with General Manager of EQA Branch in Salfeet District Dr. Ayman Shawahneh and his opinion was considered. He supported the selected barriers and focused on passing new laws and bylaws to force factories' owners for using preliminary pretreatment.

Then, several steps will be conducted for some barriers to reach the needed output as the following:

1. Proactive and reactive barriers identification

The first step to conduct RCBA is identifying the proactive and reactive barriers as done in section 3.3.5.1. All barriers were linked with its main goal and the risk which have to be implemented for.

2. Proactive and reactive barriers selection

Some barriers will be selected according to average RPN that estimated in appendix L, which related to one hazardous event for each system. Based on results from the risk assessment in section 3.3.4, the hazardous event of industrial WW will be selected for both systems because it has the higher RPN. So, the selected barriers will be in table (3.6).

Table 3.6

Selected barriers

	Selected Barriers	
System	Proactive	Reactive
WWN	(1) Awareness	(3) Laws
	(2) WWN Rehabilitation	(4) Municipal WW crews
WWTP	(5) Equipment' insurance	(7) Equipment' maintenance
	(6) Preliminary pre-treatment systems	

3. Cost estimation for selected reduction measures

After barriers have been selected in the previous step, cost of applying and using it have to be estimated. It cannot be calculated accurately, but the estimation may include purchasing, installation, maintenance and training. In this case, the cost on operator which is N.M. will be considered.

Barrier 1: Awareness

To obtain the benefit from this barrier, N.M. have to employ one employee in the title of Community Awareness Officer to be responsible for conducting awareness campaigns to industries' owners and managers. In Nablus situation, lack of awareness is existed.

According to Instruction No. (1) for the Year 2020 that related to LGUs Employee Bylaw and Instruction No. (1) for the Year 2023 that related to modifications of Instruction No. (1) for the Year 2020, the nature of work bounces in this employee is 60% (Figure 3.2).

Figure 3.2

Instruction No. (1) for the Year 2023

State of Palestine
Ministry of Local Government

دولة فلسطين
وزارة الحكم المحلي

الرقم: ..... التاريخ: .....

2. يقوم المجلس بتحديد الموظفين الذين تتوفر فيهم شروط منح علاوة المخاطرة .
3. يوقف صرف علاوة المخاطرة عن الموظف في حالة زوال السبب الذي صرفت من أجله هذه العلاوة من تاريخ زوال السبب .

مـادة (3)

تعدل الفقرة (1) من المادة (27) من التعليمات الأصلية لتصبح على النحو الآتـي :

يمنح الموظف الذي يعمل بإحدى الوظائف المدرجة في الجدول أدناه علاوة طبيعة العمل من الراتب الأساسي حسب النسب المئوية المقابلة لكل درجة وظيفية أو مهنة:

الرقم	المسمى	التخصص/ المسمى	النسبة المئوية
.1	الفئة العليا (A3-A4)	مدير عام/ مدير تنفيذي	%80
.2	الفئة الأولى (A-C)	مدير تنفيذي/ مدير بلدية مدير دائرة/ مدير وحدة	%70
.3	الطبيب البيطري		%120
.4	مهندس / مفتش أبنية / مساح	بكالوريوس هندسة	%120
.5	وظائف الفئات الثانية	بكالوريوس في مجال الإختصاص	%60

Palestine, Ramallah, P.O.Box 475, Tel: +970 2 240 1091 - Gaza: Tel.: 08 282 0273, Fax: 08 286 7509
@molgpalestine- Email: media@molg.pna.ps

The monthly salaries for the mentioned employee will be calculated as table (3.7).

Table 3.7

Community Awareness Officer salary

Title	Category	Degree	Primary Salary (NIS)	Bonuses		Overall Monthly Salary (NIS)
				Nature of work (60%)	Cost of living (30.32%)	
Community Awareness Officer	2	5/0	1,700	1,020	515.44	3,235.44

So, the cost will be: 3,235.44 Nis/month * 12 month = 38,825.28 Nis/year.

To develop the employee performance, the municipality has to send him to participate in courses that regulated by MoLG for free. Generally, these courses done in Ramallah. So, it will cost the municipality the transportation cost. By assuming 20 hours course in 5 days, the estimated cost will be 50 nis/day or 250 Nis/year.

Generally, LGUs in Palestine gives its employees 2 rewards per year; one of them for Al-Fitr Eid and the other for Al-Adha Eid. Every reward will be assumed 250 Nis.

Finally, severance pay has to be calculated.

According to Palestinian Labor Law No. (7) of the year 2000, the employee is getting one third of his monthly salary for each year he worked if he resigned. And complete monthly salary if his services are terminated.

So, the average of severance pay for one year will be estimated as the following:

3,235.44 Nis/month * 2/3 = 2,156.96 Nis/year.

The total cost for this barrier = 38,825.28 + 250 + 2,156.96 + 250 = 41,482.240 Nis/year.

In addition to the mentioned employee, N.M. can seek help from an existing public relation officer in the municipality.

Barrier 2: WWN Rehabilitation

According to N.M. data in 2023, cost of maintaining and developing WWN in the western part of Nablus city was 21,632,009 nis (Ba’ara, 2024).

Barrier 3: Laws

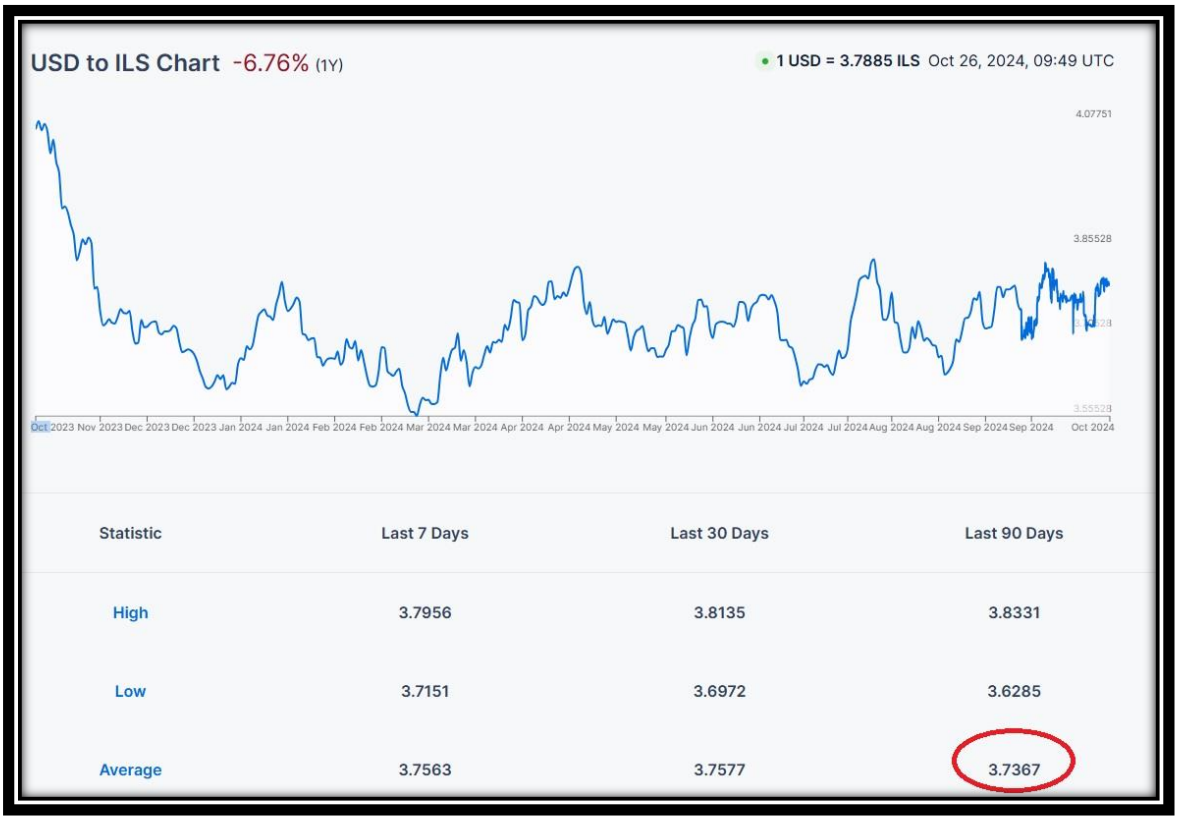
To execute this barrier, N.M. have to make a contract with a consultant. The consultant has to develop the procedures and regulations that related with industrial WW the city. It is assumed that the consultant needs 20 work days in the first year. Then the municipality has to send him its feedback at the end of the year to get the needed update from the consultant. It is assumed that the consultant needs 10 work days at the end of the year.

