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**Medical Wastes Management and Recycling: The Case of Bethlehem  
Governorate**

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**Medical Wastes Management and Recycling: The Case of Bethlehem  
Governorate**

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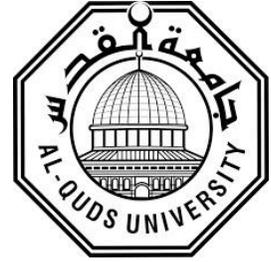
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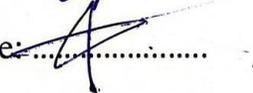
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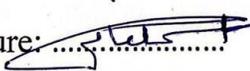
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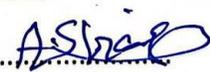
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## **Dedication**

(وَأَخِرُ دَعْوَاهُمْ أَنِ الْحَمْدُ لِلَّهِ رَبِّ الْعَالَمِينَ)

This thesis is dedicated to my loving family, whose unwavering support, encouragement, and understanding have been the foundation of my academic journey.

To my parents for their prayers, love, and endless encouragement, whose sacrifices and belief in my abilities have inspired me to reach the stars.

To my father who's always there for me when needed, my anchor through the seas of education

To my lovely mother the unlimited source of strength and support the one who's the reason of what I'm in today

To my siblings, for their patience and understanding during my ups and downs, the source of joy and support.

To my dear friend, thank you for being there for me

To all of those who have supported me through this journey, whether by a word of encouragement, a listening ear, or a helping hand. Your belief in me has been my driving force, and I am deeply grateful for your unwavering support. This thesis is dedicated to you.

**Rayyan Marwan Abuzayyad**

## **Declaration**

I certify that this thesis submitted for the degree of Master is the result of my own research, except where otherwise acknowledged, and that this thesis (or any part of the same) has not been submitted for a higher degree to any other university or institution.

21/7/2024

**Signed:**

Rayyan AbuZayyad

A handwritten signature in black ink, appearing to be 'Rayyan AbuZayyad', enclosed in a light gray rectangular box.

## **Acknowledgement**

At the outset, I express my gratitude to God Almighty, who is always with me, providing the strength that has brought me to the point where I stand today.

I extend my sincere thanks to my supervisors Professor Mahmoud El-Jafari and Dr. Maha Husseini, for generously offering their time and valuable insights, which significantly contributed to the successful completion of this thesis.

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## **Abstract**

**Background:** Medical waste management is a crucial issue in healthcare due to its potential health risks. Rapid population growth increases the demand for disposable medical equipment and supplies, leading to more medical waste.

**Purpose:** The main purpose of the study is to investigate the current medical wastes management process in Bethlehem governorate. Then addressing the required steps needed in order to implement recycling program, and highlight its impact on health and economy. It assesses current medical waste management practices, the feasibility of recycling, and the effects of medical waste on health and the environment.

**Methods and Data Collection:** The study was conducted in Bethlehem governorate, targeting healthcare facilities. Data was collected through structured interviews with healthcare management and site visits, along with secondary data from annual reports by the Joint Services Council (JSC). The study focused on facilities, which generates significant medical wastes, such as Beit Jala governmental hospital that consists of several specialized departments, that indicates the large volume of service provided, which in turn provided us with supplies and used items list that was helpful to identify and classify wastes materials to be recycled.

**Results:** The study found a direct correlation between medical waste volume and healthcare services provided. The Arab Society for Rehabilitation and Beit Jala Governmental Hospital produced the most waste in 2021 and 2022, with plastic waste making up 66% of the total. This presents both environmental challenges and opportunities for economic benefits through recycling. However, the Palestinian plastic recycling market is constrained by insufficient investment. Medical sharp wastes, representing 14% of waste, pose safety risks but can be recycled with proper treatment. Other materials which represent 20% of medical wastes, that mainly consist of bed sheets, surgical gowns and fabrics, offer economic value when recycled (140-199 \$ per ton). The annual high cost of medical waste management (242,000 – 292,000 \$) highlights the potential economic benefits of recycling, which can reduce costs, extend landfill lifespan, conserve energy, and protect public health.

The study showed that establishing a medical waste recycling facility in Bethlehem is not only feasible but also beneficial. It promises to reduce the environmental impact of medical waste, provide economic gains through revenue generation, and support the principles of a circular economy. This initiative can serve as a model for other regions, demonstrating the transformative potential of effective medical waste recycling practices.

**Conclusion:** Medical waste recycling positively impacts health, the environment, and the economy. Investing in recycling infrastructure and technology is essential to realize these benefits and reduce the costs associated with inadequate waste management practices.

**Keywords:** Medical waste, Medical waste management, Recycling, Circular economy.

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## **List of abbreviation**

BMW: Biomedical Wastes

BTU: British thermal unit

CAGR: Compound Annual Growth Rate

CE: Circular Economy

CPCB: Central Pollution Control Board

EQA: Environment Quality Assurance

GDP: Gross Domestic Product

HCW: Health Care Waste

HDPE: High Density Polyethylene

JSC: Joint Services Council

LDPE: Low Density Polyethylene

MCDM: Multiple Criteria in Decision Making

MOH: Ministry of Health

MSW: Medical Solid Wastes

MW: Medical Wastes

MWM: Medical Wastes Management

MWSC: Medical Wastes Supply Chain

PE: Polyethylene

PP: Poly Propylene

PPE: Personal Protective Equipment

PS: Polystyrene

PVC: Poly Vinyl Chloride

SDGs: Sustainable Development Goals

WHO: World Health Organization

# Chapter One

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## **Introduction**

### **1.1 Background**

World Health Organization (WHO) defines medical wastes as “waste generated by health care activities, ranging from used needles and syringes to soiled dressings, body parts, diagnostic samples, blood, chemicals, pharmaceuticals, medical devices and radioactive materials” (WHO, 2018).

It is also considered as the wastes generated from every medical practice in health care facilities. Hospitals, medical centers and other healthcare facilities such as blood banks and clinics are responsible on maintaining the public health, by providing patient care and services and preserving healthy and safe environment. Sharps, human tissues or body parts, and other infectious items are typically included in the trash produced during the course of providing medical care (Hussain et al., 2020). WHO classify these wastes into two main categories Hazardous and non-hazardous. The hazardous wastes are classified into the following categories: sharp materials, infectious, pathological, pharmaceutical (cytotoxic), chemical and radioactive (Chartier et al., 2014).

However, these wastes require special ways of treatment in order to eliminate the risk or danger that might affect public health. For many decades, medical waste management such as steam sterilization (autoclaving), thermal treatment (microwaving), chemical treatment and electrolysis have been developed. In Palestine, the most common practice is autoclaving. This procedure may solve medical solid waste management issue, but on the other hand they would cause several problems to environment and human health on the long term (Letho et al., 2021).

Medical waste management is one of the most important issues in healthcare system. Due to potentially high risks on human health and the environment, the rapid population growth requires more services which will lead to more medical equipment in use. Therefore, managing medical disposals has been considered the right way that affects the public in many different ways (Sujon et al., 2022).

Health care facilities must be aware of the risks in managing infectious waste and adhere to the highest standards of disposal and transit. Nowadays, it is essential to educate staff, patients, and community on the management of such wastes. Public attention and general understanding of their dangers increased, where lawsuits were brought against negligent authorities. Recently, several historic choices to improve hospital waste management have been taken (Padmanabhan & Barik, 2018).

Proper treatment and disposal of medical wastes have received little attention in Palestine's healthcare system. After receiving many donations to be used in treating medical waste in the West Bank and Gaza Strip, Palestinian Authority focused on the issue of medical waste management by the end of 1994. However, the lack of maintenance and experience in the Palestinian community resulted in inadequate and unsatisfactory outcomes, due to the emissions of smoke and odors that harm the local environment and public health (Radi & Ghani, 2012).

Applying medical waste management system has several financial aspects. It requires direct costs of supplies and materials used for collection, transport, storage treatment, disposal, sterilization and cleaning. Also, the training costs (labour and materials), requires well trained employees to be aware and know how to deal with medical solid wastes. Furthermore the operation costs and on-site maintenance of treatment facilities (Wisniewski et al., 2020). Generally speaking, processing recycled materials uses less energy than making items from raw

materials. Strong recycling infrastructure also fosters technological innovation in waste management, opening up new business prospects.

Moving to recycling as a solution for medical waste management issue can be game changer for various reasons such as minimization of wastes produced and the costs of management. Where these wastes are following 3Rs (reuse, reduce and recycle) (Cesario et al., 2020). As this solution supports sustainability according to Sustainable Development Goals (SDGs) and will result in preventing human and environmental health on the long term , by limiting the exposing hazards (Faiza et al., 2019)

However, the recycling process promotes the economic progress. As it lowers the demand on raw materials, where it reduces the cost of extraction and manufacture, by diverting materials from landfills and reusing them in the production cycle. This in turn encourages the creation of jobs in the recycling and other industries. All things considered, recycling has a positive economic benefit that goes beyond waste reduction and promotes a more resilient and resource-efficient economy (Xu & Peskin, 2022).

Based on the above discussion a concept of “circular economy” should be promoted, which supports the idea of production and consumption system which aims to extend the lifespan of products. The conventional linear concept of "take-make-dispose" is swapped out for a closed-loop system in a circular economy. It is also, a systematic and essential strategy to reduce the effects of medical waste on public health, environmental pollution, and climate change (Chew et al., 2022). Circular economy would decrease the greenhouse gas emissions by 70% and increase job opportunities by 4% (Amari et al., 2017).

Nevertheless, the estimated waste quantities can be predicted through reversed supply chain model, which requires a well-managed strategies and plan. It could help in optimizing the capacity, prices and the way of treatment (Kargar et al., 2020) Medical waste supply chain perform the process of treatment including generation, segregation, transfer stations, disposal facilities and landfills (Maihami & Ghalekhondab, 2022).

Palestinian healthcare sector generates approximately 5000 tons of medical wastes annually, where it require special treatment to eliminate risk and prevent dangers, because such wastes

contain infectious materials that could be harmful. However, such wastes is not always properly managed or treated.

Highlighting the issue of waste management in Palestine and directing it toward recycling as the next step showing its impact on the economy, will help in focusing on resource preservation and institutional, legal, financial assessment and framework development. Palestinian economy suffers from the scarcity of raw materials, it is obvious that political obstacles barriers and impeding have denied Palestine from develop its industry.

However, this thesis inquiries about what if medical wastes have been recycled? And make use of the raw materials produced in industry, and how it would affect the overall economy, environment and human health?

## **1.2 Problem Statement**

Medical wastes have special characteristics that can't be considered as general and normal wastes, as long as it's generated from healthcare facilities usually medical wastes contain dangerous agents, sharp materials and other contaminated objects that affect negatively the public health. So, it should be handled carefully in a safe way, it requires special kind of treatment and management to reduce its consequences and harm. However, it should be handled according to specific guidelines and particular precautions to guarantee safety for healthcare workers, janitors and public health.

Medical waste management is considered as an issue that is affected by political, legal, sociocultural, financial, technological and environmental aspects. These aspects have an interrelationship and depending on each other. Assuming that there is a viable medical waste recycling management solution, all of these problems should be resolved. Some of developing nations have stricter laws than industrialized nations which is a result of enforcement absence and/or the presence of workable substitutes (Abdel-Shafy & Mansour, 2018).

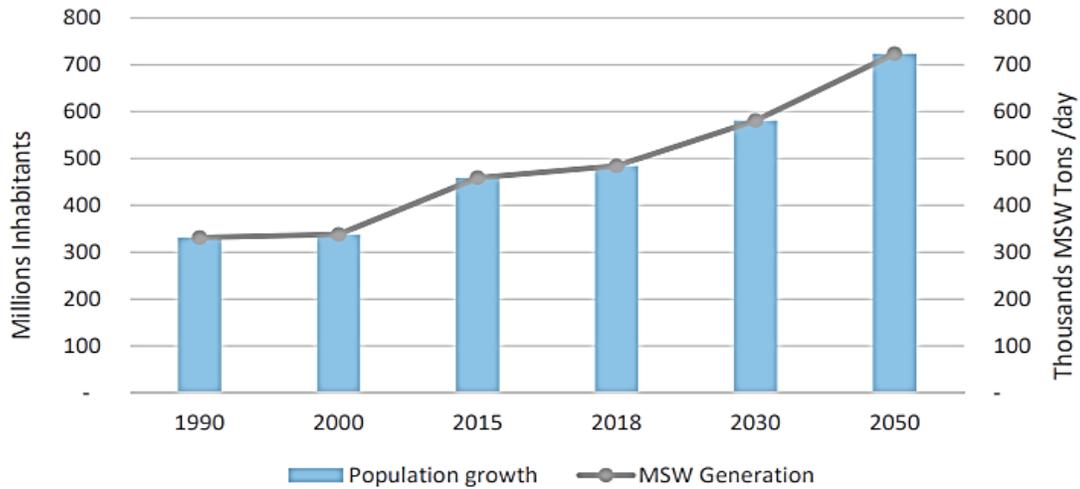
Medical waste management indeed received the lowest priority due to the poor enforcement of laws regulating the collection, disposal, and taxation of such wastes. Additionally, limited funding sources have been identified as a major issue. Furthermore, there are technical

challenges, including a lack of necessary equipment, facilities, knowledge, and plans to complete the process (Kwenda et al., 2022).

To deal with an effective medical waste management system, there should be an adequate funding, proper infrastructure and clear legislation. Where the institutional support have to cope with medical waste management plan, and that would lead to a better service delivery which mean an increase in the number of people who are ready to pay for it and benefit from it. In contrast, the absence of adequate collection and transportation infrastructure is a crucial aspect that adds to the issues with medical waste management in a developing nation. However, population growth doesn't necessarily mean an increase in government revenues for waste management (Abd El-Salam, 2010).

Yet, treatment of solid medical wastes is still subject to the absence of policies, strategies, and unambiguous criteria. Therefore, handling the effects of solid waste and environmental contamination has resulted from miss allocation of resources that may be utilized. Medical waste management in developing countries might face challenges, where many of them are hindered by institutional, financial, legal, and technical shortcomings. In other words, if donor financing and aids stopped, medical waste management services will no longer be able to be provided (Cardoso et al., 2022).

Healthcare facilities produce tons of medical wastes because of its daily basis practices that the waste generation rate increase by the growth of the population and their needs. Figure 1 shows the rate of waste production associated with the population growth in the Middle East and North Africa countries (Thabit et al., 2022). Then these wastes are managed and processed in order to sterilize them to be discarded in dumbs after that. On the long run it may cause several issues to environment and human health. This procedure has high costs and spending from the expenditure.



**Figure 1: Population growth and medical solid wastes (MSW) production rate in the Middle East and North Africa countries<sup>1</sup>**

Having an alternative way in recycling and processing medical wastes may lead to several benefits. It will help in producing raw material for manufacturing (rejuvenate medical supplies or using the produced raw materials for manufacturing different products), which as a result will help the economy and reduce import costs. Consequently, it will have a significant influence on public health and work enforcement.

Bethlehem governorate, with its significant economic role and the presence of one of the largest governmental hospitals in Palestine, serves as a crucial case study for exploring effective medical waste management solutions. The region’s industrial and tourism activities, coupled with its historical and religious significance, influence the local economy and present unique challenges and opportunities for medical waste management.

Recycling and processing medical waste could offer substantial benefits, such as producing raw materials for manufacturing, boosting the economy, and reducing import costs. Despite these potential advantages, there is a lack of comprehensive studies examining the economic benefits and effectiveness of medical waste recycling programs. This study aims to address this gap by investigating the feasibility and impact of medical waste recycling in Bethlehem, thereby contributing to better waste management practices and, community and economic development.

<sup>1</sup> (Figure 1) is taken from “Review of medical waste management in Jordanian health care organizations”

### **1.3 Study Justification**

Although Palestine is a developing country with a medical waste management issue, it is still under the Israeli occupation and has limited access on solid waste treatment. Due to continued Israeli transgressions against the people, community and the land they live on, Palestine is in a challenging situation (GIZ, 2014)

The construction of healthy landfills is likewise hampered by and even prevented by the Israeli occupation. It prevents wastes from being transported freely to landfills. This increases the strain on managing medical waste properly and calls for further consideration, assistance, and research in this area. The medical waste management sector will continue to have an impact on Palestinian everyday life in the future, thus there is a great deal of effort to be done to develop and oversee its resources.

Another reason can be added according to landfills, is that on the long run the capacity of landfills will gradually decrease and the harm of accumulated medical wastes will increase whether on the human health or the environment. One of the serious problems that can happen is the leakage of wastes toxins to ground water.

Expansion of landfills is not always a good solution, as it requires high costs, they mainly include buying a large piece of land to expand landfills and dumps. So when dealing with recycling as an alternative, it will reduce the costs and help in investing in these wastes to get an end product as raw materials to be used in industry. In turns it will affect the import cost and reduce it in a way or another. In other words, the rising amount of medical wastes production could be used and become beneficial on several scales and not only being a disposed waste, where this idea is supported by SDGs and it maintains sustainability.

However, recycling medical waste offers substantial benefits across various sectors:

- 1- Industry: Manufacturers and recycling facilities can obtain locally produced raw materials at lower prices, reducing dependency on imports and fostering advancements in waste management technologies.

- 2- Healthcare Sector: Medical institutions, pharmaceutical companies, and hospitals can benefit from reduced raw material costs, potential profits from recyclable materials, and lower disposal expenses.
- 3- Government: Local and national governments can achieve lower import costs, improved trade balances, reduced ecological restoration expenses, and enhanced public health. Regulatory authorities can more effectively meet sustainability and environmental goals aligned with the Sustainable Development Goals (SDGs).
- 4- Environmental Groups: NGOs and community activists will observe reductions in waste and pollution, leading to improved environmental and public health.
- 5- Public: The general population will enjoy a cleaner environment with fewer pollution-related risks and potentially lower costs for medical products.
- 6- Economic Impact: The local economy can expand through job creation in the recycling sector and related industries, while the global economy benefits from more efficient resource use and reduced demand for raw materials.

Efficient financing is the foundation of a successful medical waste recycling management. Additionally, it is important to evaluate the institutional, legal, financial assessment and framework development issues around medical waste recycling management. Also, how it might be strengthened in Palestine, where there are still unsustainable environmental practices.

Since waste management requires systematic institutional effort, abundant financing, and a dependable legal framework for a successful medical waste recycling management, it is vital to investigate the institutional, legal, and financial condition of medical waste recycling management in Palestine.

Even though, the West Bank health care institutions produces a rising amount of medical wastes each year, the fundamental management functions of sorting, assembly, transport; treatment, recycling, and disposal are not kept up with the field's advancements on a worldwide scale.

In cooperation with local government units (LGUs), relevant ministries, and non-governmental organizations (NGOs), various medical waste proper management initiatives have been carried out in Palestine during the past ten years. While some efforts achieved the anticipated effects, others failed to have a long-lasting impact on the improvement of medical

waste recycling management. Without this sector's steady growth, projects would not be able to maintain themselves or grow further. However, technical, financial, institutional, economic, legal, and social areas face challenges that might contribute to the failure of some initiatives for medical waste management projects. All of these elements would confirm the significance of this study.

In exploring the broader context of medical waste recycling, a recent workshop titled "The Reality of Solid Waste Management in Palestine," organized by the Coalition for Integrity and Accountability (AMAN), sheds light on these issues. The study, conducted by researcher Raida Qandil, focused on the integrity system within the Joint Services Council for Solid Waste Management in the Ramallah and Al-Bireh Governorate.

The participants stressed the need for the council to seek assistance from the Council of Ministers in signing agreements with the Ministry of Health for medical waste management, and for the council to be guided by governmental codes of conduct (Watan, 2024).

In summary, converting medical waste into valuable raw materials aligns with sustainability objectives, mitigates environmental impact, and provides significant economic benefits. This study aims to explore these multifaceted advantages, thereby supporting more sustainable and economically viable waste management practices.