Market price for consultation process is estimated about 450 $/day.

According to (XE, 2024), the average of last 90 days for exchanging USD to Nis is 3.7367.

Figure 3.3

USD to Nis chart (XE, 2024)



Statistic	Last 7 Days	Last 30 Days	Last 90 Days
High	3.7956	3.8135	3.8331
Low	3.7151	3.6972	3.6285
Average	3.7563	3.7577	3.7367

By assuming 1 $= 3.74 nis, the cost will be 1,683 Nis/day.

The total cost for this barrier = 1,620 Nis/day * 30 days = 50,490 Nis/year.

Barrier 4: Municipal WW crews

It is found there is a need to enhance the WW section works by increasing the WW crews especially in Winter. The municipality should employ another four labors and two engineers (Abu Zant, 2024).

According to Instruction No. (1) for the Year 2020 that related to LGUs Employee Bylaw and Instruction No. (1) for the Year 2023 that related to modifications of Instruction No. (1) for the Year 2020, the monthly salaries for the engineer will be calculated as table (3.8).

Table 3.8

Engineer salary

Title	Category	Degree	Primary Salary (NIS)	Bonuses			Overall Monthly Salary (NIS)
				Nature of work (120%)	Risk (25%)	Cost of living (30.32%)	
Engineer	2	4/0	1,830	2,196	457.50	554.856	5,038

To employ two engineers, it will cost N.M. 10,076 Nis/month or 120,912 Nis/year.

As mentioned in barrier one cost estimation, yearly rewards and severance pay have to be estimated.

LGUs in Palestine gives its employees two rewards per year equal 250 Nis.

Severance pay will be calculated as following:

10,076 Nis/month * 2/3 = 6,717.33 Nis/year.

So, yearly cost for two engineers = 120,912 + 2(250) + 6,717.33 = 128,129.33 Nis/year.

Assuming the labours' salaries will be as the min. in Palestine. According to Council of Ministers' decisions in its 121th session which was held on 23/08/2021, the min. monthly wage in Palestine is 1,880 Nis/month.

So, the new labours' salaries will be:

4 labours * 1,880 Nis/month = 7,520 NIS/month or 90,240 Nis/year.

Assuming two rewards per year equal 250 Nis for each labour.

Severance pay will be calculated as following:

7,520 Nis/month * 2/3 = 5,013.33 Nis/year.

So, yearly cost for four labors = 90,240 + 4(250) + 5,013.33 = 96,253.33 Nis/year.

Finally, indirect cost should be added. It includes salaries, operational and managerial expenditures for financial affairs, administrative affairs and human resources, engineering and projects, mechanical and movement departments. This indirect cost equal 1,552,156 Nis/year (Ba'ara, 2024).

The total cost for this barrier = 128,129.33 + 96,253.33 + 1,552,156 = 1,776,538.66 Nis/year.

Barrier 5: Equipment' insurance

WWTP annual insurance is 74,000 $.

By assuming 1 $= 3.74 nis, the cost will be 276,760 Nis/year (Ba'ara, 2024).

Barrier 6: Pre-treatment systems

This barrier depends on conducting the needed preliminary pre-treatment in the factories. For example, procurement of mechanical sesame seeds de hulling machine or dry peeling machine for tahina industry.

The procurement is done for stone cutting industry. KfW covered the municipality contribution percentage during direct payment to the contractor. So, the payment was not included in N.M. budget.

Therefore, the cost will be limited to coordination and control affairs. Environmental Control Unit (ECU) in N.M. will do the needed works by its crews within one year according to an estimate. Total monthly salaries for ECU crew are 21,390 Nis (Ba'ara, 2024).

Assuming that ECU needs 12 months for their work;

Annual needed salaries = 21,390 nis * 12 months = 256,680 Nis/year.

Assuming two rewards per year equal 250 Nis for each employee.

Severance pay will be calculated as following:

21,390 Nis/month * 2/3 = 14,260 Nis/year.

So, yearly cost for four employees = 256,680 + 8(250) + 14,260 = 272,940 Nis/year.

Assuming the ECU crew will visit all factories in the western region. According to table (3.1), number of heavy industries is western region in Nablus city is 66 factories.

Assuming that the transportation cost for one visit is 50 nis, the cost of transportations will be:

50 Nis * 66 factories = 3,300 Nis/year.

Since ECU work related to WW, indirect coast for WW will be added.

The total cost for this barrier = 272,940 + 3,300 + 1,552,156 = 1,828,396 Nis/year.

Barrier 7: Equipment' maintenance

WWTP maintenance in the year 2024 was estimated to be 579,000 Nis, but the actual cost in 2023 was 29,126 Nis.

So, the avg. maintenance cost in the years 2023 and 2024 is 304,063 Nis/year (Ba'ara, 2024).

The previous seven barriers' costs were summarized in table B14.

4. Benefits of risk reduction measures

In this step, the potential benefits for each selected barriers have to be evaluated. The evaluation will be based on risk reduction possibility and avoided damages taking into consideration the cost saving and reduction.

Barrier 1: Awareness

Public awareness campaigns are an important element that used in social marketing to change people's attitudes. It is defined as different activities used to increase knowledge and change in thinking and in behavior for a specific time to a specific target group. Its quality is determined on the basis of its effectiveness and impact on the audience. The influence's percentage to people is different and cannot be calculated. For example, the number of people who identified storm water runoff as the main source of water pollution over factories and industrial discharges grew by 12% in three years due to awareness campaign (Borawska, 2017).

Since awareness campaigns' target in this research is the factories owners, the percentage is expected to be increased. (Kharraz, 2024) mentioned that, the result of the ECU visits and awareness process for factories was a response about 30%.

As mentioned in section 3.1, number of heavy industries' factories in western part of Nablus city is 66. So, this barrier will affect 20 factories.

Here, the impact will be summarized through decreasing number of maintenance times per year. As a result, the annual trips by N.M. WW crews will be decreased.

Reference to (Abu Zant, 2024), N.M. was carried out 4 trips because of industrial WW problems in the first half of the year 2024.

Assuming N.M. will carry out 8 trips per year,

20 trips / 66 factories = 0.30

So, each factory needs 0.30 trip/year.

Then, 20 factories need 6 trip/year.

Since each trip costs 250 Nis (Abu Zant, 2024), the benefit will be:

250 Nis * 6 trip/year = 1,500 Nis/year.

Barrier 2: WWN Rehabilitation

Generally, this barrier will affect directly on environment because it will lead to decrease the number of WWN floods in Nablus city. Therefore, it will lead to increase WWN life time.

As Nazzal (2024) said, 1 km of developed WWN costs the municipality about 200,000$. By assuming 1 $= 3.74 nis, the cost will be 748,000 Nis/Km.

The need for N.M. is to develop its municipal WWN by 1 km/year on average (Abu Zant, 2024).

So, the WWN development cost is 748,000 Nis/year.

WWN maintenance has to be developed taking into consideration: pipeline that needs to be maintained, time for maintenance, determining the type of maintenance technology and calculating the economic cost of maintenance. If Prevented maintenance decision is taken and the its exaction was in practical way, WWN life time will be increased by 20 years (Chu et al., 2022).

With reference to the special political status of the West Bank and Israeli army practices, increasement of 10 years life time will be assumed.

The benefit of this barrier will be

10 years * 748,000 Nis/year = 7,480,000 Nis.

Barrier 3: Laws

The benefits in this barrier are represented in increasing the number of WW subscriptions.

WW subscription costs the factory 3 JD for each 1 m^2. Assuming that factories average area = 500 m^2.

The average of last 90 days for exchanging JD to Nis is 5.2704 (see figure A4). So, it will be assumed that 1 JD = 5.27 Nis.

The income from new subscriptions

= 66 factory * 500 m^2 * 15.81 nis = 521,730 Nis.

Also, laws' implementation will increase the revenue of the municipality through penalties.

According to (Ba'ara, 2024), the value of revenue for penalties related to WWN for the year 2023 is 4,250 JD, noting that it is not possible to specify the amount that related to the western region.

Total number of factories in Nablus is 224, 138 of them in the western region as explained in table (3.1).

The western region factories represent 61.61% for total factories. So, it will be assumed that 61.61% value of revenue for penalties related to WWN related to western region.

Penalties related to western region = 61.61% (4,250 JD) = 2,618.43 JD.

By assuming 1 JD = 5.27 Nis, penalties related to western region will be

2,618.43 JD * 5.27 = 13,799.130 Nis/year.

Total benefit for this barriers = 521,730 + 13,799.130 = 535,529.130 Nis/year.

Barrier 4: Municipal WW crews

If the WW crews were increased according to the actual need, this will increase the response, which will lead to less time in maintenance and development of WWN. Since the quality of WW service increased, N.M. can increase the WW tariff.

Reference to (Ba'ara, 2024), N.M. tariff for WW is 0.7 Nis/m^3 of water consumption, but the actual cost on the municipality is 1.6 Nis/m^3. So, the loss in WW service is 0.9 Nis/m^3.

Noting that N.M increases WW tariff by 0.1 Nis/m^3 every year, but this research estimations included one year only.

The number of water subscriptions in Nablus city is 56,297, but the average monthly WW quantity that entered WWTP in the first third of 2024 is 438,239 m^3 (NWWTP, 2024).

According to social responsibility, the municipality cannot increase the WW tariff by 0.9 Nis/m^3 directly. This study assumes that the municipality will increase the tariff in the stages; the first one is 0.4 Nis/m^3 which will be executed in the first year and the second one is 0.5 Nis/m^3 which will be executed in the second year after conducting new reforms and developments.

The benefit of this barrier can be estimated as following:

0.4 Nis/m^3 * 438,239 m^3 * 12 = 2,103,547.20 Nis/year.

Barrier 5: Equipment' insurance

The primary objective from equipment' insurance is compensation to protect the value of equipment. So, N.M., is willing to pay small amount compared with the actual value of the equipment. The value of the equipment in WWTP is 27,600,000 $ (Ba'ara, 2024). By assuming 1 $= 3.74 nis, the value will be 103,3224,000 Nis.

Reference to (Abu Hamdeh, 2024), the insurance company will compensate at a rate 75%. So, the benefit will be 75% (103,3224,000 Nis) = 77,418,000 Nis.

Barrier 6: Pre-treatment systems

As mentioned before, the average monthly average WW quantity that entered WWTP in the first third of 2024 is 438,239 m^3 (NWWTP, 2024).

Now, WWTP is receiving and treating residential WW only, it costs 0.7 Nis/m^3 (Ba'ara, 2024). Treated industrial WW is considered as residential WW, but if industrial WW enters WWTP, the cost of treatment will increase approximately to 2.8 Nis/m^3 (Abu Jaffal, 2024).

The benefit of preliminary pre-treatment can be estimated as following:

(Treatment cost in case of industrial WW exist - Current treatment cost) * WW quantity

= (2.8 nis/m^3 - 0.7 nis/m^3) * 438,239 m^3

= 920,301.9 nis/month, which means 11,043,622.8 Nis/year.

Barrier 7: Equipment' maintenance

WWTP maintenance is similar to insurance in result. The equipment will be protected and the municipality will not lose it. The value of the replaced equipment completely in WWTP in the last five years is 5,000,000 Nis.

WWTP supplies spare parts for its devises in the value of 250,000 Nis/year (Abu Jaffal , 2024).

So, the maintenance will reduce the equipment and spare parts replaced cost by

(5,000,000 Nis / 5 years) + 250,000 Nis/year = 1,250,000 Nis/year.

Table B15 summarizes the conducted benefit estimation.

5. Proportion factor (d) estimation

Once the cost and benefits in the previous steps were estimated, risk has to be decided if is it acceptable or not. So, the Proportion Factor (d) have to be estimated as mentioned in section 1.8.2.5.3.

Equation (1.1) will be applied:

$$d = \frac{\text{cost of the risk reduction measure}}{\text{benefit of the risk reduction}} \quad (3.1)$$

In this equation the costs that estimated in appendix P will be divided on the benefits that estimated in appendix R to find d.

But before estimating (d), disproportionality limit (do) must define. In this case, it will be assumed equal 1. So, if d larger than 1, the risk reduction measure should not be implemented, and if the d is less than or equal than 1, the risk reduction measure should be implemented.

Table (3.9) shows d results in RCBA.

Table 3.9

RCBA

System		#	Barrier	Total cost (NIS)	Benefit (NIS)	d
WWN	Proactive	1	Awareness	41,482.240	1,500	27.655
		2	WWN Rehabilitation	21,632,009	7,480,000	2.8920
		3	Laws	50,490	535,529.130	0.0943
	Reactive	4	Municipal WW crews	1,776,538.66	2,103,547.20	0.8445
WWTP	Proactive	5	Equipment' insurance	276,760	77,418,000	0.0036
		6	Pre-treatment systems	1,828,396	11,043,622.8	0.1656
	Reactive	7	Equipment' maintenance	304,063	1,250,000	0.2433

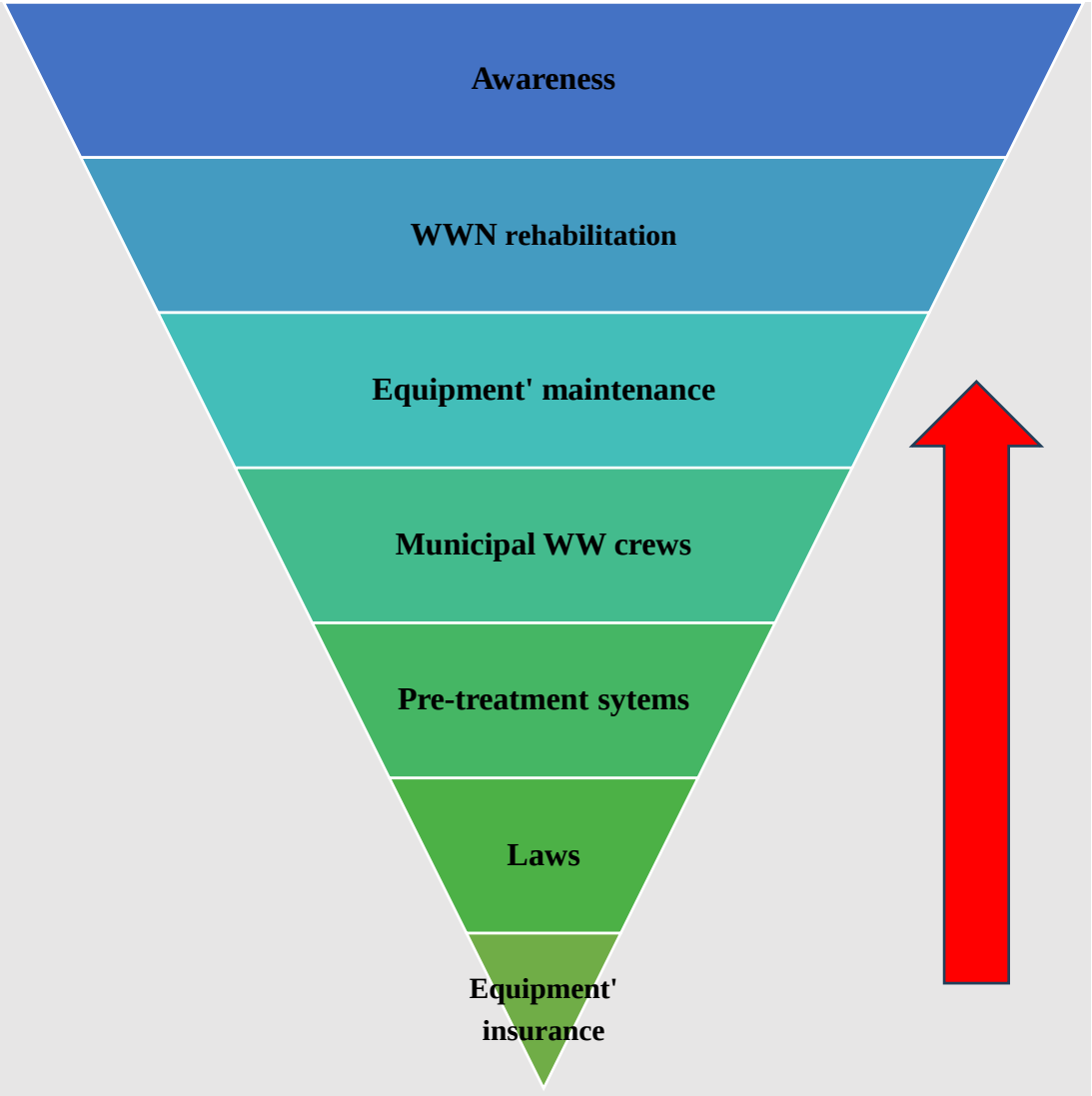
6. Prioritization

Now, it is time to priorities the barriers depending on its economic feasibility after comparing the estimated costs and benefits by calculating d.