#### **1.4 Purpose of the Study**

The main purpose of the study is to investigate the current medical wastes management process in Bethlehem governorate. Then addressing the required steps needed in order to implement recycling program, and highlight its impact on health and economy. This will be achieved by assessing the current status of medical waste management and the impact of wastes on human health and environment and clarifying the concept of recycling and its application on medical wastes. In addition, the probability of medical waste recycling and its impact on economy. Based on main objective, the study specific objectives are presented as follow:

1. To determine the amount of produced medical wastes and how it has been treated.
2. To determine the costs that they spend on medical wastes treatment.
3. To assess the impact of produced raw materials on Bethlehem industry.
4. To determine the benefits of medical wastes recycling on human health and environment.

## **1.5 Study Questions**

Palestine produces hundreds of thousands of tons of solid wastes per year as a result of its home, commercial, and healthcare industries. The following inquiries are tried to be answered by this study:

1. How to enhance the role of recycling policy in achieving health, environment and economic development in Palestine? (Main Question)
2. How would medical waste recycling affect public health?
3. How would medical waste recycling help the industry?

## **1.6 Terms Definitions**

- **Healthcare Facility:** any location where healthcare services are provided.
- **Public Health:** is the practice of preventing disease and promoting good health within groups of people, from small communities to entire countries (APHA, 2024)
- **Medical wastes:** waste generated by health care activities, ranging from used needles and syringes to soiled dressings, body parts, diagnostic samples, blood, chemicals, pharmaceuticals, medical devices and radioactive materials (WHO, 2018).
- **Medical wastes management:** is the process of collecting, sorting out and disposing of medical wastes (Bansod & Deshmukh, 2023).
- **Recycling:** is the process of collecting and processing materials that would otherwise be thrown away as trash and turning them into new products (US EPA, 2023).
- **Sustainability:** the integration of environmental health, social equity and economic vitality in order to create thriving, healthy, diverse and resilient communities for this generation and generations to come (UCLA, n.d.)
- **Circular economy:** is a model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible (Wright et al., 2019).

## **1.7 Context of the Study**

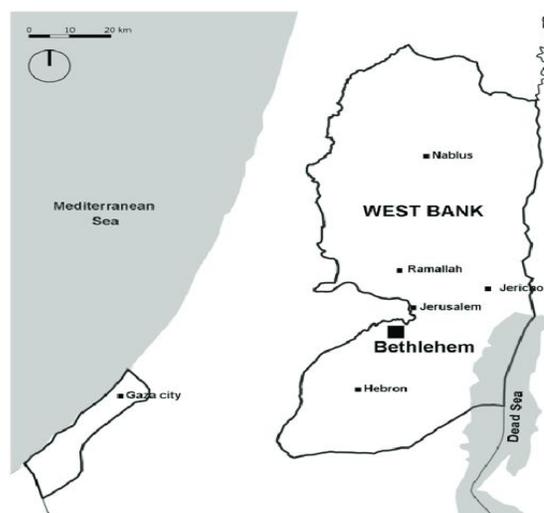
The study conducted in Bethlehem governorate to target its healthcare facilities (public and private sectors) as it has one of the largest governmental hospitals in Palestine (Beit Jala governmental hospital) and one of the largest private hospital (Holy Family) in Bethlehem Governorate.

Due to the importance of medical waste related issues, there must be a highlight of current practices for medical wastes management to implement an alternative that affect different life aspects such as economy, industry and public health.

### **1.7.1 Bethlehem Governorate**

Bethlehem is located less than 10 kilometers south of the Old City of Jerusalem, along the main road between Jerusalem and Hebron, on a mountainous plateau that rises an average of 750 to 800 meters above sea level.

However Bethlehem is tourism place of interest due to its historical and religious importance and that plays a role in developing Bethlehem local economy. It is a home to three universities as well as a number of museums and cultural centers. Most of the buildings of the old town have been restored through the efforts of the Centre for Cultural Heritage Preservation. The city's infrastructure underwent comprehensive rehabilitation in preparation for the Bethlehem 2000 celebrations to commemorate 2,000 years since the birth of Jesus Christ.



**Figure 2: Bethlehem location on the map of Palestine**

## **1.7.2 Health Sector**

The healthcare sector providers in Bethlehem governorate consist of Ministry of Health (MoH), the United Nations Relief and Works Agency for Palestine Refugees in the Near East (UNRWA), NGOs and for-profit providers. The following show an overview of Bethlehem's Healthcare Sector.

### **Public Healthcare Facilities**

Bethlehem Governmental Hospital (Beit Jala Hospital) provides various services such as emergency care, surgeries, and maternity services. Despite its importance, it faces issues like overcrowding, limited resources, and outdated equipment

### **Private Healthcare Sector**

The Holy Family Hospital, managed by the Order of Malta, is known for its maternity and neonatal care. The private sector is expanding, with new clinics and specialized centers opening, but access is often limited to those who can afford private healthcare.

Bethlehem's pharmaceutical industry is growing, producing some medications locally to reduce dependency on imports, though it faces regulatory and economic challenges.

### **Non-Governmental Organizations (NGOs)**

Bethlehem Arab Society for Rehabilitation (BASR) is a major institution offering comprehensive rehabilitation services, from medical to social rehabilitation. However, BASR, like other public facilities, struggles with funding shortages and restrictions on importing medical supplies due to the political situation.

NGOs such as Medical Aid for Palestinians (MAP) and Doctors without Borders (MSF) fill critical gaps, offering mental health counseling, physical rehabilitation, and emergency medical aid. These organizations heavily rely on international funding and face resource allocation challenges. Various NGOs also run community health programs focusing on preventive care, maternal and child health, and nutrition, which are essential in areas with limited access to healthcare facilities.

## UNRWA

There are several locations for UNRWA health centers in Bethlehem governorate camps that serve a significant number of Palestinian refugees many of whom have limited access to healthcare due to socio-economic constraints and political challenges. The health centers offer a range of services, from primary care to specialized treatments, ensuring that even the most vulnerable populations receive necessary medical attention. They are located in Aida Camp, Dheisheh Camp and Azza Camp.

### Healthcare Challenges

Bethlehem's healthcare sector is hampered by logistical issues such as restricted movement due to political instability, affecting timely delivery of healthcare services. Many facilities lack modern equipment and suffer from outdated infrastructure.

Financial constraints are significant, with both public institutions and NGOs relying on unpredictable and often insufficient donor funding. Economic instability, exacerbated by political conflict and the COVID-19 pandemic, further strains financial resources

Public health issues include high levels of trauma and mental health problems due to ongoing conflict, and an increasing prevalence of chronic diseases like diabetes and hypertension, which add pressure to the healthcare system. The COVID-19 pandemic exposed weaknesses such as a lack of ICU beds and ventilators, further straining the system.

Implementing medical waste recycling could provide economic benefits by reducing disposal costs and generating raw materials for manufacturing, alleviating some financial pressures on the healthcare sector.

## Bethlehem hospitals profile

This profile aims to provide a comprehensive overview of the main largest hospitals in Bethlehem Governorate as shown in table 1.

**Table 1: Bethlehem Healthcare facilities profile**

	<b>Arab Society for rehabilitation</b>	<b>Holy family hospital</b>	<b>Caritas Baby hospital</b>	<b>Beith Jala governmental hospital</b>
<b>Facility information</b>	A major rehabilitation center providing a range of services	Known for its maternity and pediatric services	Specializes in pediatric care	A major governmental hospital that consist of several specialized departments.
<b>Bed Capacity</b>	100	82	63	153
<b>Human Resources (staff)</b>	300	250	200	406
<b>Services and Specialization</b>	Rehabilitation services, orthopedic surgery, neurology	Maternity care, pediatrics, general surgery	Comprehensive pediatric care, neonatal intensive care	Surgery gastroscopy and colonoscopy unit, gynecology and obstetrics, oncology
<b>Financial information</b>	<p>Funding Sources: A mix of government funding, private donations, international aid, and patient fees.</p> <p>Budget and Expenditure: Facilities operate with varying budgets, dependent on their size and scope of services.</p>			
<b>Legal and regulatory compliance</b>	<p>Licenses and Permits: All facilities are licensed by the Palestinian Ministry of Health.</p> <p>Regulatory Adherence: Strict adherence to local and national health regulations ensures compliance and safety.</p>			
<b>Challenges and opportunities</b>	<p>Current Challenges: Include funding limitations, equipment shortages, and political instability affecting supply chains and infrastructure development.</p> <p>Opportunities for Improvement: Enhanced funding mechanisms, partnerships with international health organizations, and community-based health initiatives.</p>			

## Chapter Two

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### **Literature Review**

This chapter focuses on the related studies to the topic, where it reviews the concept of “medical wastes”, in terms of production rate and management globally and locally and their costs. Then moving to the idea of converting such wastes into sustainable materials and its effects on public health and economy.

#### **2.1 Medical Wastes**

Medical wastes or health care wastes are the wastes generated due to any health care facility practices, including hospitals, laboratories, clinics and research centers. They can be divided into two categories hazardous such as sharps, pharmaceutical, infectious and radioactive wastes and non-hazardous wastes like paper, cardboard, packaging etc. (Janik-Karpinska et al., 2023).

Also, it can be defined as the wastage produced in hospital during the treatment which consists of excretions of the patients through blood and other treatments. They include the used medical equipment and supplies like syringes, bottles, gloves and other personal protective equipment (PPE)” (Chew et al., 2023).

WHO classify medical wastes into four main categories: chemical, pharmaceutical, general medical wastes (non-hazardous) and hazardous or infectious medical waste. In fact, the last types require special treatment before disposal (WHO, 2018).

However, hazardous wastes represent 15-20% of total healthcare wastes where they are contaminated with infectious and harmful substances to human and public health. Therefore, it is required a special way of handling and disposal methods to minimize the risk of exposure and harm. There is a variety of materials undergo this category such as sharp wastes that include items like needles, broken glassware or scalpels, which is dangerous because it may puncture the skin and transmit an infection. Also, the infectious wastes that are responsible to bring an infection to human or animals and it can be used bandage, syringe or discarded surgical gloves. However pharmaceutical wastes are considered as hazardous ones, where they can be expired or unused medications and the manufacturing wastes (Padmanabhan & Barik, 2018).

### **2.1.1 Factors affecting production rate of medical wastes**

There are a number of factors that affect production of medical wastes. They are highly considered in this study. A proper strategy should be adopted and adapted to reduce waste to end up with the best practices of infection control and protection for public health and environment. This rate is measured by Kg/bed/day or ton/year. Some of the main factors are the type of healthcare facility its size, services and workload volume (Korkut, 2018). For example, medical waste production rate of a hospital with a variety of specialized services is greater than a clinic with limited ones. However these rates differ from country to another for example more developed countries produce up to 11 kg of hazardous wastes per bed per day such as USA rate (8.4-10.7) otherwise the developing countries rate is up to 6 kg like Jordan and Egypt as they range (2.5-6.1) and (0.7-1.7) respectively, which might be due to improper waste segregation and management as a result the rate is much higher (Janik-Karpinska et al., 2023).

As shown in one of the literature, Jenin hospitals produce 43.2% hazardous wastes from its total wastes, where primary healthcare centers generate 54% medical wastes (hazardous and non-hazardous) (Al-Khatib, 2011).

The usage of disposable medical supplies, such as PPEs, has increased significantly as a result of the COVID-19 epidemic. China and other nations with sophisticated disposal

techniques are finding it difficult to keep up and are running their incinerators to full capacity. Global healthcare systems give managing the rising amount of medical waste generated less importance than recovering viruses (Chaudhary et al., 2023).

A study on the impact of covid-19 pandemic on MWM in Lebanon showed that the estimated average of infectious wastes is 39,035 kg/month (1.3 ton/day), which became more challenging in medical waste management procedures and highlighted many risks that might be faced as it represent between 5% and 20% of total infectious wastes, with all the gaps in their wastes statistics (Maalouf & Maalouf, 2021).

A survey conducted in Jordan on four hospital and ten clinical laboratories showed that the average generation rate of medical wastes estimated to be more than 6, 5, and 4 kg/patient/day, for public, maternity, and private hospitals, respectively (Bdour et al., 2007). The rapid growth of medical waste production caused an indirect harm to human health and environment. It may release pathogens and toxins pollutants into the environment such as methane gases and sulfide which pollutes the atmosphere, it also may contaminate the drinking water and soil if the landfills are not constructed well.

### **2.1.2 Medical waste management**

Medical waste management procedure undergoes several steps: classification, segregation, minimization, handling and collection, on-site transport and storage, and lastly treatment and disposal. Also labeling can be added as an important step in order to know the type of waste, the date it has been collected in and its weight. When collecting medical wastes, it should be done the right way, as it must be classified in the first place according to the type and be put in the right container/ bag, also the healthcare worker whose responsible in this step must be aware of the proper way of collection and handling, they should know how to hold it, seal it and when to collect it. For example sharp wastes must be collected to be handled when the container is  $\frac{3}{4}$  full (Icrc, 2011).

Medical waste management is one of the most important issues in healthcare system, due to potentially high risks on human health and the environment. This is because of the rapid population growth requires more service provision which will lead to more medical equipment in use. So, managing the disposable medical wastes the right way will affect the public in many different ways (Sujon et al., 2022) (Huda et al., 2022).

Management of medical wastes is a systematic approach which includes vital steps: Collection, segregation, storage, transportation, treatment, and disposal, these steps can minimize the risks both within and outside healthcare facilities, by limiting a definitive source of preventable infection. There are various ways of disposing medical wastes like steam sterilization (autoclaving), thermal treatment (microwaving), mechanical treatment (Chemical) and electrolysis (Letho et al., 2021). Only 44% of hospitals in south-east Asia have a proper medical waste treatment methods (Chew et al., 2023).

For example, autoclaving technique depends on steam, moisture, heat and pressure, which plays an important role in inactivating microorganisms, sterilizing medical devices and treatment of medical wastes. The temperature should be at least 121°C with pressure 105 kPa for about 60 minutes, in this case the wastes become safe and sterile and ready to be recycled or disposed (Attrah et al., 2022). However, Anatomical and pathological wastes, low-level radioactive waste, organic solvents, laboratory chemicals, and chemotherapy waste should not be treated in an autoclave.

Substances placed in the autoclave produce emissions that may have unpleasant odors, and in some instances may be hazardous. However, there's a potential risk of using an autoclave such as heat and steam burns, hot fluid scalds, injuries to hands and arms from the door, and bodily injury in the event of an explosion. Also the exposure to biohazard material may occur, if biohazard waste is improperly packaged or manipulated (Ferdowsi et al., 2013).

As a very first step there must be sorting for the types of medical wastes and then weighting them in order to know the amounts that have been produced. After that a proper management process must be chosen to implement. However, multiple criteria in decision making (MCDM) methods are suggested, which are the most effective when dealing with medical waste management, as in this case the hospitals were classified according to the wastes generated and dealt with the appropriate procedure. (Chew et al., 2022).

These procedures may fail for various reasons, such as genitors and healthcare workers lack of awareness and negligence, inadequate financing and weak legislations, as it led to air water and soil pollution. Various studies showed that infectious diseases, respiratory diseases, gastrointestinal problems and injuries were due to poor medical waste handling. Proper waste

management requires awareness about the health hazards related to health-care waste, which will develop after having an adequate training (Takunda & Steven, 2023).

### **2.1.3 Medical Waste Throughout countries**

Medical waste management is a global issue that has been dealt with in several ways and the following is some of the examples:

- The Republic of Rwanda: Is considered as one of the nation's dealing with economic development issue. Over the past 20 years, Rwanda's economy has grown quickly; its Gross Domestic Product (GDP) is currently growing at a rate of 7.9%, it faces some challenges with solid waste management process and they are trying to improve the recycling rates (Kabera et al., 2019). Medical waste production rate in Rwanda is equal to 5.168 kg/day, which estimated by 60,775,164 kg annually that is consist of 74% non-infectious wastes, 24% liquid wastes, and 1.2% infectious wastes (Remezo et al., 2023). The concept of "reuse and recycle" medical wastes is present in Rwanda medical waste management system, where they put into consideration a proper way of sterilization and disinfection, to make sure that they get rid of any infectious agents. Some of the items are reusable such as blades scalpels, syringe and glass after being sterilized. There is also a recycling strategies for the non-infectious wastes such as paper glass and polythene (Ministry of Health, 2016). Some private sector companies in Rwanda support the idea of recycling and trying to implement it, and the government is looking forward to move this service to the public sector(Kabera et al., 2019).
- Pakistan: A study in Pakistan focuses on the financial benefits of employing an eccentric method to recycle medical waste in a Pakistani public hospital. The embodied energy of various waste fractions is examined, and the financial potential of currently available waste recycling methods is compared with the case of 100% recycling of valuable waste fractions. The study concludes that recyclable waste fractions have a higher value than their market prices reflect due to their latent embodied energy, and this value rises with full recycling. To reduce expenses related to the extraction and processing of natural resources, the study makes the case for source-segregation and recycling of healthcare waste. This method can be used in future research to examine the effects of waste treatment processes for hazardous medical waste (Ali et al., 2018).

- India: Medical waste has significantly increased between 2005 and 2019 by CAGR of 12.5%. In 2005 the production of medical waste was 0.179 kg/bed/day which increased to 0.709 kg/bed/day by 2019. Medical wastes are increasing as the years go by which require more attention from the stakeholders in order to take a step toward reusable materials and waste reduction strategies(Achra et al., 2021)

#### **2.1.4 Waste Management in the Middle East**

Middle East is still in early stages in the field of recycling industry. Yet, recycling rates are relatively low compared to developed countries, due to several factors such as lack of public awareness, unclear policies by the government and the gap between costs and revenue. However, there are obstacles that might face the industrial growth. In fact, most of Arab governments have understood the importance of applying an alternative and more effective solution for the issue of waste management as the following:

- Saudi Arabia: In 2017, the Public Investment Fund declared that it would create a Saudi Recycling Company to "support and operate its investments in domestic recycling projects." One of the proposed solutions was thermal plasma for ecological friendly management of medical wastes, which focuses on energy recovery (Galaly, 2022).
- Yemen: A study aims to assess current practices of medical waste management in Amanat Al-Asimah which was carried out in the four biggest private hospitals, revealed that the hospitals had no independent, specialized administrative units that would have managed, monitored, and disposed of medical waste. Additionally, there were no laws or regulations regarding medical waste management or how to deal with it (Zaid et al., 2022).
- United Arab Emirates (UAE): Healthcare facilities in UAE, especially in Dubai and Abu Dhabi, focus on sustainability and finding an environment friendly solution in the issue of medical waste management. Medical waste is separated at the source in accordance with well-established waste management guidelines, which are common in UAE healthcare facilities. Non-hazardous materials like as plastics, paper, and cardboard are frequently recycled, whereas hazardous medical waste is handled separately using techniques like autoclaving or cremation. A new federal law on integrated waste management was passed in 2018 the first in the region. Additionally, plans were made

to build a waste facility in Sharjah with a daily capacity of 900 tons, a cement waste-to-energy plant in Abu Dhabi at a cost of 28 million euros, a waste-to-energy plant in Dubai with a daily capacity of 2,000 tons, and another waste facility in Sharjah with a daily capacity of 900 tons. Although there has been a renewed interest in waste management in the area, the field is still insufficient (Shaheen, 2020) (AlHaj Ali et al., 2022).

- Morocco: Waste management in Morocco is not a well obtained system, and requires a better infrastructure to obtain sustainability (Campitelli et al., 2023). With a funding from the international bank the goal was to increase the recycled wastes by 20% by 2022, and improve the overall situation of waste field collection (Shaheen, 2020).
- Jordan: The situation of medical wastes can be summarized in: inadequate procedures for medical waste segregation, storage, transportation, and disposal present difficulties for Jordanian healthcare organizations. Healthcare personnel require better education and awareness campaigns that emphasize following national norms and regulations for efficient management. To improve medical waste management procedures in Jordan and address these concerns, comprehensive measures are needed (Al-Momani et al., 2019).

### **2.1.5 Palestine and Medical Waste Management**

According to (Al-khatib et al., 2011) the approximate quantity per month of solid waste generated by the healthcare centers in Palestine (West Bank and Gaza) was 472.9 tons, as only 38.1% of the primary healthcare centers separate wastes. On the other hand, 71% of secondary healthcare centers follow that. Where only 17.3% of healthcare facilities are managing MW properly. Al-khatib study also discussed the situation of solid waste management in healthcare centers in Palestine. For about 87.2% of healthcare facilities use an unhygienic dump owned by the local authorities as the location for the final disposal of medical waste. Healthcare waste collection, storage, and disposal represent an environmental issue that poses a serious health risk and necessitates quick attention and intervention. Facilities for storing and disposing of waste are inadequate and insufficient at healthcare facilities.

To be more specific a study conducted in Nablus and Salfit governorate, interviewed for about 190 healthcare facility, showed that 80% of wastes the non-sharp ones were separated but

the other 20% (the sharp wastes) were not put into special containers. The average of waste produced by bed per day was 98g (34 g hazardous and 55g non-hazardous) (Al-Khatib, 2013).

A recent study on three hospitals in Jenin governorate showed that the average of medical waste generation rate is 0.54 – 1.82 kg/bed/day with average weight 0.78 kg/bed/day. The management of these wastes is not fully defined in all of health care facilities but they all end up in a centralized municipal sanitary landfill. However, the hospitals might face some challenges including estimation of the data about wastes quantities and the type of them, also personnel's lack of skills and professionalism in handling such wastes (Al-Khatib et al., 2019)

In Palestine territories, the Ministry of Local Government (MOLG) has put in place extensive plans, strategies, programs, and policies pertaining to waste management, with a focus on wastes reduction and encouragement of reuse, recycling, and treatment activities. Municipal solid waste generation in Palestinian territories was predicted to be 1.423 million ton per year in 2019, with a daily generation rate of 0.9 kg/day per capita. 12.6% of MSW in the West Bank is made up of paper, 50% is organic trash, 14.6% is plastic, 1.8% is glass, 2.5% is metal, and 18.5% is other waste. In particular, waste-to-energy initiatives have become a viable renewable energy source in Palestine with favorable effects on the environment and the economy. Notwithstanding these initiatives, it is anticipated that by 2025, the world's waste production would increase to 6 million tons per day, underscoring the continued need of efficient waste management plans and environmentally friendly behaviors (Osaily et al., 2023). Even though the above information related to general waste management, but it could be an indicator to be applied on medical wastes.

One of the most common ways to manage health care wastes is autoclaving where 40% of Palestinian medical facilities rely on it (Al-Khatib, 2010). However, the waste management practices in Palestine (West Bank and Gaza) are poor and far below WHO guidelines. As a it requires an alternatives for handling wastes “a locally made autoclave integrated with a shredder” to be implemented to handle this issue (Shtayeh et al., 2009) (Mhady et al., 2019).

There's an agreement between the local government and the Japanese international cooperation agency (JICA) to build up a project for infectious medical waste treatment and management, as there is special stations for management ( Minya in the south of the West Bank,

Zahrat Al-Fanjan in the north, and another in Ramallah in the center) and they were provided with all modern technologies for that (LocalGovernment, 2022).

### **2.1.6 Medical waste management costs**

The GDP is an important indicator to measure macroeconomic development status which is reflective of economic development and medical policies in waste generation. For example the economic costs associated with medical waste ranging from \$760 billion to \$935 billion, which accounts for approximately 25% of total US health care spending (Shrank et al., 2019). Furthermore, according to (Chew et al., 2022) the cost of medical waste management will reach to \$17.89 billion in 2026 as compared to \$11.77 billion in 2018, which is equivalent to the compound annual increase of 5.3%.

### **2.1.7 Benefits of medical waste recycling**

One of the best options for medical waste treatments is recycling, which means convert these wastes into another usable form. Recycling medical wastes has a good influence on health and environment. It reduces consumption of raw material and reduces the volume of the waste materials that must be disposed in a landfill. Less medical waste in a landfill, will mean reduced emission of greenhouse gasses, less burning of fossil fuels as well as less carbon dioxide in the atmosphere (Bartl, 2014).

In other words, recycling has a significant impact on environment that shows in energy saving and resource preservation, where the discarded wastes are collected, processed and transformed into new products. Rather than the environmental importance of recycling, it has an effect on economy by increasing the resource efficiency by saving costs for individuals and industry due to expanding lifespan of products. Also, it helps in developing market after having new recycling markets, which will foster the economic resilience, suppress the reliance on global commodity market and create new employment opportunities in collection, processing and production.

However, waste management costs are high somehow, but when having a recycling system, it will decrease the amount of wastes sent to landfills and reduce the cost of waste disposal and management. Such practice requires the community engagement to increase the awareness and achieve the desired outcomes for human and public health (Tonjes & Mallikarjun, 2013).

One of the live examples recycling and moving towards sustainability in several aspects of life is Singapore. The recycling rate in Singapore currently stands at about 60%. In 2018 only 4% of plastics were recycled as the aim to increase the recycling rate to 70% by 2030 (Ministry of Sustainability and the Environment, 2023).

The higher the recyclability the lower hospital expenditure will be. Biohazard wastes reduced in Singapore general hospital which led to a decrease in its expenditure by approximately SGD 42,000\$ per year (Peishi et al., 2021).

The sustainable solid waste management system that Singapore has implemented is based on four main concepts: waste treatment that uses innovative technologies to recover energy efficiently, minimize land-take and ash residue, recycle to recover valuable materials from waste, turn waste into resources, and adopt viable and efficient recycling methods for environmental sustainability. Finally, landfill and Ash Management that maximizes landfill lifespan and turns ash residue into a resource. The remaining waste is gathered and delivered to facilities that convert waste into energy for burning. Waste can be reduced by up to 90% through incineration, conserving landfill space. The heat generated during this process is recovered to create steam, which powers turbine-generators to produce electricity, meeting up to 3% of the island's electrical demands. The remaining non-incinerable wastes and incineration ash are subsequently moved to the Tuas Marine Transfer Station (TMTS), where they are barged to Semakau Landfill for ultimate disposal (Weng, 2021).

The public and private sectors are all involved in sustainable solid waste management. In close collaboration with the key stakeholders. National Environmental Agency (NEA) has created a number of projects and activities aimed at slowing the increase of waste production. Recyclables are separated and collected for processing at the waste generation site in order to save resources (Waste Manag., 2023).

Joint Services Council (JSC) assume that there are several recyclable wastes from what they collect such as paper and cardboards, plastics, aluminum tiers, glass and organic substances. For example, when recycling 1 ton of plastic wastes will save approximately 600kg of raw materials or it saves 5.6 square meters in waste dumb, as the plastic is harmful to the environment so safe disposal will contribute in saving it.

## **2.2 Circular economy and sustainability**

Circular economy (CE) is a production and consumption system that aims to extend the lifespan of products. In other words, it is an economic and industrial framework intended to uncouple economic growth from the use of finite resources, the production of waste, and the release of pollutants. It tries to reconsider how goods and materials are produced, consumed, and disposed of through a holistic and regenerative approach to economic activity. The conventional linear concept of "take-make-dispose" is swapped out for a closed-loop system in a circular economy. It is also a systematic and essential strategy to reduce the effects of medical waste on public health, environmental pollution, and climate change (Chew et al., 2023).

However, nowadays businesses are moving towards waste reduction through circular economy (CE) where it may help in faster expansion for several industries. The circular economy has gained popularity in industrialized nations, but not in low- and middle-income countries, which are still primarily adjusting to the CE concept and its national relevance. There are still a lot of questions about the effectiveness of adopting CE practices, would it have a positive impact on sustainable development, job creation, and economic growth. The fact that lower-income nations are already more "circular" than their counterparts in affluent economies must be acknowledged. Due to lower levels of consumption and less availability of material commodities, a CE is frequently the default economy in low-income settings (Wright et al., 2019).

Circular economy would decrease the greenhouse gas emissions by 70% and increase job opportunities by 4%. There are two models of circular economy the first one rely on "reuse" materials and goods by repairing and upgrading them, and the second one is identified by "recycling" through converting materials into new ones where Human Resources are involved in both cases (Amari et al., 2017)

The idea of implementing circular economy in Middle East might face several challenges, such as developing infrastructure for recycling and waste treatment facilities, creating legal frameworks for circular economy practices, and devising efficient waste management techniques. However, there is a need of increasing knowledge and influencing consumer behavior to reduce waste and consume sustainably. So it is important to have a cooperation and

coordination between different stakeholders, such as enterprises, the public, and government officials, in order to overcome obstacles and guarantee the Middle East's effective adoption of the circular economy model (Al Kufy, 2021).

Applying a recycling program on medical wastes will be beneficial in many aspects such as environment, human health and economy. According to the product and its volume produced from healthcare facilities it still doable. There is plastic such as containers and bags, glass like tubes lab containers and paper and cardboards from packaging.

## **2.3 Similar studies**

### **2.3.1 Medical Wastes Management**

(Abouelela, 2023) suggests that direct costs could be reduced when reducing the generation of hazardous medical wastes in Egypt healthcare sector where they found a reduction by approximately 764 million EGP per year (25 million USD). In order to have this result and implement an effective medical waste management a proper segregation of HCW when generating and gathering them. Where increasing the awareness of the proper and good practices will support the procedure as a whole.

For example, in Belgium “Ecosteryl” company is concerned with sterilizing medical wastes using only electricity. The whole process starts with shredding all kind of medical wastes and then sterilizing them, to end up with sterile small pieces, which might be a recyclable solid byproduct. The procedure is eco-friendly in other words there is no generation of any polluting emission which will decrease the indirect harm to environment and health (Ecosteryl, n.d.). Such devices are used in some of Palestinian healthcare facilities to treat medical wastes.

### **2.3.2 Medical Wastes Recycling**

According to Singapore ministry of health, medical wastes increased by 5% annually during the period 2016-2020, an increase from 4400 to 5700 ton. Singapore governorate found a solution for managing such wastes by reducing and recycling them. For example, plastic packaging materials of sterile equipment, fluids, and glove wrappings would be collected as recyclable waste. This will affect public health in general as it is going to be disposed safely, where in term it will prevent cross contamination and its risk (Weng, 2021).

(Chisholm et al., 2021) suggests policies and solutions to support sustainable medical waste management in African developing countries. There are 67,740 healthcare facilities that produce 2.83 million ton of medical waste per year, which will help the stakeholders to develop strategies that enhance the quality of healthcare system by modifying eco-friendly procedures of medical waste management. Their main goal is to recycle non-hazardous wastes and find a way to recycle the hazardous waste. In order to avoid using incineration, medical waste neutralization during chemical disinfection and subsequent disposal of the safer compounds are most likely an option to heat treatment. Medical waste disposal method followed in African countries is incineration as it diminishes 90% of wastes easily and afterwards produce energy. However, the consequences from this method are awful where it can cause harm to environment and public health due to toxic emissions.

Sixty six percent of wastes saved from burning, approximately 76 tons where 71.9 tons are recyclable wastes. If the wastes are not separated properly, the hazardous and chemical wastes will spoil the rest, which in turns will cause more pollution to the environment and increase management costs by 64%. As a result recycling solution was effective in cost reduction and protecting the public health (Cesario et al., 2020).

However, a number of programs for recycling plastic-based medical waste have been developed worldwide to cycle PVC based materials like oxygen masks and tubes, such as recycling pilot developed in the UK and another one conducted by the Vinyl Council of Australia. To achieve such process, protocols and guidelines have been designed which in turns will increase the environmental and economic benefits and decrease health associated benefits (Kheirabadi & Sheikhi, 2020).

### **2.3.3 Plastic Recycling**

Plastic recycling has substantial financial and economic advantages, but it get ignored because it depend on energy saving. During the early phases of plastic recycling, approximately 100 million British thermal units (BTUs) of energy may be saved for every kilogram of plastic, which is equal to 17 barrels of oil. Manufacturing products using recycled materials is a cheaper option than using virgin materials. It reduces the amount of waste that would ends up in landfills. Since oil is a nonrenewable resource at this moment, such process may save manufacturing

costs, energy expenditures, and the negative effects of extracting and processing virgin materials. CPCB (Central Pollution Control Board) 2020 established the Extended Producer Responsibility regulation, which will assist prevent plastics out of the environment while returning the cost of negative externalities to producers (Sahoo et al., 2024).

Medical supplies mostly are made from plastics as they are considered more durable than glass and ceramics, also it is more compatible with recycling practices in contrast of non-plastic ones (Kheirabadi & Sheikhi, 2020). According to United Nations Sustainable Development Goals (SDGs) alter the importance and the urgency of recycling plastic based materials (Walker, 2021).

(Beloel & Albaladejo, 2021) showed that when applying 5Rs rule, there would be improvements towards reducing the environmental footprint. Additionally, the greening of operating rooms requires the dedication of all medical staff members as well as other departments (pharmacy, hygiene), as well as management.

#### **2.3.4 Medical Wastes Costs**

As noted, healthcare industry spends 40.3 billion US dollars annually on disposable medical supplies, and healthcare facilities generate an average of 1.5 billion kilograms of solid waste each year. A study conducted to review the experiences of managing medical waste in healthcare facilities worldwide, focusing on studies published between January 2020 and April 2022, aimed to gain insights into the concept of green hospitals. An initial investment is required to optimize processes, it is expected that reducing, recycling, and reusing tools and instruments can lead to annual savings of thousands of dollars due to the cost-effectiveness of waste management in hospital settings. The primary recommendation was to follow the 5 Rs rule (reduce, reuse, recycle, rethink, and research) to maximize the benefits of supplies while minimizing waste. It is suggested that managers be made aware of this issue by including the costs of waste disposal, warehousing, occupational health, and environmental impact in the purchase price of disposable medical items to determine their total acquisition cost. The study categorized waste into five types: general, clinical, recyclable plastics, paper, and sharps (Lattanzio et al., 2022).

There's an increase in medical waste production rate by 3% annually in Bangladesh. They're trying to implement circular economy concept and life cycle assessment in order to achieve a sustainable and effective medical waste treatment, as their current model of medical waste management is far from sustainability. The estimated medical waste generation in Bangladesh would be approximately 50,000 tons (1.25 kg/bed/day) in 2025, out of which 12,435 tons were predicted to be hazardous wastes, without considering any unusual medical emergencies (Rahman et al., 2020).

Import spending and costs on raw materials are high. So when having raw material locally without importing them it will help the overall industry economy. For example when recycling plastic disposal waste like syringe, it will form plastic as raw material, which will help manufacturing and industry field where plastic import cost has reached US\$327.34 Million during 2021, according to the United Nations COMTRADE database on international trade (Hopewell et al., 2009).

A study titled "A reverse supply chain for medical waste: A case study in Babol healthcare sector" aims to create a supply chain model for safe disposal. It will take into consideration the unpredicted amount of medical wastes volume, where it will optimize the number, capacity and prices and the way of treatment. And that would be achieved through several integrated models to work as a reverse procedure (Kargar et al., 2020). As the term medical waste supply chain (MWSC) performs treatment processes for medical waste. A typical MWSC includes waste generators, contractors (or transfer stations), disposal (or treatment) facilities, and landfills" (Maihami & Ghalekhondab, 2022).

### **2.3.5 Summary**

The above studies highlight the significant financial and environmental benefits of proper medical waste management. For example, reducing hazardous medical waste in the healthcare sector can lead to substantial cost savings, primarily through proper waste segregation and increased awareness of best practices. An eco-friendly method developed in Belgium shreds and sterilizes medical waste without generating harmful emissions, and this approach has been adopted in various regions to improve waste management practices. Similarly, in response to increasing medical waste, some regions have promoted recycling initiatives that reduce cross-contamination risks and enhance public health. In developing countries, sustainable waste

management strategies, such as recycling and chemical disinfection, are preferred over incineration, which, although efficient, has severe environmental and health consequences.

Efforts to recycle plastic-based medical waste are gaining momentum globally, with programs focused on recycling materials like PVC-based medical supplies. These initiatives, supported by proper guidelines, offer substantial environmental and economic benefits. Regulatory measures are also being implemented to encourage recycling and reduce reliance on nonrenewable resources. Additionally, the "5Rs rule has been advocated as a way to minimize the healthcare industry's environmental impact, which currently spends billions on disposable supplies. Some regions, facing increasing medical waste, are working towards implementing circular economy principles for sustainable waste management. Optimizing medical waste supply chains has also been suggested as a means to enhance efficiency, reduce costs, and contribute to more sustainable healthcare practices.

## Chapter Three

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### **Framework and Methodology**

This chapter represents a detailed description of the study's methodology and procedure that this research would make use of operational and conceptual framework, method and design, the sample and data collection (interviews).

#### **3.1 Framework**

The connection between poor solid waste management and adverse health effects is evident and straightforward, but it can also be indirect and not obviously tied to negative health outcomes in populations. This study offers a framework to understand the links between inadequate solid waste management and health, highlighting the importance of efficient waste management as a means to prevent illness and promote wellness. The chapter explores various aspects of medical waste management and combined impacts on health in developing countries.

The information supporting the concept of the impact of medical wastes management is divided into two sections: exposure to solid waste and the mechanisms that cause ill health outcomes; and unfavorable health consequences. Under exposure, five types of exposure are considered: i) exposure to waste by waste generators; ii) exposure from waste handling among waste collectors; iii) pickers at dump sites; iv) living/working in neighborhoods near dumping

sites and incinerators; and v) accumulation of noxious substances such as heavy metals in the environment.

Figure 3 represents the factors that are associated with the conceptual framework components for the impact of medical wastes recycling. The conceptual framework model is adopted after studying similar studies. The medical wastes recycling conceptual framework which consists of (Human health, healthcare facility, industry and environment) and they are affected as the following:

- **Human Health:** Recycling medical waste helps protect human health by reducing exposure to hazardous materials. Proper waste management minimizes the risk of spreading infections and prevents accidents with sharp or toxic waste. Safe recycling practices ensure that harmful substances are treated properly, lowering health risks for patients and the community.
- **Healthcare Facility:** For healthcare facilities, recycling medical waste enhances operational efficiency and reduces disposal costs. Effective recycling programs improve safety and cleanliness, comply with regulations, and promote sustainability. This approach also helps manage resources better, leading to a more efficient and cost-effective healthcare environment.
- **Industry:** The medical waste recycling industry benefits from innovation and growth opportunities. Efficient waste processing can create valuable byproducts and drive technological advancements. Increased demand for recycling services supports job creation and aligns with trends towards environmental responsibility, boosting the industry's reputation and economic potential.
- **Environment:** Recycling medical waste reduces landfill use and environmental contamination. It cuts greenhouse gas emissions and conserves resources by reprocessing waste into new products. Sustainable recycling practices lessen the environmental impact of medical waste, contributing to a healthier and cleaner planet.