The main decision standard will be the cost-benefit ratio. So, the smallest d will be the priority as shown in figure (3.4).

Figure 3.4

Barriers' prioritization



7. Decision making

Here, it is the decision-making phase which includes taking the most appropriate decision to implement the proactive and reactive barriers based on cost-benefit ratio. Then, to develop a practical implementation plan which contains the needed resources, timeline and monitoring process for each barrier.

Since barrier one (Awareness) has d = 27.655 and barrier two (WWN rehabilitation) has d = 2.8920, which are larger than one, these barriers have to be excluded because the measures are uneconomical and no need for risk reduction measures.

Then, N.M. should execute the remaining barriers from smallest d in ascending order as the following:

1. Equipment' insurance (d = 0.0036).
2. Laws (d = 0.0943).
3. Pre-treatment system (d = 0.1656).
4. Municipal WW crews (d = 0.8445).
5. Equipment' maintenance (d = 0.2433).

8. Implementation and review

Finally, the previous plan has to be implemented by N.M. and the stakeholders by installation the selected barriers and monitor their effectiveness over time by continuous evaluation in terms of hazard mitigation.

The d factor has to be reviewed and updated regularly to reflect the risk changes and the priorities to identify new opportunities for optimization the risk management strategies to enhance the overall efficiency and cost effectiveness.

So, N.M. can systematically evaluate the costs and benefits of implementing risk reduction measures and make data-driven decisions to enhance industrial WW management practices.

Chapter Four

Discussions and Conclusions

4.1 Overview

This chapter summaries thesis's results through conclusion. It includes needed recommendations and suggests future studies.

4.2 Conclusion

Based on the presented data and results in this research, the following are the main conclusions:

- In the last years, the correlations between growth of industrial sector and the environmental pollution became notable.
- West Bank suffers widely from wrong disposal of WW.
- WW is one of the most important issues that represent a threat to the environment and public health.
- Industrial WW in Nablus city has different hazardous effects on the surrounding environment and public health, especially in the western part of the city.
- Industrial WW a causes major damages to the municipal WWN and reduces its life span.
- WWTP in the western region in Nablus city greatly affected by industrial WW through damages to its equipment and equipment.
- Risk analysis (RA) is the first tool in risk management process used to analyse and identify the possible hazards and consequences.
- Risk assessment process includes RA and Risk Evaluation (RE) for decision taking to put the most suitable barriers.
- Proactive and reactive barriers were chosen in Risk Control (RC) process, such as: awareness campaigns, increasing crews and equipment insurance.

- Cost and benefit for each barrier were estimated by Risk Cost Benefit analysis (RCBA).

- Last but not least, this research has demonstrated the RBM and RCBA techniques with industrial WW and its effects. Linking previous two aspects has contributed a different view towards risk management and the potential risk that may affect Nablus city municipal infrastructure.

4.3 Recommendations

Based on the outcome of this study, the following can be recommended:

- The government, ministries, authorities and LGUs have to take serious actions regarding industrial WW in order to minimize the adverse effects of this enormous event.

- The necessary to implement the concept of local community participation.

- Raising the awareness of the public by spreading the needed knowledge into communities.

- More related data on industrial WW in Palestine are recommended to be gathered and saved in special units.

- More detailed estimations to include the cost for the private sector.

- Considering the time value of money for all estimations.

- Stakeholders should monitor barriers effectiveness over time by continuous evaluation in terms of hazard mitigation.

- The need for studying WW and WWTP services for community and citizens.

- Governments should be oriented to focus on identifying long-term, broadly-supported strategies for risk reduction.

- Creating a new unit in all ministries and LGUs which works on risk studies in order to save the records in it, monitor, review and update the assessed risks.

- Conducting the needed training for LGUs engineers on risk topic.

4.4 Future Work

Depending on results of this research, the following topics are recommended for studies in this area:

- The first topic to consider the selected barriers to find practical methods to reduce the cost of each barrier.
- The second topic related with social side by studying the behaviour and future trends of Nablus' citizens when focused awareness campaigns are conducted in the many coming years.
- Considering the cost on private sector for the same barriers.
- Application of RCBA on similar events in other cities in Palestine.

List of Abbreviations

Abbreviation	Meaning
$/day	Dollar per Day
%	Percent
PEAD	Palestinian Expatriate Affairs Department
°C	Celsius
ALARP	As Low as low as Reasonably Practicable
ARIJ	Applied Research Institute - Jerusalem
CA	Causal Analysis
CBA	Cost Benefit Analysis
CDEMA	Caribbean Disaster Emergency Management Agency
CEA	Cost Effectiveness Analysis
COD	Chemical Oxygen Demand
d	Proportion Factor
do	disproportionality Limit
ECU	Environmental Control Unit in Nablus Municipality
EIA	Environmental Impact Assessment
EPA	United States Environmental Protection Agency
EQA	Environment Quality Authority
ETA	Event Tree Analysis
FTA	Fault Tree Analysis
g/L	Gram per Liter
GoC	Government of Canada
HI	Hazard Identification
IIA	The Institute of Internal Auditors
ISO	International Organization for Standardization
JD	Jordanian Dinar
KfW	German Development Bank - Kreditanstalt für Wiederaufbau
Km	Kilometer
Km/hr	Kilometer per Hour
Km/year	Kilometer per Year
Km^2	Square Kilometer

L	Liter
L/d	Liter per day
L/d/c	Liter per Capita per Day
LGU	Local Government Unit
m.a.s.l.	Mean above Sea Level
m^2	Square Meter
m^3	Cubic Meter
m^3/y	Cubic Meter per Year
mbar	Millibar
MCA	Multi Criteria Analysis
mg/L	Milligram per liter
Min.	Minimum
mm	Millimeter
MoLG	Ministry of Local Government
MoP	Ministry of Planning
N.M.	Nablus Municipality
Nis	New Israeli Shekel
Nis/day	New Israeli Shekel per Day
Nis/km	New Israeli Shekel per kilometer
Nis/m^3	New Israeli Shekel per Cubic Meter
Nis/month	New Israeli Shekel per Month
Nis/year	New Israeli Shekel per Year
NNU	An-Najah National University
NW-WWTP	Nablus-West Wastewater Treatment Plant
PCBS	Palestinian Central Bureau of Statistics
PHA	Preliminary Hazard Analysis
PHA	Preliminary Hazard Analysis
PNA	Palestinian National Authority
RA	Risk Analysis
RBDM	Risk Based Decision Making
RBM	Risk Based Management
RC	Risk Control
RCBA	Risk Cost Benefit Analysis

RE	Risk Evaluation
RIDM	Risk Informed Decision Making
RPN	Risk Priority Number
SAH	Specialized Arab Hospital
SIM	Social Impact Assessment
W.A.L.	Western Australia Legislation
WN	Water Network
WTP	Willingness to Pay
WW	Wastewater
WWN	Wastewater Network
WWTP	Wastewater Treatment Plant

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Appendices

Appendix A

Figures of Study

Figure A1

Mean annual rainfall in Nablus city from 2012 and 2021 (ARIJ, 2014)

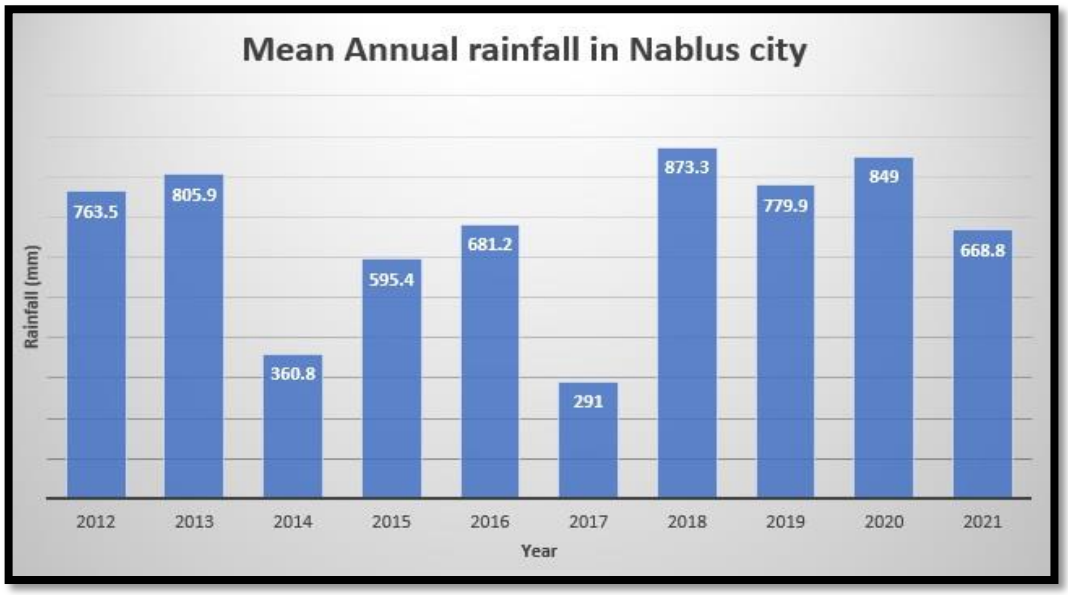


Figure A2

Number of rainfall days in Nablus city from 2010 and 2018 (ARIJ, 2014)

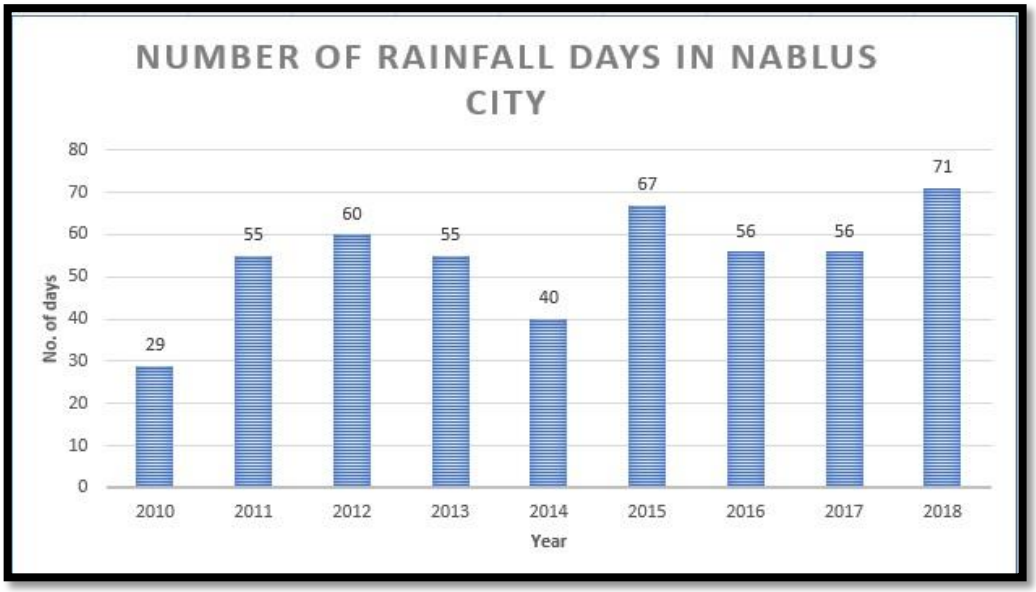
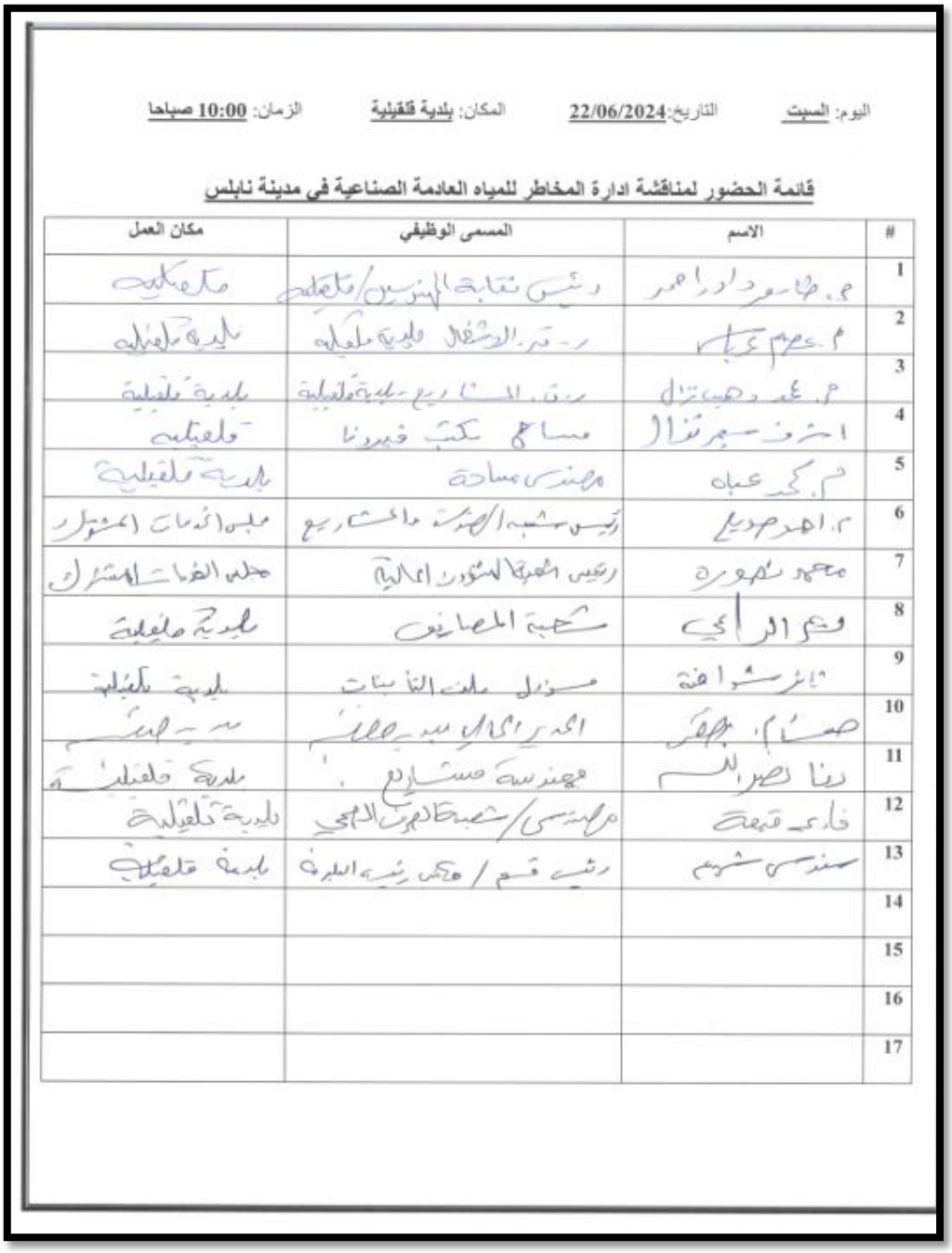


Figure A3

Signatures of attendance in the brainstorming session



اليوم: السبت التاريخ: 22/06/2024 المكان: بلدية قلقيلية الزمان: 10:00 صباحا

قائمة الحضور لمناقشة ادارة المخاطر للمياه العادمة الصناعية في مدينة نابلس

#	الاسم	المسمى الوظيفي	مكان العمل
1	م. طارق دار احمد	رئيس نقابة المهندسين/قلقيلية	مكتبه
2	م. عصام عباد	رئيس دائرة الاشغال بلدية قلقيلية	بلدية قلقيلية
3	م. غ. وهيب نزال	رئيس قسم التخطيط بلدية قلقيلية	بلدية قلقيلية
4	اشرف سمرين زال	مساعد مكتب فيدونا	قلقيلية
5	م. كمال عياد	مهندس مساحة	بلدية قلقيلية
6	م. احمد صويلح	رئيس شعبة الصحة والمشاريع	مجلس الخدمات المشترك
7	محمد نصوره	رئيس الهيئة المشرفة للمشروع	مجلس الخدمات المشترك
8	وضاح الراعي	شعبة المصانع	بلدية قلقيلية
9	ماجد شواهنة	مسؤول ملف النفايات	بلدية قلقيلية
10	حسام [illegible]	المدير الاداري [illegible]	[illegible]
11	رنا الصراف	مهندسة مشاريع	بلدية قلقيلية
12	فادي قمحة	مراقب شعبة المياه والصحي	بلدية قلقيلية
13	سندس شومر	رئيس قسم / مكتب رئيس البلدية	بلدية قلقيلية
14			
15			
16			
17			