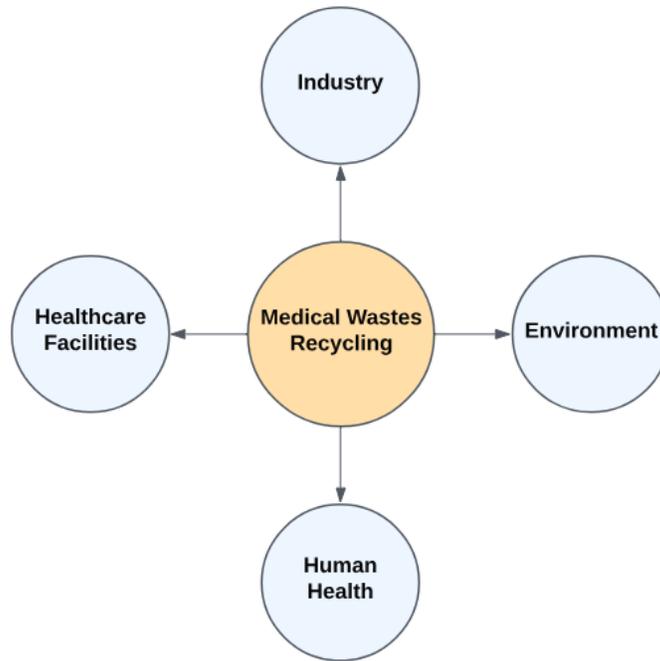


Figure 3: Conceptual Framework: the main factors that are affected by medical wastes recycling

### 3.2 Method and Design

As depicted in figure 4, this study used a retrospective design in which the available report reviewed to achieve the aims of the study. As a primary source the data was collected through

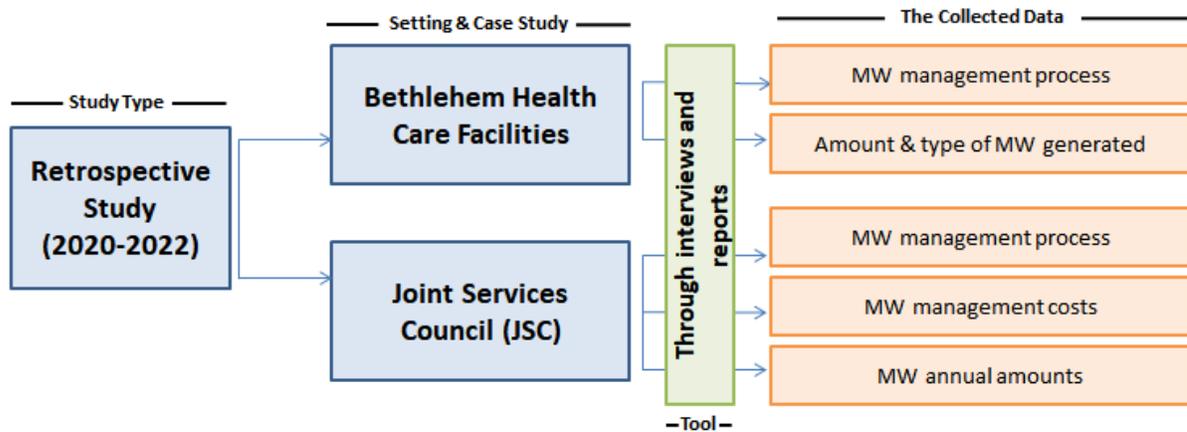


Figure 4: Study Methodology

interviews and visits, whereas the secondary data was collected from annual reports and the data provided by healthcare facilities. A retrospective study was carried out in a short period and provides a 'snapshot' of the outcome and the characteristics associated with it. It is also relatively inexpensive and takes up little time to conduct.

Choosing a retrospective study design to look into how medical waste recycling affects the economy can be justified through several reasons. First of all, retrospective studies allow researchers to look at previous trends and patterns using current data from sources like, medical waste management reports, costs and supply reports and documented data. This method allows for the long-term analysis of medical waste recycling, including the expenses associated with waste disposal, the money made from recycling programs, and any noted shifts in the economic activity around recycling activities.

However, it is important to note that this design provide findings that could be translated into valuable insights for stakeholders, which can be helpful in future policies, contribute the investment in recycling infrastructure, and encourage the development of sustainable waste management practices regulations.

Furthermore, by utilizing retrospective data, researchers can save time and money by examining the relation between recycling and economic outcomes without having to go through extensive prospective data sets. In order to promote sustainable waste management, retrospective studies can also be utilized to identify patterns and linkages that will guide future resource allocation and economic policy decisions. Generally, it provides a practical and helpful approach to examine the financial effects of medical waste recycling programs.

The source of data was provided by Joint Services Council for solid waste management and some of health care facilities.

### **3.2.1 Case Study**

This study conducted on Bethlehem governorate to target health care facilities, public and private sectors, as it has different styles of healthcare facilities such as clinics, pharmaceutical factory, laboratories and hospital, including one of the largest governmental hospitals in Palestine (Beit Jala governmental hospital).

Bethlehem has several healthcare facilities with different type of services provided, which mean a larger variety of several types of medical wastes. It has 9 main hospitals 3 general hospitals, 1 specialized hospital, 1 rehabilitation hospital 3 Maternity hospitals, 1 military hospital and 1 hospital for children (in total of 597 beds). Also, there are 4 primary healthcare facilities and 3 UNRWA clinics. There are also several charities and medical institutions and private health clinics, specialized in the field of health care and social development. In addition to a number of medical laboratories, radiology centers, public health clinics, and pharmacies (Appendix 6).

### **3.2.2 Sampling**

The sample was selected according to the need of the information about the amount and type of medical wastes generated, which can be provided by hospitals and health care facilities in Bethlehem, which basically depend on the type of wastes generated throughout their daily practices. The disposables used end up as medical wastes, where the quantity of them might vary according to the services provided. So large healthcare facilities like Beit Jala hospital and Arab society for rehabilitation were helpful in classifying wastes according to the material they were made from, because of the large variety, the volume of the services provided and different tools used, which is considered as a crucial step in recycling. The variation of items used during medical procedures and service delivery had to be effectively managed during waste classification, following the Palestinian Ministry of Health Guidelines, that include using color-labeled bins (each color refers to certain type of wastes) that is clearly labeled to follow the proper way of disposal, where the staff is trained and aware of these guidelines. In addition, the items used were also identified by supply / purchase items lists of these hospitals. However, the total volume of medical wastes disposed was measured by Joint Services Council JSC.

### **3.2.3 Eligibility criteria**

#### **3.2.3.1 Inclusion criteria**

- Healthcare facilities (hospitals, health centers, and labs) in Bethlehem governorate.

#### **3.2.3.2 Exclusion criteria**

- Healthcare facilities (hospitals, health centers, and labs) outside Bethlehem governorate.

### **3.2.4 Tools of data collection**

The data was collected through interviews and some site visits. The interviews included some questions based on what was found in the literature to understand the current situation of medical waste management and how it had been treated in health care facilities and JSC. Also, to consider the amount of wastes generated and its type.

Moreover, there were a provision of medical wastes reports including the information about medical wastes management, the wastes generated annually and its types, in addition to purchase costs and management cost for each kg.

The data was collected through six interviews and site visits. The interviews and visits were conducted as follow: an interview with the financial manager and quality assurance department manager of Beit Jala Pharmaceutical company, the audit manager and quality control department head of Al Yamama Hospital (private hospital), the administrative manager of Beit Jala governmental hospital (governmental Hospital) and with the head of JSC in southern directorate at joint services council for solid wastes in Tuqu'. However, these six interviews were enough because the responses where almost similar to each other, since all of healthcare facilities in Bethlehem governorate are following the same instructions and policies issued by MoH.

The questions to collect data through the interview were prepared after reading in the literature and looking at data collection tools including questionnaires that were related to the topic, see appendix 1.

Beit Jala governmental hospital is one of the largest healthcare facilities in Palestine which has a capacity of 153 beds, maintaining an occupancy rate of 97%. Its departments encompass emergency, general surgery and vascular surgery, operating rooms, gastroscopy and colonoscopy unit, intensive care unit, gynecology and obstetrics, nursery, pediatrics, Huda Egyptian Centre for pediatric oncology, outpatient clinics, otolaryngology, physiotherapy, radiotherapy, pharmacology, laboratory and blood bank. The hospital is staffed by a workforce of 406 individuals, including 41 specialists and 48 general practitioners. Notably, in 2013, it earned accreditation as a pediatric oncology center in Palestine.

So, according to its importance and the variety of the services provided, where different tools and supplies are used, it was considered as base to classify the disposables into major waste categories depending on the materials they made from. They provided us with reports of their supply orders and costs for the year 2022 and 2023. The quantities of medical wastes produced can be estimated their quadrant supplies order (order every 3 months). The categories were as the following: plastic, sharps and other disposals, in order to know the majority of wastes types, which is important to know what if it's recyclable or not.

From the visits of the interviewed healthcare facilities, the observed practices was collecting medical wastes and segregate them in specific containers, to be sealed in special barrels labeled with the type of waste, the date of collection and the facility name to be stored and collected within 24 - 48 hours. After that Joint Services Council vehicles collect these wastes from healthcare facilities. As a first step they weigh each barrel and replace it with clean and sterilize one, to be taken to waste management stations. However, joint services council for solid wastes in Tuqu' has provided us with the reports concerned with the quantities produced from healthcare facilities in Bethlehem by the year 2021 and 2022 (appendix 2).

### **3.3 Ethical Consideration**

The process of obtaining ethical approval for a research proposal from Al Quds University - Public Health Research Ethics Committee signifies a commitment to upholding ethical standards and ensuring the integrity of the research. This approval acknowledges that the proposed research meets ethical guidelines and safeguards the rights and well-being of participants (Appendix 3). After having the approval, the data was collected through interviews that were arranged with several healthcare facilities (Beit Jala Pharmaceutical Company, Yamama Hospital, Beit Jala governmental hospital and Joint Services Council for solid wastes).

These interviews likely involved engaging with healthcare professionals, administrators and other relevant stakeholders to gather valuable insights and perspectives for the study. Collaborating with these institutions to conduct research demonstrates a dedication to practical application and community involvement, which amplifies the significance and influence of the study outcomes.

Additionally, adherence to ethical principles throughout the data collection process ensures that the rights and confidentiality of participants are respected, maintaining the trust and credibility of the research endeavor.

## Chapter Four

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### **Descriptive Analysis of Interviews**

This chapter represents a complete and detailed view of the most important findings of the study, including the amount of wastes generated, the procedure of waste management and costs of management, that were obtained by the interviews that the researcher has conducted and site visits.

#### **4.1 Summary of the Interviews**

This part includes an overview of the conducted interviews and visits, highlighting the main questions were asked and the common practices within healthcare facilities and Joint Service Council (JSC).

##### **4.1.1 Medical waste management classification**

Medical wastes types were classified according to the material that has been made of. So, there was a need to look at supplies and disposable equipment's which were used in healthcare facilities when providing services. Beit Jala hospital<sup>1</sup> provided reports of their supply orders and costs for the year 2022 and 2023, which were helpful to cover up most of the disposable items

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<sup>1</sup> Beit Jala governmental hospital visit 5.10.2023

in use, it was considered as a base to compare other healthcare facilities with. In other words, the quantities and type of wastes produced can be estimated by their quadrant supplies order (order every 3 months).

#### **4.1.2 Medical waste management**

Beit Jala hospital plays a significant role in Bethlehem that emphasized by the substantial volume of medical waste it generates, estimated at approximately 2 tons per month. To manage the large volume of wastes produced responsibly, the hospital follows a systematic process. Initially, the medical waste undergoes sterilization via autoclaving, ensuring the elimination of any potential pathogens. Following sterilization, the waste is systematically sorted and placed into specially designated bins. These bins are sealed and prominently labeled to denote their contents, maintaining strict adherence to safety protocols. Subsequently, the sealed bins are handed to the Joint Services Council (JSC), a key partner in waste management initiatives. The JSC assumes responsibility for the transportation and final disposal of the medical waste, operating under a structured system where the weight of the waste is carefully recorded and payment is made accordingly for each kilogram handled. This comprehensive approach not only ensures the safe and efficient management of medical waste but also highlights the hospital's commitment to environmental sustainability and public health.

However, Al Yamama Hospital<sup>1</sup> adheres to a similar waste management protocol as Beit Jala Governmental Hospital. Waste is segregated into special bags and containers, and then sterilized in autoclaves. The JSC conducts regular visits to collect and weigh the sterilized waste for disposal.

Furthermore, when they were asked “Is there a main temporary collection point (storage center/treatment unit) within healthcare facility used to store medical wastes in preparation for transferring it to treatment sites and landfills by external contractors?”

Beit Jala hospital administrative manager: “Yes, there is storage or point of storing medical wastes. They are stored in place that is closed and the access is limited only for the workers in responsible, which is also far from patients” (Beit Jala hospital interview, 2023).

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<sup>1</sup> Al Yamama hospital interview 15.03.2023

Beit Jala Pharmaceutical Company<sup>1</sup> known for its diverse product line comprising creams, liquids, and tablets, generates an estimated 2 - 3 tons of waste annually. Their waste categorization system separates active and non-active types before storage in the company warehouse. The procedure followed for medical solid waste is the same as the previously mentioned healthcare facilities procedure. Otherwise, one of the major medical wastes problems is liquid wastes, as its somehow hard to be managed and there is no advanced technology to be used in treating it. As managing liquid waste poses challenges due to its toxin-laden nature from drug production, regardless of its high costs. To address this, the company collaborates with Tabib Toxic Wastes Services Ltd.

Medical waste management programs require a strategic planning and fund, in order to eliminate danger and harm to human and environment, so there were a question through the interviews” Does your healthcare facility administrates pay real attention to mitigate the severity of medical wastes elements by using less dangerous and safer items? E.g. electronic devices instead of mercury, less toxic fume-producing materials, less toxic sterilizing agents, etc.”

Beit Jala hospital administrative manager: “within the healthcare facility we try our best to stick to MoH guideline” this answer was similar to Al Yamama hospital.

“Unfortunately, there is lack of fund that supports such programs” (JSC head manager, interview 2024).

#### **4.1.3 Joint Services Council (JSC) role**

The Joint Services Council (JSC) <sup>2</sup> in Tuqu’ is dedicated to manage solid waste for the Bethlehem and Hebron governorates. It operates a landfill spanning 280 acres and employs 100 individuals. The JSC is committed to fostering a healthier environment and promoting collaborative efforts among local entities to enhance service quality. Their mission revolves around optimizing resource utilization and fostering capabilities for sustainable development, achieved through the implementation of comprehensive policies and community awareness initiatives. Moreover, the council recognizes the vital role of community engagement in driving sustainable development forward. Through proactive community awareness initiatives, the JSC

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<sup>1</sup> Beit Jala pharmaceutical company 15.03.2023

<sup>2</sup> Join Services Council visit and interview 18.01.2024

attempt to empower individuals and communities to adopt environmentally friendly practices and contribute to the collective effort towards sustainability.

The visit to the JSC main purpose was to gain insights into their medical waste management processes and procedures. This included a comprehensive understanding of their operational strategies, technological capabilities, and adherence to regulatory standards. The visit also entailed a guided tour of their waste management facilities, providing direct exposure to their operational framework and infrastructure. Through this experience, valuable insights were sought to be acquired, which would inform our understanding of best practices in medical waste management and contribute to ongoing efforts to enhance waste management strategies in the region.

In the beginning, it was noted that their office had been relocated from Hebron to its current location since 2012, driven by the availability of better and larger space, to expand the area by buying the adjacent property.

The services provided served to the local communities in Bethlehem and Hebron, encompassing the management of solid waste in all its forms, including medical waste. And that lead to an important question “Are medical wastes disposed of using the sanitary landfill method?”

JSC head manager: “Yes, the wastes are disposed in landfills where a depression (cells) is made by removing soil and then lined with synthetic plastic or isolation materials to prevent leakage and leachate from wastes. The depth of the cell depends on the level of hazardousness of waste, so medical wastes cells are deeper than general wastes” (JSC interview, 2024).

In more details, general wastes are disposed of in landfills, where of pit or depression cells is made, 3-4 meters in depth, involves the excavation of soil and subsequent lining with synthetic plastic or isolation materials to mitigate leakage and leachate from the waste. The depth of these cells depends on the hazardousness level of the waste. The medical waste department, comprising 7 employees (2 processing unit staff, 2 drivers, and 3 workers), is responsible for handling medical waste management operations.

The services provided by JSC extend to a significant number of small health centers and laboratories, totaling between 70-100 establishments. This widespread participation underscores

the comprehensive nature of the waste management initiative, ensuring that even smaller facilities are included in the systematic waste collection and disposal process.

#### **4.1.4 Collaboration between JSC and healthcare facilities**

The initial phase of the medical waste disposal process begins with the carefully prepared specialized vehicles designed exclusively to transport hazardous wastes and materials. These vehicles are equipped with sophisticated cooling units, precisely engineered to maintain the integrity and safety of the waste throughout its journey to the designated processing center, typically overseen by JSC.

So when healthcare facilities were asked “Is transporting medical wastes from healthcare facilities to treatment units and landfills are conducted only by the authorized local authority?”

Al Yamam audit manager responded: “Yes, transferring medical wastes to treatment units are only done by JSC vehicles” (Al Yamama hospital interview, 2023).

With more information about vehicles were added by JSC: “The vehicles are equipped and cooled on the required standards” (JSC interview, 2024).

Healthcare facilities or organizations vested in the responsible management of medical waste engage in annual contracts with JSC to ensure the seamless and safe disposal of these materials. Upon arrival at the healthcare facility, the driver or worker, alongside a representative committee from the facility, starts the process of weighing the stored waste. This step is crucial as it determines the precise quantity of waste to be measured and pay for it.

Following the weighing process, the driver or worker affixes a stamp onto the documentation, detailing essential information such as the date of collection, the measured weight of the waste, and the corresponding price for disposal services provided. This stamped documentation serves as a formal record of the transaction, ensuring transparency and accountability in the medical waste disposal process.

“Is there documentation of the quantities and types of the Medical wastes generated?”

JCS head manger: “Yes, the quantities of generated medical wastes by healthcare facilities in Hebron and Bethlehem is measured then documented, and then they’re provided with the reports and numbers registered”.

Also, Beit Jala hospital administrative manager said: “There is an initial documentation, and then a full report is provided by JSC”

However, it’s important to mention that in adherence to safety protocols, healthcare workers place medical waste into specialized bags designed with specific characteristics tailored for such hazardous materials. These bags are then carefully placed within special bins, ensuring proper sealing to prevent any leakage or exposure. Additionally, each bag is labeled with relevant information, including the name of the facility and from what department it is produced, serving as a crucial measure to mitigate any potential contamination or infection risks.

Moreover, the interviews included questions about the awareness of workers:” Does the healthcare facility staff receive the necessary awareness content on the subject of medical wastes management?”

Beit Jala hospital administrative manager: “we can say that the process of medical waste management within he healthcare facility is divided into two steps, the first one includes the healthcare workers where they should be aware with the type of medical wastes they’re dealing with to discard it in the right container, and he second step include the janitors where they collect the containers to be stored and treated. So, these two parties are trained and aware”. (Bei Jala hospital interview, 2023)

But JSC head manager respond was: “Unfortunately, not all workers or janitors are aware, for example some of them don’t stick with using PPE’s. Also, one of the serious problems that we faced, that they threw a metal chocolate box with medical wastes that result in breaking down the microwave used in waste treatment and that cost a lot”. (JCS interview, 2024)

It’s important to ensure that healthcare workers are aware and updated with medical waste management trainings. Regarding whether employees are receiving updated training, we asked the question: Is there an updated training for employees about collecting, sorting and labeling medical wastes elements?

AL Yamama quality control manager: “Yes, the quality control coordinators make semi-annual training for employees about medical wastes management”.

Once filled and securely sealed, the bins undergo a meticulous process of replacement, wherein they are exchanged with sterile counterparts of equal quantity. The exchange procedure

is essential in maintaining the integrity of the waste disposal system, guaranteeing the continued safety of both healthcare workers and the broader community.

#### **4.1.5 Transportation and collection of wastes**

Before handing waste to JSC, healthcare facilities engage in a critical process of segregating waste into hazardous and non-hazardous categories. Sorting is an essential step to ensure that potentially dangerous materials are handled carefully and that all waste is appropriately managed. Distinguishing between hazardous and non-hazardous waste, healthcare facilities uphold safety standards and mitigate risks associated with improper disposal. This careful attention to the right process confirms their commitment to safeguarding public health and the environment, laying the groundwork for the responsible transfer of waste to the designated disposal service.

To ensure a continuous enhancement in service quality, a systematic practice is in place where the vehicles and cars utilized for medical waste transfer from site to another are renewed every three years. This involves replacing the existing vehicles with newer, technologically advanced models. These new vehicles are carefully selected to incorporate the latest innovations in safety features, efficiency, and environmental considerations, thereby increasing the overall quality of service provided. This proactive approach not only maintains the reliability of the transportation infrastructure but also underscores the commitment to ongoing improvement and optimization in delivering essential medical waste management services.

The collection of waste from healthcare facilities by JSC is organized based on the volume generated, adhering to a systematic schedule. Typically, waste collection occurs on specific days of the week, tailored to the needs of each region. For instance, in Bethlehem, collections are scheduled for Saturday, Monday, and Wednesday, while in Hebron, they occur on Sunday, Tuesday, and Thursday. To accommodate the varying quantities of waste produced, specialized vehicles are deployed accordingly. For larger quantities, specialized large trucks are utilized, equipped to handle substantial loads efficiently and smaller healthcare centers and laboratories receive waste collection services via smaller vehicles, either on-call or with a scheduled visit at least once per week.

#### **4.1.6 JSC machines and technology**

Upon arrival at the JSC stations, the workers initiate the process of waste segregation to ensure proper management. Medical waste management involves the utilization of specialized equipment, including an incinerator with a capacity of 45 liters per hour (Figure 6). However, this method is not the most preferred due to emissions generated during the incineration process.

Alternatively, a microwave system with a capacity of 75 liters per hour (Figure 5) is employed, offering a more environmentally friendly approach as it operates without emitting harmful substances. However, this method necessitates heightened awareness among workers and meticulous segregation of waste at the initial stage. Mixing different types of waste can compromise the effectiveness of the microwave process, potentially rendering it ineffective.



**Figure 5: Microwave 75 L used in JSC<sup>1</sup>**



**Figure 6: Incinerator 45L used in JSC<sup>2</sup>**

The final product of the waste management process consists of small shredded pieces, achieved through the chosen method of disposal. This approach ensures that waste is managed efficiently and in compliance with environmental regulations, minimizing negative impacts on both public health and the environment.

One of the main problems they face is managing liquid medical waste that is mostly generated by nephrology departments. The microwave can only take up to 15% liquid to be managed per run.

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<sup>1,2</sup> The pictures shown in figure 5 and 6 were taken at JSC (18.01. 2024)

The procedure of medical waste management followed is according to Ministry of Health policies (see appendix 3). Some of the participant is not fully committed in payment and have debts, but the JSC can't forbid the service because of its importance and it would lead to many consequences if that happen. If it's a governmental organization, ministry of health is paying for the service, where the private sector from its own expenses.

#### **4.1.7 Ministry of Environment role**

Ministry of environment keeps on tracking and maintaining the quality of service. The process is done through filling a checklist (see appendix 4). This list is intended to assist Environmental Quality Assurance (EQA) inspectors to inspect and monitor medical waste management. The main items are:

- Characteristics of the vehicle that transport wastes from healthcare facility
- Vehicle's travel route
- Waste management and the way of disposal

For their Vision and further improvement, they are looking forward for making healthcare facilities manage the wastes initially by autoclaves to make them sterile in the first place and then collected to manage it in a final way. However, they had an agreement with MoH that none of healthcare facilities can take an accreditation without having a contract with the JSC to guarantee the commitment with the service.

There are some limitations that JSC face; one of them is the occupation as there is a lot of limitations for the capabilities and proficiency of the services provided. As there were restriction of transport and working in the past few months. Also, the step of segregation in the production site is not always done properly which lead to some complications such as the damage of the processing machines such as the microwave and required more efforts from the workers when handling the waste in the site of management. However, the microwave is working fully by electricity where any power cut during the work can damage the device (the wastes form clogs when cool down which block the path where the wastes move through) as the expenses of maintenance and repair is high.

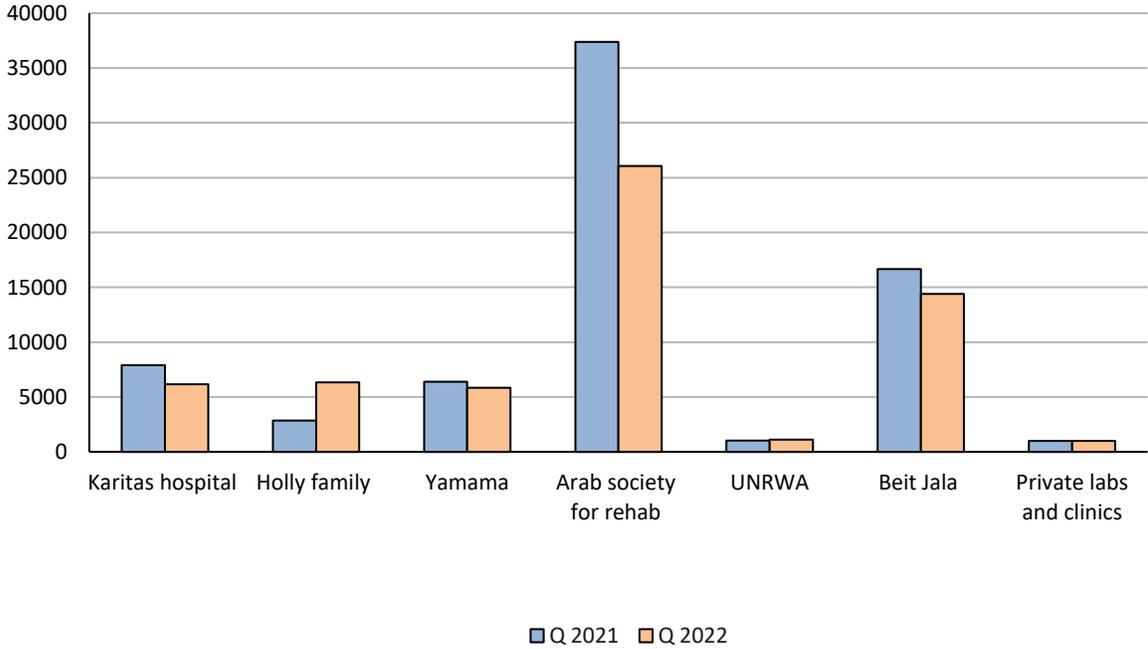
To conclude, when talking about medical waste management in Palestine we found that most of healthcare facilities are depending on local community services, as there is no on-site medical

waste processing or disposal, and a very little number of healthcare facilities have a sterilization step before hand them to JSC.

**4.2 The amount of wastes generated**

The amount of medical wastes generated from any healthcare facilities are directly proportional with the volume of the services provided. In Bethlehem the variation of medical wastes produced is due to the size of the organization, as shown in figure 7. Arab society for rehabilitation has the highest amount produced in the past few years, where the total of the private labs and clinics was the lowest, and that can be related to the size of services provided

This data was provided by Joint Services Council for solid wastes management (JSC) for Bethlehem and Hebron governorates, where they noted that there was an increase of medical wastes produced in 2023 by 20% than 2022. As shown in the figure the production of wastes in the year 2021 was higher due to Covid-19 which was exclusion for the linear annul increase of medical waste generation.



**Figure 7: Medical waste quantities (Kg) generated by Bethlehem governorate healthcare facilities in 2021 & 2022, obtained by JSC**

However, after discussing the quantities with JSC manager “According to the data about medical wastes quantities, do you think that the raw materials resulted from medical wastes recycling is economically feasible?” the respond was “Yes, it would be supportive; according to the numbers and reports we observe there’s a genuine increase with the quantities of medical wastes throughout the years” (JSC head manger interview, 2024).

According to - one of the largest governmental hospitals in Palestine – Beit Jala hospital reports, the material of the majority of the medical wastes produced is plastic including tubes, cuvette, syringe, cups and bags.

#### **4.3 The procedure of medical wastes management**

The procedure of medical wastes management is followed by the guidelines established by Ministry of Health (MOH), where it has various steps as the following:

##### **1. Segregation and Collection**

**Segregation:** The process of separating and sorting medical waste requires to be done at the site of production. Using sufficient numbers, types, colors and sizes of bags/containers necessary to collect waste, according to the recommendation by MOH as shown in (table 1). The container should not be filled by more than 75% of its capacity, and the tightly sealed with adhesive plastic strips or using self-sealed plastic bags/containers (no metals should be used for sealing) to prevent any leakage or accidently falling of wastes from the container. The waste is then transported by special vehicle to the waste processing unit or temporary storage place within the healthcare facility. The packaging collected is replaced by new packaging instantly.

**Collection:** the segregated wastes are collected in certain container that is viable for each type, then labeled with the type of waste, the date and the facility that it came from. After that every facility collects these containers and sterilize it (if there is a sterilization unit on the site) to be stored, then transfer to the site of management.

**Table 2: Types and colors for medical wastes containers**

Type of waste	Color	Type of container
General wastes	Black	Normal plastic bags
Infectious wastes	Yellow	Yellow plastic containers, leak-free, labeled can be sterilized with steam
Sharp wastes	Yellow or Red	Plastic container or made of cardboard, leak-free, labeled
Pathological wastes	Red	Plastic container, leak-free, labeled
Pharmaceutical wastes	Brown	Plastic container, leak-free, labeled
Mixed types of wastes	According to the highest danger	Plastic container, leak-free, labeled that its mixed wastes

## 2. Transfer and Storage

The collected and sterilized wastes should be transferred to the site of storage in the healthcare facility in special carts through specific passage to prevent any harm or infection toward patients and the society in general. The warehouse should be cooled and the entry is only allowed for the employees. Then special vehicles from JSC come to healthcare facility to weight the wastes and transfer them to the site of management in Tuqu', where they make sure that everything is segregated the right way to start the process of management.

The special vehicles for transferring medical wastes should have a cooling unit inside it, symbols to show the purpose of it and enough space and height for the collected wastes.

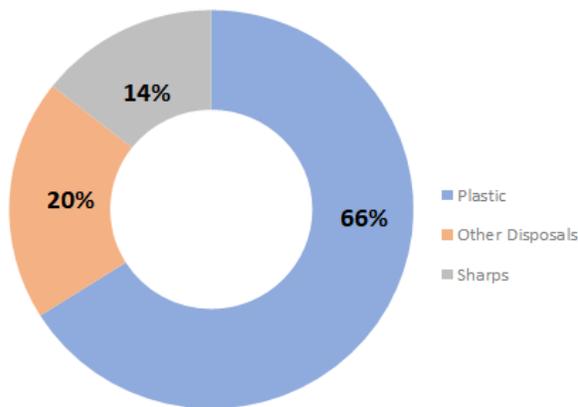
## 3. Medical Wastes Processing and Disposal

Medical wastes processing starts when making sure that everything is segregated the right way, then transfer them into (ECOSTERYL075) microwave with 75L capacity. It starts with sterilizing wastes on high heat then shredding them into small pieces as final

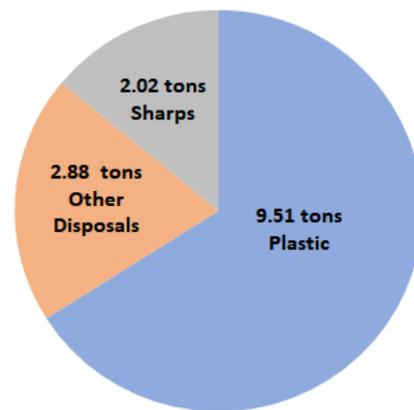
product. Or it can be disposed using an incinerator (INCENOR8) with 45L capacity which is an odor free. As a final step it disposed in landfills, to be put in cells with at least 1.8 meters in depth – depth depend on the level of danger of the waste- , with special lining in order to prevent any leakage to reach the groundwater.

#### **4.4 Medical wastes types**

BeitJala’s hospital supply report for 2022 and 2023 was considered as a base for the



**Figure 8: Medical wastes categories percentage**



**Figure 9: Beit Jala medical wastes in 2022**

disposable supplies to be ordered by healthcare facilities, because it’s the largest in Bethlehem governorate. The reports consist of the ordered and consumed supplies quantities and their costs. These supplies (items list) were categorized into three main categories: plastics, sharp materials, other disposals. The majority of wastes were made of plastics (see figure 8). For example, BeitJala governmental hospital waste in the year 2022 were 14.4 tons divided as shown in figure 9

Plastic wastes category consists of: syringes, cannulas, catheters, tubes, plastic bags, urine cups / bags, autoclave bags, IV sets, gloves, medicine cups, petri-dish, droppers/ pasture pipette, cuvettes and umbilical clamps.

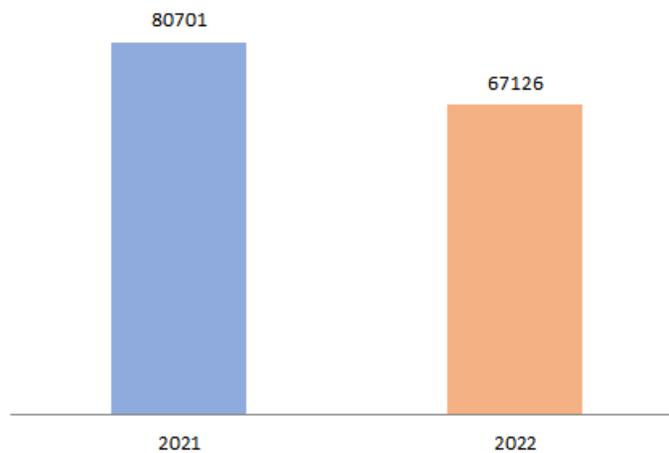
Sharp wastes category consists of: disposable lancets, sterile blades, needles and slides.

“Other disposals” category consists of: bed dressing, bandage, cotton, gowns, masks and tongue depressor.

## **4.5 Medical wastes management costs**

Medical wastes management costs can be divided into several aspects. Operational costs including buying new machines, their maintenance and transferring wastes from site to another with the special vehicles. One of the main problems that JSC face is the electric shortcut, which result in breaking down the machines, so it require high costs for maintenance that might reach 40,000\$.

Also, the cost of processed and disposed wastes, where JSC consider the fee for managing every kilogram of medical wastes costs 4 ILS (see figure 10).<sup>1</sup>



**Figure 10: Medical wastes management costs (\$) in 2021 & 2022**

Where the small health centers or labs they pay 60 shekels per month and the little bigger ones 120 shekels (720 - 1440 shekels annually) and that is determined according to the quantity of wastes produced, the money is taken by a fee collector.

And that's according to JSC head manager when asked "what are the costs of medical wastes management process?"

He responded:" the costs of this process can be divided into three parts: operational costs, materials and human resources. For example, the cost of managing 1 kg of medical wastes is 4 ILS (1.1\$), also the cost of wastes containers and bags where each has its own price. However, on the long term there would be a need for buying new landfills"

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<sup>1</sup> Assuming that 1 \$ = 3.63 ILS

According to the respond, there are additional costs for the containers and bags used for medical wastes collection. Some of the containers are purchased by healthcare facilities and the others by JSC, and their costs are shown in table 3.

**Table 3: Medical wastes container costs**

Type of Container	Cost \$ / Piece
<b>Yellow Bag</b>	0.03 - 0.06
<b>Red Bag</b>	0.03 - 0.06
<b>Sharp Box</b>	0.6 - 3.12

Despite the need for buying new landfills every several years, the answer about “Does recycling medical wastes reduces the number of used landfills, which in turn improves the quality of the environment?” was “Yes, it would. Actually, the landfills are getting bigger as the time pass, and of course there is a need to buy new ones, so recycling and reducing the dumped wastes would be a great solution” (JSC head manger, interview 18<sup>th</sup> Jan 2024).

Plastic represents 66% of medical wastes produced by healthcare facilities in Bethlehem governorate, which equals 48335.76 Kg (48 ton) produced annually. Recycling 1 ton of medical plastic save 147 USD and selling a processed recycled ton cost 368.8 USD according to 2021 indicators (RecyclingMarkets, 2021).

However, recycled medical waste plastics can be used in several industries such as constructions industry where it can be helpful in making composite lumber which has several uses like outdoor furniture and fencing. Also, it can be turned into pallets, pipes, building insulation and other durable products. Furthermore, consumers’ good can be incorporated into these industries including bins, buckets, hoses and other household items. In addition to many other plastic products that can be far from the personal human use.

**Table 4: Types of medical wastes annual quantities in tons**

Type of Waste	Annual Quantity in ton
<b>Plastic</b>	48.33576
<b>Sharp wastes</b>	10.25304
<b>Other disposal</b>	14.6472

Sharp wastes are mainly made of steel, which represents 14% of medical wastes produced by healthcare facilities in Bethlehem, which equals 10253.04 Kg (10 ton) produced annually. Selling a processed recycled 1 ton in 2021 cost was 102.81 USD (RecyclingMarkets, 2021).

Other disposals are mainly consisting of dressing's gowns and masks, which can be segregated and shredded to produce manufactured wool. This category represents 20% of medical wastes produced by healthcare facilities in Bethlehem, which equals 14647.2 Kg (14 ton) produced annually. 1 ton of recycled fabrics costs 76 USD (RecyclingMarkets, 2021).

## Chapter Five

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### **Medical Solid Waste Recycling (Benefits and Feasibility)**

After examining the current state of medical waste management in the Bethlehem governorate, which is similar to other regions in the West Bank, this chapter will present the benefits and feasibility of medical waste recycling. Additionally, we will explore the potential for establishing a factory dedicated to medical waste recycling.

#### **5.1 Recycling Process**

Recycling process converts waste materials into new, reusable products, where it conserves natural resources, reduce pollution and minimize landfill use. It promotes sustainability and support circular economy through transforming disposed items into valuable resources. The proposed project is concerned with recycling plastic medical wastes (Orlov et al., 2021). Currently there are no recycling projects or station are set in West Bank so this project is considered as initiative for it, where it would serve Bethlehem healthcare facilities in the first place then the rest of other healthcare facilities in WB. Bethlehem healthcare facilities were the case because there is a variety of services and establishments to be served.

In addition to general medical waste management steps (collection, segregation, transferring, storage, processing and disposal) there are extra steps to be done in order to achieve an overall recycling process.

As shown in figure 11, the process of recycling medical wastes includes several steps (Solevåg, 2023) underlies as the following:

- **Transportation:** Mixed plastic waste is transported from health care facilities to the recycling station.
- **Sorting:** The mixed plastic wastes like containers, syringe, oxygen masks etc., are made from various types of plastics, such as HDPE, LDPE, and PET. Each type of plastic should be separated before recycling.
- **Sterilization:** Waste should be sterilized at very high temperature 121°C using autoclaves with high pressure in order to get rid of any infectious substances attached to them.
- **Grinding:** The plastics are then ground or cut into smaller pieces to increase their surface area for washing and drying. At this stage, the pieces are still too large for reprocessing.
- **Washing:** Plastics are often contaminated with residues; the plastics need to be washed to remove these contaminants.
- **Drying:** After washing, the plastics are wet and must be completely dried before further processing.
- **Granulation:** The plastics are ground into flakes, turning the smaller pieces from the grinding process into micro-pellets for compounding.
- **Compounding:** In this step, the polymer is melted down in an extruder. The extrudate is then cooled into a solid phase as it exits the die and is pelletized for reprocessing.
- **Distribution:** Finally, the processed plastics are distributed to consumers.



**Figure 11: Medical wastes recycling steps**

## **5.2 Bethlehem Medical waste quantities in ton**

The results in chapter 4 showed that the quantities of medical waste generated by healthcare facilities in Bethlehem governorate in the year 2021 and 2022 were 72.236 tons and 59.917 tons respectively. The quantities in 2021 were higher due to covid-19 pandemic where there were an increase in the use of PPEs and disposable medical supplies, but generally the annual increase of medical wastes is approximately by 30%. However, the total amount generated daily is 184.99 kg/day that include hospitals, clinics and centers.

As stated in chapter 4, the materials of medical wastes were categorized into 3 main groups: Plastic, sharp materials and other disposals. Plastic constitute 66% of wastes, sharp wastes 14% and other disposals 20%. Each has a special way of treatment. The main focus would be on plastics as it is the largest quantity produced.

However, there are many factors affecting recycling process, such as type of plastic, recycling infrastructure, system and technologies. If all of the factors are addressed and engaged optimally, the percentage of plastic recycling can reach 70-80% from the overall plastic waste quantity (Yu & Zhu, 2022).