Figure A4

JD to Nis chart (XE, 2024)

Statistic	Last 7 Days	Last 30 Days	Last 90 Days
High	5.3534	5.3787	5.4063
Low	5.2399	5.2147	5.1178
Average	5.2980	5.3000	5.2704

Appendix B

Tables of Study

Table B1

Correlation between the WWN hazardous events and its hazards

WWN System	Floods in WWN	Pipes breaking	Incorrect practices	Industrial WW effluent	Rising of WWNs material price	Loss of expertise
Human	✓	**X**	✓	✓	**X**	**X**
Assets	✓	✓	**X**	✓	**X**	**X**
Environment	✓	✓	✓	✓	**X**	✓
Reputation	✓	✓	✓	✓	✓	**X**

Table B2

Correlation between the WWTP hazardous events and its hazards

WWTP System	Shortening the useful life of the equipment	Increasing the operational cost	Industrial WW effluent
Human	✓	**X**	✓
Assets	✓	✓	✓
Environment	**X**	**X**	✓
Reputation	**X**	**X**	✓

Table B3

PHA – RA

System one: WWN		
Hazardous Event	Cause	Consequences
Hazard / threat: Human		
Floods in WWN	1. Fault in Design. 2. Solid waste entering to WWN. 3. Excessive rainwater. 4. Solids resulted from the stonecutter factories. 5. Solids and bones from slaughterhouses. 6. Clogging the sewer system. 7. Corrosion and failure of concrete sewers. 8. Lack of periodic cleaning for manholes. 9. Old WWN.	- Diseases spreading. - An uncivilized sight. - Loss of confidence in the municipality. - Obstructing inhabitants' movement. - Clogging the sewer system which affect houses WWN.
Incorrect practices	1. Illegal Connection. 2. Lack of implementation for laws. 3. Absence of control. 4. Weakness of awareness. 5. Absence of needed pre-treatment. 6. Dangerous materials decomposition.	- Increasing WW toxicity. - Shortage of water sources. - Health problems. - Unsuitable effluent for WWTP which affect irrigation.
Industrial WW effluent	1. WW to Wadi. 2. Very toxic WW. 3. No organic content. 4. High COD content in (Tahina, olive oil mill, slaughterhouses) industries' WW 5. Excessive salt and sodium concentrations. 6. High chloride content in Tahina industry's WW. 7. Existing of phenols, pathogenic organisms and other toxic substances. 8. Excessive salt concentrations. 9. High concentration of dye in jeans washing industry's effluent.	- Salts will accumulate in the top soil layers, which hurts the plants. - Impossible for aquatic life to survive. - Decreasing soil permeability - Not effective reused water. - Increasing the operational cost on N.M. which may increase the WW tariff.
Hazard / threat: Assets		
Floods in WWN	1. Fault in Design. 2. Solid waste entering to WWN. 3. Excessive rainwater to WWN. 4. Solids resulted from the stonecutter factories. 5. Solids and bones from slaughterhouses. 6. Clogging the sewer system. 7. Corrosion and failure of concrete sewers. 8. Lack of periodic cleaning for manholes. 9. Old WWN.	- Side effects on citizens' assets like: cars and shops. - Raw sewage overflows into the streets, which lead to accidents. - Farmers'' crops damages.
Pipes Breaking	1. Duration life of WWN. 2. Excavation and maintenance works. 3. Solids resulted from the stonecutter factories. 4. Solids from slaughterhouses. 5. Improper pipes materials. 6. Corrosion and failure of concrete sewers. 7. Effluent overflows. 8. Old sewer pipes.	- Side effects on citizens' assets like: cars and shops. - Raw sewage overflows into the streets. - Obstructing traffic. - Increasing the possibility of work accidents.
	1. WW to Wadi. 2. Very toxic WW.	- Clogging WWN may result WW will not drain from houses.

Industrial WW effluent	3. No organic content. 4. High COD content in (Tahina, olive oil mill, slaughterhouses) industries' WW 5. Excessive salt and sodium concentrations. 6. High chloride content in Tahina industry's WW. 7. Existing of phenols, pathogenic organisms and other toxic substances. 8. Excessive salt concentrations. 9. High concentration of dye in jeans washing industry's effluent.	- Decreasing soil permeability. - Corrosion of sewer pipes.
Hazard / threat: Environment		
Floods in WWN	1. Fault in Design. 2. Solid waste entering to WWN. 3. Excessive rainwater. 4. Solids resulted from the stonecutter factories. 5. Solids and bones from slaughterhouses. 6. Clogging the sewer system. 7. Corrosion and failure of concrete sewers. 8. Lack of periodic cleaning for manholes. 9. Old WWN.	- Diseases spreading. - Pollution of the environment. - Odours spreading. - Leakage of WW to ground water. - Mixing WW with surface water. - Soil toxicity.
Pipes Breaking	1. Duration life of WWN. 2. Excavation and maintenance works. 3. Solids resulted from the stonecutter factories. 4. Solids from slaughterhouses. 5. Improper pipes materials. 6. Corrosion and failure of concrete sewers. 7. Effluent overflows. 8. Old sewer pipes.	- Floods in WWN. - Pollution of the environment. - Odours spreading. - Disabling other services.
Incorrect practices	1. Illegal Connection. 2. Lack of implementation for laws. 3. Absence of control. 4. Weakness of awareness. 5. Absence of needed pre-treatment. 6. Dangerous materials decomposition.	- Increasing the WW toxicity. - Reducing the permeability of the soil.
Industrial WW effluent	1. WW to Wadi. 2. Very toxic WW. 3. No organic content. 4. High COD content in (Tahina, olive oil mill, slaughterhouses) industries' WW 5. Excessive salt and sodium concentrations. 6. High chloride content in Tahina industry's WW. 7. Existing of phenols, pathogenic organisms and other toxic substances. 8. Excessive salt concentrations. 9. High concentration of dye in jeans washing industry's effluent.	- Salts will accumulate in the top soil layers. - Impossible for aquatic life to survive. - Decreasing soil permeability. - Decreasing the effective of reused water. - Not suitable for irrigation.
Loss of Expertise	1. Low salaries in Palestine compared with neighbour countries. 2. A gap between the educational system and practical situation. 3. Aptitudes and experts' immigration.	- Low quality WWN. - Not match the international codes. - Fault in design. - Illegal connections. - Not suitable pre-treatment. - Increasing the operational cost on N.M.
Hazard / threat: Reputation		
	1. Fault in Design. 2. Solid waste entering to WWN. 3. Excessive rainwater.	- An uncivilized sight. - Loss of confidence in the municipality. - Obstructing traffic and inhabitants'

Floods in WWN	4. Solids resulted from the stonecutter factories. 5. Solids and bones from slaughterhouses. 6. Clogging the sewer system. 7. Corrosion and failure of concrete sewers. 8. Lack of periodic cleaning for manhole. 9. Old WWN.	movement. - Loss donors' confidence.
Pipes Breaking	1. Duration life of WWN. 2. Excavation and maintenance works. 3. Solids resulted from the stonecutter factories. 4. Solids from slaughterhouses. 5. Improper pipes materials. 6. Corrosion and failure of concrete sewers. 7. Effluent overflows. 8. Old sewer pipes.	- An uncivilized sight. - Loss of confidence from people.
Incorrect practices	1. Illegal Connection. 2. Lack of implementation for laws. 3. Absence of control. 4. Weakness of awareness. 5. Absence of needed pre-treatment. 6. Dangerous materials decomposition.	- Losing fees for N.M. - Decreasing the work quality of WWTP. - Decreasing penalties rate.
Industrial WW effluent	1. WW to Wadi. 2. Very toxic WW. 3. No organic content. 4. High COD content in (Tahina, olive oil mill, slaughterhouses) industries' WW 5. Excessive salt and sodium concentrations. 6. High chloride content in Tahina industry's WW. 7. Existing of phenols, pathogenic organisms and other toxic substances. 8. Excessive salt concentrations. 9. High concentration of dye in jeans washing industry's effluent.	- Salts will accumulate in the top soil layers. - Turbidity - Impossible for aquatic life to survive. - Decreasing soil permeability. - Not effective reused water. - Not suitable for irrigation. - Corrosion of sewer pipes. - Increasing the operational cost on N.M. - Ground water
Rising of WWNs materials price	1. Inflation and globalization. 2. Rising of raw material price. 3. International pandemic such as: COVID19. 4. Closing borders. 5. Emergency and political situation.	- Higher cost leads to raise the fees on people. - Higher maintenance cost affecting N.M. reputation.
System two: WWTP		
Hazardous Event	Cause	Consequences
Hazard / threat: Human		
Shortening the useful life of the equipment	1. Overload the grit removal. 2. Primary settling equipment.	- Increasing injuries rate. - Increasing replacement times. - Increasing maintenance times.
Industrial WW effluent	1. WW to Wadi. 2. Very toxic WW. 3. No organic content. 4. High COD content in (Tahina, olive oil mill, slaughterhouses) industries' WW. 5. Excessive salt and sodium concentrations. 6. High chloride content in Tahina industry's WW. 7. Existing of phenols, pathogenic organisms and other toxic substances. 8. Excessive salt concentrations. 9. High concentration of dye in jeans washing industry's effluent.	- WWTP employees' injurie. - Increasing number of WWTP crews. - Obstacles with neighbours. - Death during cleaning.