## **5.3 Medical waste quantities in West Bank and the estimated recycling quantities**

To have a better insight about the generated quantities from other cities of west bank compared to the generated quantities from Bethlehem healthcare facilities which represent a small portion of them (1/11). The data shown in table 5 represent the estimated quantities generated in West Bank's health care facilities in kg/day for the year 2022<sup>1</sup>. In addition, the percentage of quantities for each city in the West Bank compared to Bethlehem was estimated for the benefits of recycling, the whole quantities of medical solid waste recorded annually in the West Bank.

On average, West Bank produce 1.82 ton per day which equals 664.3 tons annually. The material of concern in this project is plastic that represents 66% of medical wastes, which mean that 438.4 tons of medical plastic wastes are generated annually in WB.

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<sup>1</sup> Infectious Waste Management in West Bank, MoLG-JICA CDSWMP-III and COVID 19 Emergency Project Inventory and Estimated Generation Amount of Infectious Waste in West Bank.

**Table 5: Medical wastes estimated quantities generated in West Bank**

City Name	Medical Waste quantity (Kg/day)	Quantities compared to Bethlehem
<b>Bethlehem</b>	148.99	100.00%
<b>Hebron</b>	476.9	320.09%
<b>Jenin</b>	187.5	125.85%
<b>Ramallah</b>	293.72	197.14%
<b>Jerusalem</b>	175.06	117.50%
<b>Nablus</b>	271.1	181.96%
<b>Jericho</b>	32.27	21.66%
<b>Tubas</b>	27.44	18.42%
<b>Tulkarm</b>	105.79	71.00%
<b>Qalqiliya</b>	71.33	47.88%
<b>Salfit</b>	28.43	19.08%
<b>Total</b>	1818.53 (1.82 ton)	

#### **5.4 Plastic as Raw material (Creating raw materials from medical disposals)**

Plastic is one of the main materials used in industry nowadays due to its importance, abundance, durability, versatility and cost-effectiveness. Which can be categorized according to the domain it used in into six main categories: PE, HDPE, LDPE, PVC, PP and PS (Bobulski & Kubanek, 2021). For example, PP and PE are used in automotive industry to create dashboards, interior trim, and battery cases. Moreover, the construction sector use plastic like PVC and HDPE can be used in insulation, piping, window frames and flooring, which is considered an ideal choice for building applications (Cirino et al., 2023). Medical field is mainly dependent on plastic supplies and disposables, which results in significant waste generation (Kheirabadi &

Sheikhi, 2020). Table 6 shows each of these plastic categories and the source of medical plastic waste type they produced from, also the end products that can be made of after recycling.

**Table 6: Products from recycled medical plastic wastes**

Category	Medical Plastic waste	Products
<b>Polyethylene PE</b>	Syringe	Plastic bags
	Tubing	Containers
		Agriculture films
<b>Polypropylene PP</b>	Medical trays	Automotive parts
	Containers	Constructions materials
	Disposable instruments	Storage bins
		Garden furniture
<b>Polyvinyl Chloride PVC</b>	IV bags	Pipes, window frames, flooring
	Oxygen masks	Floor mats
		Cable insulation
<b>High-Density Polyethylene HDPE</b>	Bottles	Playground equipment
	Rigid containers	Plastic lumber
		Piping
<b>Polystyrene PS</b>	Medical trays	Insulation materials
	Packaging	Office supplies (rulers, desk organizers etc.)
<b>Polylactic acid PLA</b>	Biodegradable medical products	Compostable packaging
		Disposable cutlery
		Agriculture mulch films

Plastic industry in Palestine comprises 243 establishments, which is significantly contributing to the country's economy. They affect the economic landscape, adding real value to the industry. The added value reaches \$64 million, which plays a critical role in economic development with the potential of future growth (PCBS, 2023). Moreover, this industry creates job opportunities and stimulates other sectors which highlight its importance in the larger economic framework.

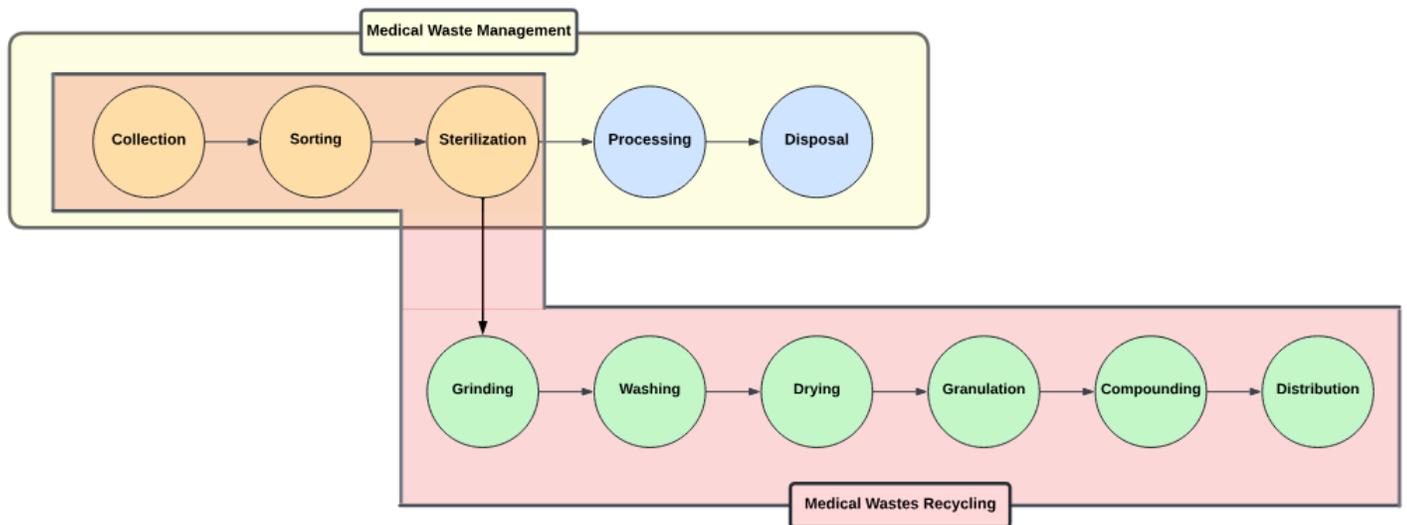
For example, HDPE cost in the market starts at approximately 1320\$ per ton, while PP is priced 1400\$. These prices represent the current market rates and indicate the costs of the materials used in the plastic industry, which in turns influence the production expenses and the pricing of plastic products (Prenovitz et al., 2023). This means that producing raw materials from such wastes would definitely enhance the economy and reduce the prices.

## **5.5 Cost of medical wastes management and recycling**

The idea of medical wastes recycling highlights the importance of moving from linear economy into circular economy (Orlov et al., 2021), where the costs of medical wastes management turn into revenues.

The supplies used in the process of waste management costs starts from the bags and containers used for collecting wastes, moving to operational costs that include transferring wastes from the site of collection to management station, running processing machines and the station. As mentioned in chapter 4, the management process of medical wastes in Bethlehem healthcare facilities cost was 81,148 \$ (292,944 ILS) in 2021 and 67,221 \$ (242,668 ILS) in 2022.

As shown in figure 12, most of the management steps are included in the recycling process, except the two last steps (processing in the machine and disposal). That means part of the cost of the recycling steps are already paid for the management, also we would get rid of the cost of these two excluded steps in case of recycling. As mentioned in one of the literature that the annual cost of recycling wastes is 141,370\$ where recycling 1 ton cost 136\$. So in our case if the generated wastes in Bethlehem healthcare facilities in the years 2021 and 2022 were recycled that would cost 9,824\$ and 8,3228\$ respectively.

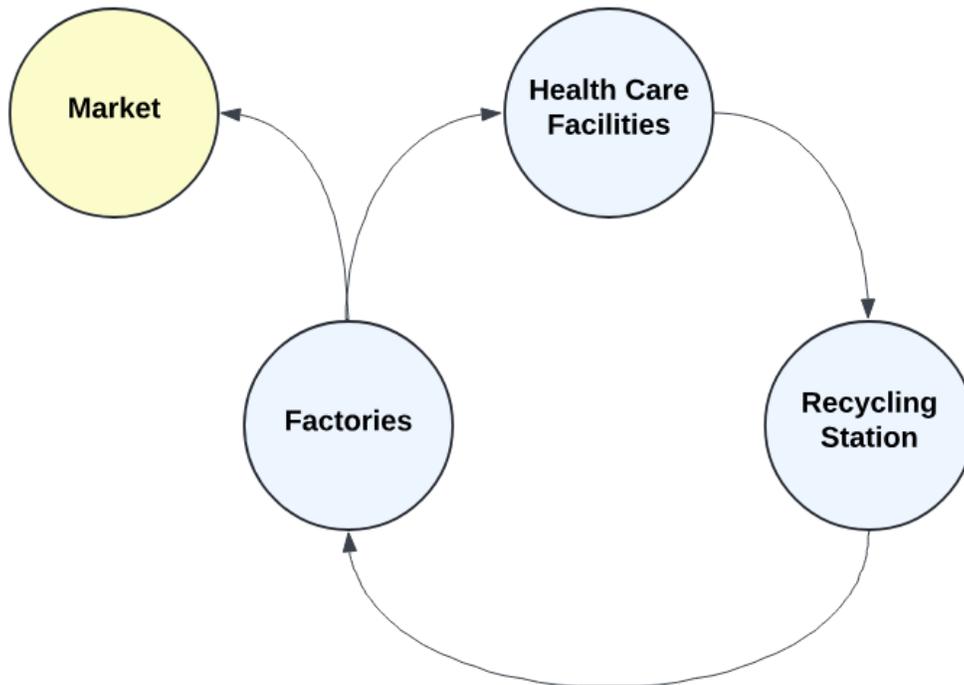


**Figure 12: Medical waste management and recycling steps**

As shown in figure 13, if medical wastes have been recycled, it would create a closed loop as the following:

- **Healthcare facilities** pay for having medical waste management services, so when it became recyclable they would be more conscious and concerned about medical wastes segregation and collection as they should collect it the right way using the right containers, because there would be a return from this process even if its paid back or having some intensives.
- **Recycling station** would buy medical wastes from healthcare facilities in order to start processing it to develop raw materials.

- **The factories (manufacturers, consumers)** buy the produced raw materials which would be cheaper than importing it. The new products generated can be beneficial for healthcare facilities utility and the public.



**Figure 13: Medical waste recycling loop**

### **5.6 Imported raw materials**

According to PCBS the cost of imported raw materials for the year 2019 and 2020 reached 112 and 127 \$million respectively which shows an increase by 13.36% (PCBS, 2021). So, when recycling medical wastes and producing raw materials locally, it would be beneficial in many different ways. The companies can reduce their reliance on imported raw materials, potentially leading to significant cost savings. Moreover, it would help in mitigating the environmental impact associated with importing materials by conserving resources, reducing energy consumption, and lowering greenhouse gas emissions. This not only aligns with sustainability goals but also enhances supply chain resilience by broadening raw material sources and reducing exposure to risks. However, complying with regulations promoting the use of recycled materials can help companies avoid penalties and maintain regulatory compliance, while also enhancing their market competitiveness by attracting environmentally

conscious consumers and investors. Overall, integrating recycling and local production of raw materials into business operations not only fosters sustainability but also contributes to economic efficiency and market success which in turns serves the concept of circular economy that main goal is to keep the resource in use as long as possible.

### **5.7 Revenue from the recycled medical wastes**

Medical waste recycling process is not only reducing the costs related to waste disposal but also creates a revenue from the sales of recycled materials. However, an intensive investment in recycling infrastructure, system and advanced technologies can promote the efficiency and effectiveness of such program. In other words turning medical wastes into resource, this would significantly offset the costs of waste management in the medical field and support more sustainable future (Cirino et al., 2023).

There are several factors that affect the amount of money that can be made per ton of recycled plastic such as the quality of the plastic, market demand, and the current market prices for recycled plastic. However, HDPE and PP are more common than other types of plastic that have higher demand with higher market values, especially for better quality recycled plastic. Their cost can be ranged from few hundred dollars to over thousand dollars per ton. Moreover, transportation costs, processing costs, government incentives or subsidies and the efficiency of recycling process are factors that can affect the profitability of plastic recycling (Bobulski & Kubanek, 2021).

Revenue from waste recycling per ton for a specific country is challenging due to several factors that can be widely vary such as: market conditions, processing costs, regulations, and commodity pricing. Based on (Seal et al., 2021) the revenue from recycling 1 ton of wastes is approximately 26.6\$. according to the financial analysis from waste management in Tulkwila which me serve as a rough benchmark for other countries. So, the estimated revenue from recycling the overall quantity of medical wastes in Bethlehem governorate is 1446.5 \$ annually, where the revenue of west bank quantities 17,670\$ as shown in table 7<sup>1</sup>.

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<sup>1</sup> The revenue was calculated according to the estimated revenue defined by city of Tulkwila recycling tonnage and revenue in 2021.

**Table 7: Estimated revenue from recycled medical plastic wastes in West Bank**

City Name	Estimated Annual Quantity in Ton	Estimated Recycling Revenue in \$
<b>Bethlehem</b>	<b>54.4</b>	<b>1446.5</b>
<b>Hebron</b>	<b>174.1</b>	<b>4630.2</b>
<b>Jenin</b>	<b>68.4</b>	<b>1820.4</b>
<b>Ramallah</b>	<b>107.2</b>	<b>2851.7</b>
<b>Jerusalem</b>	<b>63.9</b>	<b>1699.7</b>
<b>Nablus</b>	<b>99.0</b>	<b>2632.1</b>
<b>Jericho</b>	<b>11.8</b>	<b>313.3</b>
<b>Tubas</b>	<b>10.0</b>	<b>266.4</b>
<b>Tulkarm</b>	<b>38.6</b>	<b>1027.1</b>
<b>Qalqiliya</b>	<b>26.0</b>	<b>692.5</b>
<b>Salfit</b>	<b>10.4</b>	<b>276.0</b>
<b>Total</b>	<b>663.8</b>	<b>17,656.1</b>

### **5.8 Palestinian establishments concerned with waste recycling**

There are recycling initiatives in the West Bank that handle several types of waste materials, which include sorting, treatment, and recycling. Some of them were successful whereas the other didn't receive the required support and fund.

In Nablus, the Sairafi Company with collaboration with the Nablus Municipality, are interested in waste transfer and sorting procedures. Also, other companies like the Palestinian Recycling Company and Green Palestine were concerned with waste treatment and recycling but both projects failed. A Jordanian enterprise called Special Waste Solution SWS was involved in Zahrat Al Finjan landfill project in Jenin, where it faced challenges and it stopped (GIZ, 2014).

On the other hand, Al Bal'awi Company for Cardboard and Papers Recycling in Jenin is a successful example of recycling, which collects paper and cardboard as they press these materials and then export it to Israel. Moreover, In Hebron village Al Shyoukh, the Union of Plastic Industries play a big role in sorting and recycling plastic. Also, Al Andalus Company located in Bani Na'em introduced efforts in plastic recycling. Rather than plastic, glass takes place in the recycling industry in Hebron which is represented in The Hebron Glass and Ceramics Industry, located in Ras Eljora.

However, there are some examples of paper and cardboard collecting, pressing and recycling institutions in Ramallah such as Green City and Tadweer, where they both export cardboard to Israel (GIZ, 2014).

These establishments represent the basis of Palestine's recycling and waste management initiatives, demonstrating the industry's vast potential as well as its constant difficulties in supporting project sustainability and economic viability. However, the collaborative efforts of these firms highlight their ongoing dedication to enhance waste management procedures in West Bank despite the obstacles they might face. From this point there is a need for intensive efforts and support for recycling projects in Palestine that would be beneficial for human health environment and economy.

## Chapter Six

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### **Discussion, Conclusion, Recommendation and Limitation**

This chapter represents results interpretation and discussion according to prior studies, followed by the conclusion, recommendation and the limitations of the study.

#### **6.1 Discussion**

From the previously reviewed results:

The comprehensive review of medical waste management practices reveals a multifaceted approach employed by healthcare facilities in Bethlehem governorate, underscored by the pivotal role of responsible waste management in safeguarding public health and environmental sustainability. Building upon the findings obtained from interviews and site visits, coupled with insights from prior research, this discussion aims to provide a detailed analysis of the key aspects pertaining to medical waste management.

##### **6.1.1 Relationship between Waste Generation and Healthcare Services**

The volume and type of medical waste generated by healthcare facilities exhibit a direct correlation with the scope and nature of services rendered (Korkut, 2018) Notably, the Arab Society for Rehabilitation emerged as a significant contributor to medical waste generation, followed closely by Beit Jala Governmental Hospital. This underscores the importance of

understanding the intricate relationship between service provision and waste generation patterns, which informs strategic waste management initiatives.

### **6.1.2 Guidelines and Awareness in Medical Waste Management**

Adherence to establishing guidelines is paramount in ensuring effective waste management within healthcare settings (Letho et al., 2021). Health care workers play a crucial role in segregating and discarding waste according to its type, using designated containers and following prescribed protocols. This initial step is foundational in the waste disposal process, setting the stage for subsequent handling and management procedures.

### **6.1.3 Challenges and Opportunities in Plastic Waste Management**

Plastic waste management presents a significant global challenge, exacerbated by its prevalence in medical waste streams (Saha et al., 2023). With approximately 66% of medical waste comprised of plastic, there is a pressing need for sustainable solutions to mitigate environmental impact. Recycling initiatives offer a promising avenue, with potential benefits for health, the environment, and the economy, although challenges persist in the Palestinian context due to limited investment and infrastructure (Matar, 2019).

### **6.1.4 Special Considerations for Sharp Wastes and Other Disposables**

Medical sharp wastes, comprising 14% of total medical waste, necessitate specialized handling protocols to mitigate risks associated with infectious agents (Ziqubu et al., 2023). Similarly, other disposables such as bed dressings, surgical gowns, and masks, predominantly composed of polyester or polyester-cotton blends, hold potential for recycling and industrial repurposing, offering economic and environmental benefits (Do Amaral et al., 2018).

### **6.1.5 Financial Implications and Environmental Impact of Waste Management**

The financial burden of medical waste management is substantial, with annual costs ranging from 67,221 \$ to 81,148 \$ in Bethlehem governorate alone. Despite these costs, the current approach predominantly entails disposal in landfills, highlighting the need for sustainable alternatives that leverage recycling and resource recovery. Recycling initiatives not only reduce the environmental footprint but also contribute to cost savings and energy conservation (Neto et al., 2023).

### **6.1.6 Positive Impact of Recycling on Health and Environment**

Medical waste recycling holds inherent benefits for human health and environmental sustainability. By reducing the volume of disposed waste, recycling efforts contribute to preventing exposure to harmful agents and prolonging the lifespan of landfills. Moreover, recycling initiatives align with broader sustainability objectives, offering a pathway towards resource conservation and environmental stewardship.

### **6.1.7 Moving from waste management to waste recycling**

The analysis of medical waste management in Bethlehem and the broader West Bank region highlights the substantial potential for recycling medical plastic waste. With plastic accounting for 66% of medical waste, recycling offers a viable solution to reduce landfill use, conserve resources, and minimize pollution. Implementing a recycling process involving transportation, sorting, sterilization, grinding, washing, drying, granulation, and compounding, as outlined, can effectively transform medical plastic waste into valuable raw materials.

Bethlehem produces around 72.236 tons of medical waste annually, with a daily generation rate of 184.99 kg. The projected benefits extend to the entire West Bank, which generates approximately 1.82 tons of medical waste per day (664.3 tons annually). By focusing on recycling medical plastic waste, significant environmental and economic benefits can be achieved. The analysis indicates that, with optimal engagement of factors such as recycling infrastructure and technology, plastic recycling rates could reach 70-80%.

Recycling medical waste not only reduces disposal costs but also generates revenue. The cost of recycling medical waste in Bethlehem is estimated at \$141,370 annually, with a per-ton cost of \$136. If the medical waste from Bethlehem's healthcare facilities were recycled, the costs would amount to \$9,824 for 2021 and \$83,228 for 2022. Additionally, recycling 1 ton of medical plastic waste can save \$147 and generate revenue of \$368.8 per ton, leading to estimated annual revenue of \$1,757 for Bethlehem and \$17,670 for the entire West Bank.

## **6.2 Conclusion**

This study explores medical waste management practices in Bethlehem governorate, highlighting significant challenges and opportunities. The findings showed that the volume of medical waste generated correlates with the services provided by healthcare facilities, where the amount of wastes generated increase by the increase by the population growth. This underscores the need for tailored waste management strategies that consider the specific contexts of different healthcare settings.

However, the study emphasizes the importance of adhering to established guidelines and protocols for effective medical waste management and focus on suggesting more sustainable alternative such as recycling. Healthcare workers play a crucial role in proper waste segregation, containerization, and documentation. However, maintaining high levels of awareness and compliance among staff remains a challenge, necessitating targeted training and interventions.

Plastic wastes are identified as a major concern due to its significant presence in medical wastes, posing environmental risks. The local plastic recycling market faces obstacles such as limited investment and infrastructure, highlighting the urgent need for sustainable waste management solutions. Additionally, the management of medical sharp wastes requires careful handling to minimize safety and environmental risks, with recycling options for materials like steel.

Financial implications further underscore the importance of efficient waste management, with substantial costs associated with traditional disposal methods. Recycling presents a promising alternative, offering potential economic and environmental benefits. Establishing a medical waste recycling station/factory in Bethlehem could reduce environmental impact, provide economic gains, and support a circular economy.

Overall, the study suggests prioritizing investments in recycling infrastructure, promoting awareness, and the development of supportive policies. By embracing innovative solutions and fostering collaboration, Bethlehem governorate can achieve sustainability, health, and economic growth. This initiative can serve as a model for other regions, demonstrating the transformative potential of effective medical waste recycling practices.

### **6.3 Recommendation**

Based on the findings of the study, the following recommendations were proposed:

#### **Ministry of health and Ministry of environment**

- Reconsider and reassess the current situation of medical waste management in Palestine, because of the increasing rate of medical waste production and the sizes of the landfills.
- Increase the awareness of healthcare workers to the policies concerned with medical wastes management and soon recycling.
- Think of medical waste recycling as a serious solution for medical waste issue.
- Create a clear policy for medical waste recycle because of its beneficial outcomes on human health and environment. Having a strategic plan and guidelines would lead to better understanding for the process and its importance.
- Implement a medical waste recycling station that serves all cities in West Bank.
- Increase the public awareness about the importance of recycling practices.
- The main source of energy to operate medical waste recycling project should mainly rely on solar energy.

#### **Al-Quds University**

- Propose the idea of this thesis to stakeholders that might help in implementing the project.

#### **Further research**

- Thinking of the issue of medical waste management requires an intensive research effort, because it's a lifelong problem as long as there is a medical waste production.
- There is a need for local studies that resemble the idea of medical waste recycling and how it affects the economy, so this requires further research on the topic.
- Based on this thesis, the researcher recommends creating a feasibility study for establishing initiative for medical waste recycling.
- As an extension of this thesis, it is recommended to conduct a study on the economic impacts of medical waste recycling. It should focus on how recycling practices can enhance employment opportunities and reduce the import costs of plastic raw materials.

#### **6.4 Study Limitation**

- Due to the absence of a clear policy for waste recycling, it was difficult to implement the study to the level of the West Bank, Gaza Strip and East Jerusalem.
- Lack of local research and studies concerned with this topic that it was difficult to obtain the influencing factors without field data collection.
- Due to the time constrain we were unable to access all health care facilities in Bethlehem city.

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## معالجة و إعادة تدوير النفايات الطبية: حالة محافظة بيت لحم

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### ملخص :

**مقدمة:** تعتبر إدارة النفايات الطبية الصلبة واحدة من أهم القضايا في نظام الرعاية الصحية. نظراً لاحتلال وجود مخاطر عالية على صحة الإنسان والبيئة، ومن جهة أخرى تتطلب أن يتم معالجتها بالطرق الصحيحة لتقليل أضرارها وتجنبها. يتطلب النمو السكاني السريع مزيداً من الخدمات الصحية والتي ستؤدي إلى زيادة استخدام المعدات والمستلزمات الطبية.

**الهدف** تهدف الدراسة إلى دراسة وضع وآليات معالجة النفايات الطبية في محافظة بيت لحم. ومن ثم سيتم دراسة الخطوات اللازمة من أجل تطبيق برنامج لإعادة التدوير وتسهيل الضوء على أثرها في مجالي الصحة والاقتصاد. وسيتحقق ذلك بتقييم الحالة الراهنة لإدارة النفايات الطبية واحتمال إعادة تدويرها، وكيفية تأثير هذه النفايات على صحة الأفراد والبيئة، وتوضيح مفهوم إعادة التدوير وتطبيقه على النفايات الطبية.

**منهج الدراسة و جمع البيانات:** استخدمت الدراسة منهجية مرجعية لما هو قائم. فقد أجريت مقابلات منهجية مع مسؤولي المؤسسات الصحية والطبية في محافظة بيت لحم. كان المصدر الرئيسي لجمع البيانات هو التقارير السنوية لكميات النفايات الطبية الصادر عن مجلس الخدمات المشترك للنفايات والنظر لدراسات مماثلة. بالإضافة إلى زيارات لمواقع معالجة النفايات الطبية ومقابلات مع مؤسسات صحية مختلفة. فقد كانت هناك زيارة لأحد أكبر المستشفيات الحكومية في بيت لحم (مستشفى بيت جالا الحكومي) الذي يتألف من عدة أقسام وتخصصات مما يشير إلى حجم الخدمات الكبير، والذي بدوره قام بتزويدنا بقائمة المواد ذات الاستخدام الواحد والتي من شأنها أن تدخل في عملية إعادة التدوير حيث ساعدت في معرفة أنواع النفايات وتصنيفها.

**النتائج:** تشير النتائج إلى وجود علاقة طردية بين حجم النفايات الطبية المتولدة ونوع ومدى خدمات الرعاية الصحية المقدمة، حيث تنتج الجمعية العربية ومستشفى بيت جالا الحكومي أعلى كميات من النفايات الطبية كما لوحظ في عامي 2021 و2022. وتتطلب إدارة النفايات الطبية ضرورة الالتزام بالإرشادات لضمان التخلص السليم، حيث تشكل النفايات البلاستيكية ما نسبته 66% من إجمالي النفايات الطبية. تمثل هذه النسبة الكبيرة من النفايات البلاستيكية تحديات بيئية ولكنها تمثل أيضاً فرصاً لتحقيق فوائد اقتصادية وبيئية من خلال إعادة التدوير. على الرغم من هذه الفرص، يواجه سوق إعادة تدوير البلاستيك الفلسطيني قيوداً كبيرة بسبب عدم كفاية الاستثمار من كل من القطاع الخاص ومجالس الخدمات المشتركة، مما يحد من إمكانات النمو لهذا القطاع وفعاليتيه.

علاوة على ذلك، فإن الأدوات و المستلزمات الطبية الحادة، التي تمثل 14% من النفايات الطبي، تشكل مخاطر على السلامة العامة ولكن يمكن جعلها قابلة لإعادة التدوير من خلال المعالجة المناسبة. كما توفر مواد النفايات الطبية الأخرى، مثل الضمادات والملابس الطبية والأقنعة، والتي تشكل 20% من النفايات الطبية، فرصاً لإعادة التدوير بقيمة اقتصادية تتراوح بين 140 - 199 دولاراً أمريكياً للطن. إن التكلفة العالية لإدارة النفايات الطبية، والتي تتراوح بين 242 ألف إلى 292 ألف دولار أمريكي سنوياً، تسلط الضوء على التكاليف المادية العالية على مرافق الرعاية الصحية والفوائد الاقتصادية المحتملة عند تطبيق برامج إعادة التدوير. لا تؤدي إعادة التدوير إلى خفض التكاليف فحسب، بل تعمل أيضاً على إطالة عمر مدافن النفايات والحفاظ على الطاقة، مما يساهم في حماية البيئة والصحة العامة.

أظهرت الدراسة أن إنشاء منشأة لإعادة تدوير النفايات الطبية في بيت لحم ليس ممكناً فقط بل ومفيداً أيضاً لما له دور في تقليل التأثير البيئي للنفايات الطبية، وتحقيق مكاسب اقتصادية من خلال توليد الإيرادات، ودعم مبادئ الاقتصاد الدائري. يمكن أن تكون هذا المبادرة نموذجاً للمناطق الأخرى، مما يُظهر الإمكانيات لممارسات إعادة تدوير النفايات الطبية الفعالة.

**الاستنتاجات:** تؤثر إعادة تدوير النفايات الطبية بشكل إيجابي على الصحة والبيئة والاقتصاد. حيث أن الاستثمار في بنية تحتية وتقنيات إعادة التدوير ضروري لتحقيق هذه الفوائد وتقليل التكاليف المرتبطة بممارسات إدارة النفايات غير الكافية.

**الكلمات المفتاحية:** النفايات الطبية، إدارة النفايات الطبية، إعادة التدوير، الاقتصاد الدائري.

## Appendices

### **Appendix 1: Some questions that have been asked during the interviews**

<b>Administrative and Compliance Questions</b>	
1.	Is there an independent administrative branch responsible for medical waste management processes as per standards in your facility?
2.	Does the healthcare facility adhere to the Palestinian Ministry of Health legislation regarding the use of special containers for the collection and sorting of medical waste?
3.	Is there documentation of the quantities and types of medical waste generated?
<b>Employee Training and Safety</b>	
4.	Do employees receive necessary training and awareness on medical waste management, including packaging, labeling, and handling of different types of medical waste?
5.	Are there periodic medical checks for staff exposed to medical waste, and do they receive necessary preventive vaccinations?
6.	Are medical waste management personnel provided with protective clothing and equipment, such as gloves and coats, and do they adhere to safety provisions and identification card?
7.	Are medical waste management personnel qualified, with practical experience, and do they receive updated training courses?
<b>Waste Handling and Management</b>	
8.	Is there a main temporary collection point (storage center/treatment unit) within the healthcare facility for storing medical waste before transfer to treatment sites or landfills?
9.	Are medical waste collection points safe and compliant with regulations?

10.	Is medical waste properly segregated, sorted, and identified according to specifications?
<b>Risk Management and Environmental Impact</b>	
11.	Does the healthcare facility use sanitary landfill methods for waste disposal, and are these landfills located safely away from residential areas?
12.	Does recycling medical waste reduce landfill use and toxic emissions from incineration, improving environmental quality?
13.	Is there a plan to reduce the amount of medical waste produced and mitigate its severity using safer items or alternatives?
<b>Community and Economic Considerations</b>	
14.	Will the community accept products made from recycled medical waste, and the generated raw materials?
15.	Do you believe that the economic benefits of recycling medical waste outweigh the costs, and can it support the economy?
16.	According to the data about medical wastes quantities, do you think that the raw materials resulted from medical wastes recycling is economically feasible?

## Appendix 2: Joint Services council medical wastes quantities

State of Palestine  
Ministry of Local Government  
Joint Service Council  
For Solid Waste Management  
Hebron - Bethlehem



محافظة الخليل - بيت لحم  
Hebron & Bethlehem Governorates

دولة فلسطين  
وزارة الحكم المحلي  
المجلس المشترك لإدارة  
النفايات الصلبة  
في محافظتي الخليل وبيت لحم

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التاريخ : ٢٠٢٣/١٢/٢١

**كميات جمع النفايات الطبية من محافظة بيت لحم**

قائمة بأسماء المستشفيات الحكومية والخاصة التي يتم جمع النفايات الطبية منها وكميات النفايات الطبية لعامين ٢٠٢١ و ٢٠٢٢ :

الرقم	اسم المستشفى	النوع	كميات سنة ٢٠٢١	كميات سنة ٢٠٢٢
١ -	مستشفى الكريetas	خاص	7904	6162
٢ -	مستشفى العائلة المقدسة	خاص	2867	6329
٣ -	مستشفى الجمعية العربية	خاص	37383	26057
٤ -	مستشفى اليمامة	خاص	6394	5834
٥ -	عيادات وكالة الفوئ/ بيت لحم	خاص	1029	1130
٦ -	مستشفى بيت جالا الحكومي	حكومي	16659	14405
المجموع الكلي/ كيلوغرام			72,236 كغم	59,917 كغم

بالإضافة الى خدمة ما يقارب ٥٠ مختبر وعيادة ومراكز ومستشفيات صغيرة تقدر كمياتها ١٠٠٠ كيلوغرام/ سنة .

مع فائق الاحترام

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صندوق بريد: ١٧٣ الخليل

## Appendix 3: Al Quds University Ethical Committee Approval

Al-Quds University  
Jerusalem  
School of Public Health



جامعة القدس  
القدس  
كلية الصحة العامة

التاريخ: 14/2/2023

عزيزتي الطالبة رايان ابو زياد المحترمة  
برنامج ماجستير السياسات والادارة الصحية

الموضوع: موافقة لجنة اخلاقيات البحث العلمي

قامت اللجنة الفرعية لأخلاقيات البحث التابعة لكلية الصحة العامة بمراجعة مشروع الرسالة بعنوان:

**“The Impact of Medical Wastes Recycling on Bethlehem Economy”**

المقدم من (مشرف البحث/د. محمود الجعفري ود. مهى الحسيني).

يعتبر مشروعك مستوفياً لمتطلبات أخلاقيات البحث في جامعة القدس.

نتمنى لكم كل التوفيق في تسيير المشروع.

ملاحظة: في حالة الحاجة الى موافقة من اللجنة المركزية في الجامعة، تستطيع التقدم باستخدام هذه

الموافقة على الرابط. <https://research.alquds.edu/en/ethics/48-how-to-apply.html>

رئيسة اللجنة الفرعية لاخلاقيات البحث

كلية الصحة العامة

د. نهى الشريف



نسخة/ أعضاء لجنة البحث

نسخة/ الملف

## Appendix 4: Medical waste management policy by Ministry of health

### الفصل الثالث فصل وجمع النفايات

#### مادة ( 13 ) اجراءات فصل النفايات

- يجب على المؤسسة الالتزام بفصل النفايات ووضعها في عبواتها الملائمة ، والتأكد من عدم اختلاطها ببعضها البعض في أي حال من الاحوال وفق الاجراءات الآتية :
1. أن تتم عملية الفصل والفرز والتعبئة في مصدر إنتاج النفايات.
  2. توفير الأعداد والكميات الكافية من الأدوات اللازمة لجمع النفايات مع مراعاة توفير الألوان والأحجام التي تتناسب مع نوع وكمية النفايات المنتجة.
  3. توفير العبوات الملائمة لفصل النفايات في مصدر إنتاجها تكون متوافقة مع دليل ادارة النفايات المصادق عليه من الوزارة.
  4. يمنع تعبئة العبوات بأكثر من 75% من سعتها مهما كان نوع النفايات او العبوات المستخدمة.
  5. إغلاق العبوات بإحكام بشكل يمنع تساقط او تسرب او خروج النفايات من عبواتها من خلال ربط العنق أو باستخدام الشرائط البلاستيكية اللاصقة أو باستخدام الأكياس البلاستيكية ذاتية الإغلاق ويمنع إغلاق الأكياس بالمشابك أو الملاقط المعدنية.
  6. في حال حدوث خطأ في فرز نوع من النفايات بوضعها في عبوة غير مخصصة لذلك النوع من النفايات فيمنع تصحيح الخطأ ويترك الوضع على ما هو عليه، على أن يذكر نوع هذه النفايات على تلك العبوة.
  7. في حال تعبئة النفايات العادية في عبوة مخصصة للنفايات الطبية فيجب معاملة هذه النفايات معاملة النفايات الطبية.
  8. يمنع تراكم عبوات النفايات الممتلئة في أماكن إنتاجها، وعدم تجميعها أو وضعها في الممرات والردهات أمام المارة والزوار.
  9. يجب وضع علامة على كل عبوة يتم إرسالها من الأقسام المختلفة إلى مختبر التحاليل تبين مصدر العبوة وطبيعتها ودرجة خطورتها حتى يتم التعامل معها ومعالجتها والتخلص منها.
  10. تنقل النفايات بعربات خاصة إلى وحدة معالجة النفايات أو مكان التخزين المؤقت داخل المؤسسة.
  11. استبدال العبوات التي تم جمعها بعبوات جديدة مباشرة.

#### مادة (14)

#### نوع ولون العبوات المخصصة للفصل

تستخدم العبوات اللازمة في جمع النفايات داخل المؤسسة وفق الدليل اللوني حسب الجدول الآتي:

الرقم	نوع النفايات	اللون	نوعية الحاوية
1	النفايات العادية	اللون الأسود	أكياس او حاويات بلاستيكية
2	النفايات المعدية	اللون الأصفر	اكياس داخل حاويات بلاستيكية صلبة وغير مسربة للسوائل ويمكن تعقيمها بالبخار

3	النفائيات الطبية الحادة	اللون الأصفر	صندوق من البلاستيك الصلب أو الكرتون المقوى وغير مسرب للسوائل.
4	النفائيات المرضية والتشريحية	اللون الأحمر	أكياس داخل حاويات بلاستيكية صلبة وغير مسربة للسوائل
5	النفائيات الدوائية والكيميائية	اللون البني	حاويات بلاستيكية صلبة وغير مسربة للسوائل مع ملصق يوضح نوع النفائيات.
6	النفائيات المشعة	بدون لون	حاويات من الرصاص عليها علامة المواد المشعة.
7	النفائيات المختلطة	لون النفائيات الأكثر خطورة	حاويات بلاستيكية صلبة وغير مسربة للسوائل، على أن توضع علامة واضحة على تلك الحاوية تبين نوع النفائيات المختلطة.
8	النفائيات الخطرة الأخرى	اللون الأحمر	حاويات بلاستيكية صلبة وغير مسربة للسوائل، على أن توضع علامة واضحة على تلك الحاوية تبين نوع تلك النفائيات.

#### مادة (15)

##### جمع النفائيات الحادة

1. تجمع النفائيات الحادة في صناديق من البلاستيك أو الكرتون المقوى قابلة للاشتعال ذات غطاء محكم الإغلاق يسمح بإدخالها ولا يسمح بخروجها ويوضع عليها ملصق يكتب عليه عبارة "**تحذير - نفائيات خطيرة**".
2. يشترط في هذه الصناديق أن تكون غير مهلجنة وصلبة ومتينة وغير قابلة للتقرب أو الكسر ولها مقبض يودي لحملها بواسطته.
3. يجب استخدام صناديق أو عبوات صغيرة من البلاستيك المقوى عليها إشارة "**النفائيات الخطرة**" لجمع بقايا الإبر والحقن بعد استخدامها مباشرة ، بحيث لا تسمح هذه الصناديق أو العبوات بخروج النفائيات منها.
4. يجب وضع النفائيات الحادة في الصناديق بشكل كامل وبدون كسرها، ويجب استخدام مواد التعقيم المناسبة مثل الكلور أو أي مادة أخرى بحسب تعليمات المؤسسة.
5. يتم إغلاق صناديق النفائيات الحادة بإحكام وتعقيمها ويوضع حولها شريط لاصق قوي قبل إرسالها إلى وحدة معالجة النفائيات أو مكان التخزين المؤقت.

#### مادة (16)

##### جمع النفائيات المعدية

1. تجمع النفائيات المعدية في حاوية بلاستيكية صلبة غير مهلجنة وقابلة للاشتعال ذات غطاء محكم الإغلاق توضع عليها ملصق ينص على عبارة "**تحذير - نفائيات خطيرة - معدية**"، وتحتوي بداخلها على كيس بلاستيكي أصفر يستخدم لمرة واحدة فقط مطبوع عليه ذات التحذير .
2. عند امتلاء الحاوية يربط الكيس الذي بداخلها بإحكام مع مراعاة عدم تسرب أو بروز أي من المواد المعبأة منه ثم إغلاق الحاوية بشكل محكم ويوضع حولها شريط لاصق مقوى قبل إرسالها إلى وحدة معالجة النفائيات.