Hazard / threat: Assets		
Shortening the useful life of the equipment	1. Overload the grit removal. 2. Primary settling equipment.	- Do not give the needed results. - Do not properly work - Destroys plants.
Increasing the operational cost	1. Illegal discharge. 2. The influent doesn't match the hydraulic design. 3. The influent doesn't match the designed organic load. 4. Increasing maintenance rate. 5. Shortening useful life of WWTP equipment.	- Decreasing the development rate for devices and equipment. - Decreasing projects by N.M. - Fiscal Deficit. - Inapplicable strategic plan. - Increasing needed labours number
Industrial WW effluent	1. WW to Wadi. 2. Very toxic WW. 3. No organic content. 4. High COD content in (Tahina, olive oil mill, slaughterhouses) industries' WW. 5. Excessive salt and sodium concentrations. 6. High chloride content in Tahina industry's WW. 7. Existing of phenols, pathogenic organisms and other toxic substances. 8. Excessive salt concentrations. 9. High concentration of dye in jeans washing industry's effluent.	- Increasing treatment process operational cost. - Increasing maintenance cost. - Decreasing useful life for WWTP equipment. - Overload the grit removal and primary settling equipment. - Increasing the financial burden on the municipality. - Decreasing the effectiveness of the disinfection process.
Hazard / threat: Environment		
Industrial WW effluent	1. WW to Wadi. 2. Very toxic WW. 3. No organic content. 4. High COD content in (Tahina, olive oil mill, slaughterhouses) industries' WW. 5. Excessive salt and sodium concentrations. 6. High chloride content in Tahina industry's WW. 7. Existing of phenols, pathogenic organisms and other toxic substances. 8. Excessive salt concentrations. 9. High concentration of dye in jeans washing industry's effluent.	- Decreasing useful life for WWTP equipment. So, inability to receive WW. - The effluent doesn't appropriate for irrigation. - Bad quality effluent.
Hazard / threat: Reputation		
Industrial WW effluent	1. WW to Wadi. 2. Very toxic WWN. 3. No organic content. 4. High COD content in (Tahina, olive oil mill, slaughterhouses) industries' WW. 5. Excessive salt and sodium concentrations. 6. High chloride content in Tahina industry's WW. 7. Existing of phenols, pathogenic organisms and other toxic substances. 8. Excessive salt concentrations. 9. High concentration of dye in jeans washing industry's effluent.	- Loss of donors' confidence. - Obstacles with neighbours.

Table B4

Risk matrix and scenarios' of RPN

Frequency → / Consequence ↓	1	2	3	4	5
1	2	3	4	5	6
2	3	4	5	6	7
3	4	5	6	7	8
4	5	6	7	8	9
5	6	7	8	9	10

Scenario	Light Risk	Medium Risk	High Risk
Rank	2 3 4	5 6 7	8 9 10

Table B5

WWN and WWTP hazardous events' symbols

Hazardous event	Floods in WWN	Pipes breaking	Incorrect practices	Industrial WW effluent	Rising of WWNs material price	Loss of expertise
Symbol						

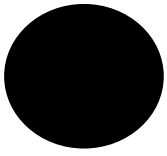
Hazardous event	Shortening the useful life of equipment	Increasing the operational cost	Industrial WW effluent
Symbol			

Table B6

People Risk Matrix

Frequency		1	2	3	4	5
Consequence		Very rare	Rare	Possible	Likely	Very likely
1	No injury	**2**	**3**	**4**	**5**	**6**
2	Minor injury	**3**	**4**	**5**	**6**	**7**
3	Major injury	**4**	**5**	**6**	**7**	**8**
4	Single fatality	**5**	**6**	**7**	**8**	**9**
5	Multiple fatalities	**6**	**7**	**8**	**9**	**10**

Table B7

Assets Risk Matrix

Frequency		1	2	3	4	5
Consequence		Very rare	Rare	Possible	Likely	Very likely
1	No damage	**2**	**3**	**4**	**5**	**6**
2	Slight damage	**3**	**4**	**5**	**6**	**7**
3	Minor damage	**4**	**5**	**6**	**7**	**8**
4	Major damage	**5**	**6**	**7**	**8**	**9**
5	Extensive damage	**6**	**7**	**8**	**9**	**10**

Table B8

Environment Risk Matrix

Frequency		1	2	3	4	5
Consequence		Very rare	Rare	Possible	Likely	Very likely
1	No effect	**2**	**3**	**4**	**5**	**6**
2	Slight effect	**3**	**4**	**5**	**6**	**7**
3	Minor effect	**4**	**5**	**6**	**7**	**8**
4	Major effect	**5**	**6**	**7**	**8**	**9**
5	Massive effect	**6**	**7**	**8**	**9**	**10**

Table B9

Reputation Risk Matrix

Frequency		1	2	3	4	5
Consequence		Very rare	Rare	Possible	Likely	Very likely
1	No impact	**2**	**3**	**4**	**5**	**6**
2	Minor impact	**3**	**4**	**5**	**6**	**7**
3	Limited impact	**4**	**5**	**6**	**7**	**8**
4	National impact	**5**	**6**	**7**	**8**	**9**
5	International impact	**6**	**7**	**8**	**9**	**10**

Table B10

RPN estimations

Hazard / Hazardous Event	Human			Assets			Environment			Reputation			Avg. RPN
WWN	F	C	RPN	F	C	RPN	F	C	RPN	F	C	RPN	
Floods in WWN	**5**	**2**	**7**	**5**	**2**	**7**	**5**	**4**	**9**	**5**	**3**	**8**	**8**
Pipes breaking	**5**	**1**	**6**	**5**	**3**	**8**	**5**	**2**	**7**	**5**	**4**	**9**	**8**
Incorrect practices	**5**	**3**	**8**	**5**	**1**	**6**	**5**	**3**	**8**	**5**	**3**	**8**	**8**
Industrial WW effluent	**5**	**4**	**9**	**5**	**3**	**8**	**5**	**5**	**10**	**5**	**4**	**9**	**9**
Rising of WWNs material price	**2**	**1**	**3**	**2**	**1**	**3**	**2**	**1**	**3**	**2**	**2**	**4**	**3**
Loss of expertise	**4**	**1**	**5**	**4**	**1**	**5**	**4**	**2**	**6**	**4**	**1**	**5**	**5**
WWTP													
Shortening the useful life of the equipment	**3**	**2**	**5**	**3**	**4**	**7**	**3**	**1**	**4**	**3**	**1**	**4**	**5**
Increasing the operational cost	**4**	**1**	**5**	**4**	**3**	**7**	**4**	**1**	**5**	**4**	**3**	**7**	**6**
Industrial WW effluent	**5**	**3**	**8**	**5**	**5**	**10**	**5**	**4**	**9**	**5**	**5**	**10**	**9**

Table B11

List of attendance during the brainstorming session

	Name	Title	Workplace
1	Eng. Tareq Dawood Ahmad	Head of Qalqilya Branch	Engineers Association
2	Eng. Issam Arabas	Head of Works Department	Qalqilya Municipality
3	Eng. Mohmmad Nazzal	Head of Projects Department	Qalqilya Municipality
4	Ashraf Sameer Nazzal	Surveyor	VERONA Engineering Office
5	Eng. Mohammad Abah	Surveying Engineer	Qalqilya Municipality
6	Eng. Ahmad Swaileh	Head of Projects Division	Joint Services Council for Solid Waste Management
7	Mohammad Nassoura	Head of Financial Affairs Division	Joint Services Council for Solid Waste Management
8	Reem Ra'ei	Accountant	Qalqilya Municipality
9	Tha'er Shawahneh	Insurance Officer	Qalqilya Municipality
10	Hisham Khader	Financial Manager	Qalqilya Municipality
11	Eng. Rana Nasrallah	Projects Engineer	Qalqilya Municipality
12	Eng. Fadi Quba'	WW Engineer	Qalqilya Municipality
13	Sondos Shraim	Mayor's Office Manager	Qalqilya Municipality

Table B12

Barriers in WWN system

#	WWN System	Reducing Measures (Barriers)	
		Proactive	Reactive
1	Floods in WWN	1. Providing suitable studies about surface water. 2. Developing the WWN. 3. Awareness campaign for inhabitants. 4. Cleaning before winter season and rainfall. 5. Rehabilitating WWN continuously.	1. Awareness campaign for inhabitants in the target region. 2. Manholes cleaning. 3. Transfer the high flow to other pipe lines.
2	Pipes breaking	1. Using high quality manholes and pipes. 2. Qualifying old parts of WWN. 3. Strong control for in-site excavations and works. 4. Offering detailed WWN drawings. 5. Using qualified staff.	1. WWN improvements. 2. Available craws in all times. 3. Improving N.M. materials standards. 4. Providing more engineers in the water and WW Departments crew.
3	Incorrect practices	1. Strong Control by N.M. 2. Implementation of laws. 3. Awareness campaign about current laws.	1.Imposing penalties and fines. 2. Monitoring on commitment.
4	Industrial WW effluent	1. Awareness campaign industries' owners and directors. 2. Rehabilitating and developing WWN continuously.	1. Implementation of laws. 2. Increasing municipal WW crews.
5	Rising of WWNs material price	1. Governmental polices improvements. 2. Find alternative materials. 3. Self-production of materials.	1. Increasing the local and foreign grants. 2. Continues maintenance.
6	Loss of expertise	1. Increase the salaries for engineers to work in Palestine. 2. Updating the educational system. 3. Training courses.	1. Recommendation to decrease the immigration rate. 2. Devolving technical crews' skills.

Table B13

Barriers in WWTP system

#	WWTP System	Reducing Measures (Barriers)	
		Proactive	Reactive
1	Shortening the useful life of the equipment	1. Expertise increasing. 2. Regular monitoring. 3. Suitable outlet water tests.	1. Crews training. 2. Reducing work time. 3. Increasing equipment' protection rate. 4. Equipment' insurance.
2	Increasing the operational cost	1. Qualifying the equipment. 2. Strong control. 3. Permanent maintenance.	1. Replacing old equipment by new ones. 2. Reducing the flow quantity.
3	Industrial WW effluent	1. Equipment' insurance. 2. Preliminary pre-treatment systems.	1. Equipment' maintenance.

Table B14

Cost estimation

No.	Barriers	Estimated Yearly Cost (NIS)				
		Purchasing	Installation	Maintenance	Training	Total
1	Awareness	38,825.28	0.0	0.0	250	39,075.28
2	WWN Rehabilitation		21,632,009		0.0	21,632,009
3	Laws	48,600	0.0	0.0	0.0	48,600
4	Municipal WW crews	211,152	0.0	0.0	0.0	211,152
5	Equipment' insurance		266,400			266,400
6	Pre-treatment system	256,680	3,650	0.0	0.0	260,330
7	Equipment' maintenance	0.0	0.0	304,063	0.0	304,063

Table B15

Benefits estimation

System	No.	Barriers	Estimated Benefit (NIS)
WWN	1	Awareness	247.50
	2	WWN Rehabilitation	7,200,000
	3	Laws	569,400
	4	Municipal WW crews	2,103,547.20
WWTP	5	Equipment' insurance	74,520,000
	6	Pre-treatment system	11,043,622.8
	7	Equipment' maintenance	1,250,000

جامعة النجاح الوطنية

كلية الدراسات العليا

إدارة المخاطر للمياه العادمة الصناعية في مدينة نابلس

إعداد

عتيد عفانه

إشراف

د. عبد الفتاح حسن

قدمت هذه الرسالة استكمالا لمتطلبات الحصول على درجة الماجستير في الإدارة الهندسية، من كلية الدراسات العليا، في جامعة النجاح الوطنية، نابلس– فلسطين.

2024

إدارة المخاطر للمياه العادمة الصناعية في مدينة نابلس

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الملخص

تعد مياه الصرف الصحي الصناعية ملوث كبيرا للبيئة إذا لم يتم التعامل معها بشكل صحيح، حيث أنها تؤثر على البنية التحتية للصرف الصحي بشقيها: التجميع والمعالجة.

معظم المياه المستهلكة الى مياه عادمة في عدة أشكال ومنها: السكنية والصناعية والتجارية وغيرها. تعتبر مياه الصرف الصحي الصناعية مصدر قلق مهم، لجميع البيئات الصناعية التي تفتقر إلى البنية التحتية للتعامل مع مثل هذه المياه.

بشكل عام، تمثل مياه الصرف الصحي الصناعية في فلسطين تحديًا كبيرًا للبيئة والبنية التحتية البلدية، خصوصا المدن الصناعية مثل مدينة نابلس.

تهدف هذه الأطروحة إلى إيجاد الحلول الأكثر ملاءمة لمنع أو تقليل المخاطر الناتجة عن مياه الصرف الصحي الصناعية على البنية التحتية للصرف الصحي وعملها.

استخدم البحث نهج إدارة المخاطر لاقتراح حواجز وحلول استباقية وبعدية لمخاطر وتأثيرات مياه الصرف الصناعي، وقد تم استخدام تحليل التكلفة والفائدة لتقدير التكاليف والفوائد لكل حاجز تم تحديده للقيام بالإجراءات الإدارية اللازمة.

تم إجراء تحليل المخاطر لتحديد مخاطر وتأثيرات مياه الصرف الصحي الصناعية على البنية التحتية؛ شبكة مياه الصرف الصحي في نابلس ومحطة معالجة مياه الصرف الصحي الغربية في نابلس، ثم تم استخدام تقييم المخاطر لتحديد الأولويات من خلال حساب (درجة الخطورة) لقياس المخاطر.

أظهرت النتائج أن مياه الصرف الصحي الصناعية والتي كان لها درجة خطورة تساوي 9، تشكل تهديدًا كبيرًا للبنية التحتية للبلدية. وقد نتج عن ذلك أضرار بالبنية التحتية وانعدام الكفاءة التشغيلية.

وللوصول إلى هدف هذه الأطروحة، تمت مناقشة الاستراتيجيات المقترحة للحد من التأثيرات السلبية والتي تمت مناقشتها من خلال نهج التحكم في المخاطر.

بعد إجراء تحليل تكلفة وفائدة المخاطر، وُجد أنه يجب استبعاد الحواجز المتعلقة بالتوعية وتأهيل شبكة الصرف الصحي لأن عامل نسبتها أكبر من 1، ولكن يجب تنفيذ الحواجز الأخرى من قبل البلدية، ونظرًا لأن تأمين المعدات في محطة التنقية له أصغر معامل نسبة وهو 0.0036، فيجب اعطاؤه الأولوية ثم تنفيذ الحواجز المتبقية من أصغر معامل نسبة الى الأكبر أي بترتيب تصاعدي.

وأخيرًا، يعد نهج ادارة المخاطر وعملية تحليل تكلفة وفائدة المخاطر أدوات مفيدة للغاية للتخفيف من المخاطر وتكييفها من أجل تحسين الاستعداد والاستجابة للهيئات المحلية، خاصة في مجال إدارة مياه الصرف الصحي.

ان نتائج هذه الأطروحة يجب أن توجه تنفيذ ممارسات الإدارة الفعالة التي تضمن حماية البيئة ومرونة البنية التحتية.

الكلمات المفتاحية: مياه الصرف الصحي الصناعية، شبكة الصرف الصحي البلدية، إدارة المخاطر، محطة التنقية، تحليل تكلفة وفائدة المخاطر.