#### مادة (17)

##### جمع النفائيات شديدة العدوى

1. يجب فرز النفائيات شديدة العدوى عن النفائيات المعدية الأخرى وغيرها من النفائيات و إن يتم إجراء معالجة أولية لها مباشرة داخل الأقسام الطبية والبحثية المنتجة لها وذلك من خلال تعقيمها بإحدى الوسائل الآتية:
  - أ - التبخير يعتمد زمن ودرجة الحرارة المستخدمة في الجهاز على الحجم والوزن الإجمالي للمواد المراد تعقيمها وعلى نوعية الميكروبات ودرجة مقاومتها للبخار، وذلك بحسب تعليمات الشركة المنتجة لجهاز التعقيم.
  - ب - وضعها في فورما لين بتركيز 10% لمدة أربعة وعشرون ساعة.
  - ت - وضعها في براد تقل درجة حرارته عن (20) درجة مئوية لمدة لا تتجاوز الأسبوع.
2. تجمع نواتج النفائيات شديدة العدوى بعد إجراء المعالجة الأولية لها على انها نفائيات معدية .

## مادة (18)

### جمع النفايات الدوائية والكيميائية

تجمع النفايات الدوائية والكيميائية في حاوية بلاستيكية صلبة غير مسربة للسوائل ذات غطاء قابل للإغلاق بشكل محكم ويسمح بإعادة فتحه لوضع النفايات فيه، ويوضع عليها ملصق يوضح نوع النفايات.

## مادة (19)

### جمع النفايات المرضية (الباثولوجية)

1. تجمع النفايات المرضية التي يقل وزنها عن 100 غرام في أكياس بلاستيكية تستخدم لمرة واحدة فقط يطبع عليها بخط واضح ومقروء "نفايات مرضية أو بقايا جثث".
2. تجمع عينات المختبر من النفايات المرضية غير الناتجة عن زراعة الكائنات المجهرية في حاوية خاصة تحتوي في داخلها على كيسان بلاستيكيان بحيث يكون أحدهما داخل الآخر ويتم إفراغ الحاوية من الأكياس بواسطة سحب الكيسين معاً وربطهما بإحكام وفقاً للضرورة عند امتلاء الكيس وفي كل الأحوال يجب إفراغ الحاوية مرة واحدة على الأقل يومياً والتأكد من عدم تسرب أو بروز أي من النفايات الموجودة بداخله.
3. تحفظ أعضاء جثث الموتى في ثلاجات خاصة تتراوح درجة حرارتها ما بين (3) إلى (8) درجات مئوية، ويجب مراعاة القيم والتقاليد السائدة المتعلقة بالتخلص من الجثث والأجنة الميتة والأعضاء المبتورة من جسم الإنسان والتي يزيد وزنها عن 100 غرام ومعالجتها وفقاً للقوانين ذات العلاقة مع مراعاة إزالة أسباب الخطورة.

## مادة (20)

### جمع النفايات المشعة

1. يتم التعامل مع النفايات المشعة من خلال موظفين مختصين ومهملين للتعامل بها يخضعون لرقابة وإشراف مكثفين ويتم إعادة توجيههم وتدريبهم بشكل دوري.
2. تتم المعالجة والتخلص النهائي من الأدوات والمواد التي تعرضت للنفايات المشعة وفقاً لأحكام هذا النظام باعتبارها نفايات مشعة.
3. يجوز حفظ بعض الأدوات والمواد التي تعرضت للنفايات المشعة في الأماكن المخصصة إلى أن يتم تنظيفها وتعقيمها بشكل يزيل الخطر الإشعاعي عنها ويسمح بإعادة استخدامها، وتحدد الوزارة المواد والأدوات التي يجوز تنظيفها وتعقيمها بعد تعرضها للنفايات المشعة وطريقة التنظيف والتعقيم المستخدمة والتي تسمح بإعادة استخدام هذه المواد والأدوات.
4. تتولى وزارة البيئة بالتنسيق مع الجهات المختصة إصدار التعليمات الخاصة بإدارة النفايات المشعة والتخلص منها بشكل آمن ونهائي.

## مادة (21)

### جمع النفايات المختلطة

1. يمنع خلط النفايات مع بعضها البعض في أي حال من الأحوال وفي حال اختلاط أي منها يمنع العمل على فصلها عن بعضها أثناء عملية الفرز والجمع وتأخذ صفة النفايات الأكثر خطورة وتعامل معاملة.
2. يجب إبلاغ مدير المؤسسة أو الشخص المسؤول على الإشراف المباشر والرقابة على عملية إدارة النفايات حال اختلاطها مع غيرها، وذلك لاتخاذ الإجراءات المناسبة للحيلولة دون وقوع أية أضرار.

## مادة (22)

### جمع النفايات الأخرى

1. تفصل النفايات غير الوارد ذكرها في هذا الفصل ويجمع كل نوع منها في حاويات بلاستيكية خاصة تكون صلبة لها غطاء قابل للإغلاق بشكل محكم وتوضع عليها لافتة تنص على عبارة "**تحذير- نفايات خطرة**" مع تحديد نوع هذه النفايات، ويتم اتخاذ إجراءات السلامة المناسبة عند عملية الجمع بشكل يمنع الخطر.
2. تنقل هذه النفايات إلى مكان التخزين المؤقت أو وحدة المعالجة عند امتلاء الحاويات أو في فترات محددة وفقاً لطبيعة هذه النفايات ونوعها.

## الفصل الرابع

### نقل النفايات وتخزينها داخل المؤسسة

## مادة (23)

### نقل النفايات العادية

تجمع النفايات العادية في أكياس سوداء خاصة ويتم نقلها ومعالمتها معاملة النفايات العادية المنزلية بمعزل عن النفايات الطبية.

## مادة (24)

### نقل النفايات الطبية

- يتم نقل النفايات داخل المؤسسة وفق الاجراءات الاتية :
1. وضع برنامج محدد لجمع ونقل النفايات من مكان تجميعها إلى مكان تخزينها المؤقت داخل المؤسسة بصورة دورية.
  2. تنقل النفايات داخل المؤسسة بواسطة عربات أو حاويات لها عجلات مخصصة لهذه الغاية، تتوفر فيها الشروط الاتية:
    - أ - أن تكون مصنوعة من مادة قادرة على الصمود ضد التآكل بسبب المحاليل والمواد الكيميائية و مواد التنظيف.
    - ب - أن تكون ذات سطح أملس يضمن سهولة التفريغ و التنظيف.
    - ت - عدم وجود زوايا حادة تؤدي إلى تمزيق أو اتلاف الاكياس أو العبوات أثناء التحميل والتفريغ.
    - ث - أن تكون غير منفذة للسوائل.
  - ج - وجود ملصق يتضمن تحذيراً بوجود النفايات داخل الحاوية ، مرفق بقائمة تبين محتويات النفايات ونوعها وكمياتها والقسم الذي انتجت منه وتاريخ الانتاج .
  - ح - أن تكون قابلة للإغلاق بشكل محكم.
3. يمنع نقل النفايات الطبية باستخدام العربات المخصصة لنقل النفايات العادية أو العكس ويجب التأكد من تخزين هذه النفايات بشكل منفصل عن بعضها البعض.
4. تحديد مسار عربات نقل النفايات داخل المؤسسة بشكل لا يعرض حياة المرضى للخطر ويقلل من انتشار التلوث داخل المؤسسة.
5. ضمان سهولة وصول الموظفين وعمال النظافة في المؤسسة وعربات النقل إلى مكان التخزين والتأكد من وصول اكياس النفايات مغلقة وسليمة في نهاية عملية النقل .
6. حفظ العربات بعد انتهاء عملية الجمع بمكان آمن وبعيد عن العامة والعبث.
7. يجب تنظيف العربة والحاوية اسبوعياً أو مباشرة حال حدوث أي تسرب أو انسكاب من الاكياس أو الحاويات على سطح وسيلة النقل ويحدد مكان مخصص لغسل وتنظيف العربات والحاويات يكون مزوداً بمصدر مياه ضغط وخرطوم وله أرضية مبلطة وناعمة ووحدة لمعالجة المياه الناتجة عن التنظيف قبل تصريفها.

## مادة (25)

### مواصفات أماكن التخزين

- تكون المؤسسة مسؤولة عن التخزين المؤقت للنفايات إلى حين نقلها إلى محطة المعالجة خارج المؤسسة أو مكب النفايات على ان يتوافق مع الشروط و المواصفات التالية كحد ادنى:
1. ان يكون منفصلاً عن بقية الأقسام وعلى بعد معقول من اماكن اعداد الطعام وغرف المرضى والموظفين والمناطق السكنية .
  2. أن يتناسب حجمه ومساحته موقع مع حجم النفايات المنتجة ونوع وطبيعة البرنامج الزمني لنقل النفايات من المؤسسة إلى موقع التخزين.
  3. أن تكون الارضية مصنوعة من مادة صلبة، وغير نفاذة وملساء وسهلة التنظيف والتعقيم مزودة بنظام صرف صحي ملائم.
  4. أن تكون الجدران ملساء ومصقولة على ارتفاع لا يقل عن 1.5 متر.
  5. توفير البنية التحتية اللازمة من خدمات الماء والكهرباء والاتصالات.
  6. توفير الاضاءة الجيدة بشكل يسمح الرؤية بوضوح وأن يحتوي على فتحات للتهوية تتناسب مع حجم ونوع النفايات.
  7. أن يكون محمياً من أشعة الشمس وعوامل المناخ المختلفة.
  8. أن يوضع عليه تحذير يتضمن عبارة "نفايات طبية خطيرة" وإشارة أو علامة متعارف عليها دولياً تكون معلومة لدى جميع الأشخاص توضح بأنه مكان لتجميع وتخزين النفايات الطبية.
  9. أن يكون سهل الوصول والدخول من قبل الموظفين المكلفين بنقل ومناولة النفايات ومن قبل مركبات نقل النفايات لخارج المؤسسة.
  10. أن يكون قريباً من مكان وجود مواد ووسائل ومعدات التنظيف والتعقيم ومعدات الوقاية الشخصية وأكياس وأوعية النفايات.
  11. أن يكون قابلاً للإغلاق بشكل يمنع دخول الاشخاص الغير مصرح لهم والحيوانات والطيور والحشرات.

## مادة (26)

### اجراءات التخزين

- تلتزم المؤسسة باتخاذ اجراءات التخزين المؤقت الاتية :
1. ترتيب النفايات بأسلوب يكفل سلامة النفايات المخزونة ، ويمنع تخزين أية مواد اخرى غير النفايات الطبية الناتجة عن المؤسسة .
  2. تنظيف مكان التخزين المؤقت بشكل كامل وبصورة منتظمة ودورية لمرة واحدة على الاقل اسبوعياً .
  3. تنظيف مكان التخزين المؤقت مباشرة حال انسكاب او تسرب النفايات .

٤. ان لا تزيد مدة التخزين المؤقت للنفايات في مكان التخزين منذ انتاجها وحتى نقلها الى خارج المؤسسة للمعالجة او التخلص النهائي منها عن احدى المدد الآتية :
- أ. بما لا يزيد عن 48 ساعة خلال الاشهر من تشرين ثاني الى آذار .
- ب. بما لا يزيد عن 24 ساعة خلال الاشهر من نيسان الى تشرين اول .
٥. تخزين النفايات المرضية (الباثولوجية ) التي يزيد وزنها عن 100 غرام ، والنفايات المعدية في درجة حرارة ما بين (3) الى (8) درجات مئوية ، في حالة استمرار التخزين لأكثر من اسبوع .
٦. تحديد الزمن الاقصى للتخزين على حسب سعة التخزين بالمبردات وبما يتلائم ونوع النفايات .
٧. ان تكون اماكن التبريد والتجميد للنفايات مغلقة بإحكام ، ويجب وضع علامات واضحة على المبردات تدل على نوع النفايات ، وعبارة ممنوع الدخول لغير الموظفين المختصين .
٨. عدم تخزين النفايات في الزجاج والبيلاستيك في درجات تبريد متدنية .
٩. عدم ضغطه وكبس النفايات غير المعالجة والمحتوية على الدم وسوائل الجسم الاخرى .

#### مادة ( 27 )

#### التخزين خارج المؤسسة

تنطبق الاحكام المنصوص عليها في المواد ( 25 ، 26 ) من هذا النظام على عملية تخزين النفايات خارج المؤسسة .

#### الفصل الخامس

#### نقل النفايات الطبية خارج المؤسسة

#### مادة ( 28 )

#### مسؤولية نقل النفايات خارج المؤسسة

١. تكون مسؤولية نقل النفايات من المؤسسة الى وحدة المعالجة خارج المؤسسة ا والى مكب النفايات من صلاحيات الهيئة المحلية ، ولها تفويض هذه الصلاحيات الى أية جهة مختصة ومرخص لها بذلك .
٢. لا يسمح لأية جهة التعامل ونقل والتخلص من النفايات إلا بعد الحصول على التراخيص الخاصة بذلك من الجهات المختصة .
٣. يكون لوزارة البيئة صلاحية الرقابة والإشراف على عملية نقل النفايات خارج المؤسسة وفقاً لأحكام هذا النظام.

#### مادة ( 29 )

#### نقل النفايات غير المعالجة

١. تتم عملية نقل النفايات غير المعالجة الى خارج المؤسسة في الحالات الآتية :
- أ. اذا لم تتوفر وحدة معالجة للنفايات داخل المؤسسة .
- ب. اذا لم تتوفر في وحدة المعالجة احدى آليات المعالجة الواردة في هذا النظام .
- ت. في حال حدوث خلل او تعطل وحدة المعالجة في المؤسسة .
٢. على المؤسسة الت لا تتوفر لديها وحدة لمعالجة النفايات إشعار الوزارة والهيئة المحلية التي تتولى نقل النفايات غير المعالجة من المؤسسة الى وحدة المعالجة خارج المؤسسة ، ومن ثم الى مكب النفايات لقاء بدل خاص يفرض على المؤسسة تحددته الهيئة المحلية .

#### مادة ( 30 )

#### الاحتياطات اللازمة لنقل النفايات

يلتزم الناقل باتخاذ جميع الاحتياطات اللازمة لمنع سقوط النفايات او بروزها او تسرب أي من السوائل منها او انسكابها ، وفي حال حدوث أي منها ، يجب على الناقل الالتزام بالتعليمات والإجراءات الخاصة بالتعامل مع هذه الحوادث او غيرها .

### مادة (31)

#### نموذج نقل النفايات

١. تقوم المؤسسة عند نقل النفايات بتعبئة النموذج ، ويتم توقيعه من المؤسسة والوزارة والناقل الذي يقوم بتعبئة القسم الخاص به ، وتسليمه الى الشخص المسؤول عن محطة المعالجة او مكان التخزين خارج المؤسسة او مكتب النفايات الذي يقوم بالتوقيع على الاستلام وتعبئة الجزء الخاص به ، وتسليم نسخة منه الى وزارة البيئة .
٢. تحتفظ كل جهة بنسخة عن النموذج حسب اختصاصها موقع من الجهات ذات العلاقة .

### مادة (32)

#### مركبات نقل النفايات

يجب ان تتوفر في المركبة المخصصة لنقل النفايات خارج المؤسسة المواصفات الآتية :

١. ان تكون مخصصة لنقل النفايات فقط ويمنع استخدامها لأية اغراض اخرى ، وان يكتب على جسم المركبة الخارجي :
  - أ. عبارة "نفايات طبية " مع الرموز المناسبة المتعارف عليها .
  - ب. رقم هاتف الطوارئ للاتصال في حال حدوث طارئ.
  - ت. اسم وعنوان الناقل ورقم هاتفه الارضي والناقل .
٢. ان تكون مزودة بغطاء محكم ويمنع استخدام المركبة المفتوحة والمزودة بضغط .
٣. ان تكون مقطورة النفايات منفصلة عن مقطورة السائق ومزودة بنظام لربط الحاوية داخل المقطورة لتثبيتها ، ومصمماً بطريقة تمنع وصول الصدمات الى النفايات او تسربها او انسكابها حتى عند وقوع الحوادث .
٤. ان يكون السطح الداخلي للمركبة املساً وخالياً من الزوايا ، وسهلاً للغسل والتعقيم بعد كل نقل وتفرغ للنفايات .
٥. ان تكون المادة المصنوعة منها المركبة قادرة على الصمود ضد التآكل بسبب المحاليل والمواد الكيميائية ومواد التنظيف .
٦. ان لا يقل ارتفاع الجسم الداخلي لمقطورة النفايات عن 1,85 متر .
٧. ان تكون سعة المركبة مناسبة لكميات النفايات التي تقوم بنقلها وقابلة للتبريد في حال بقاء النفايات فيها لمدة تزيد عن ست ساعات .
٨. ان تحتوي المركبة على وسيلة اتصال مناسبة وعلى المعدات الآتية :
  - أ - معدات وقاية شخصية وتشمل : كمامات خاصة ، مريول ، قفازات ، نظارات ، وأحذية سلامة .
  - ب - ادوات ومواد التنظيف والتطهير الضرورية.
  - ت - ادوات ومواد لمعالجة في حال سقوط النفايات او بروزها او حدوث تسرب او انسكاب .
  - ث - صندوق اسعافات أولية مزود بكافة المستلزمات الطبية الضرورية للإسعاف الاولي .
  - ج - ميزان لقياس درجة الحرارة يعلق داخل مقطورة النفايات .
٩. ان تكون المركبة سهلة التحميل و التفرغ .
١٠. وضع جميع المركبات في مكان آمن بعيد عن العبث بعد انتهاء عملية نقل النفايات .
١١. يحدد مسار المركبة مسبقاً وبأسرع واقصر طريق مروري - وتجنب المرور من الشوارع المزدحمة .

## Appendix 5: Environment quality assurance checklist

قائمة فحص وتدقيق لمفتشي وزارة البيئة : تهدف هذه القائمة إلى مساعدة مفتشي سلطة جودة البيئة لفحص ومراقبة إدارة النفايات الطبية.

### قائمة فحص وتدقيق – وزارة البيئة

ملاحظات	لا	نعم	الهدف من التحقق
			<b>المركبات التي تنقل النفايات الطبية خارج المنشأة الصحية تمتلك المواصفات التالية:</b>
			- المركبة تنقل النفايات الطبية فقط
			- المركبة لديها علامة تشير إلى "النفايات الطبية" مع رموز خاصة معروفة ، بالإضافة إلى رقم الهاتف في حالات الطوارئ
			- اسم الناقل / السائق، أرقام الهواتف النقالة والهاتف مبينة على المركبة
			- السطح الداخلي للمقطورة أملس، مع عدم وجود زوايا، وسهل التنظيف والتعقيم
			- المقطورة مصنوعة من مواد مقاومة للتآكل
			- سقف الجزء الداخلي للمقطورة لا يقل ارتفاعه عن 1.85 متر
			- المركبة يمكن تبريدها في حالة بقاء النفايات فيها لأكثر من ست ساعات
			- مزودة بغطاء ثابت وآمن
			- المقطورة حيث يتم شحن / تخزين النفايات مفصولة عن مقصورة السائق
			- المركبة من السهل أن يتم تحميلها وتفريغها
			- المركبة تشمل الأدوات والمعدات التالية: <b>1. معدات الوقاية الشخصية مثل قناع خاص، وثوب، وقفازات، ونظارات وأحذية السلامة</b> <b>2. معدات التنظيف والتعقيم الضرورية</b> <b>3. أدوات المعالجة اللازمة في حالة سقوط النفايات ، أو إراقها أو تسربها</b> <b>4. الإسعافات الأولية مع جميع الأشياء اللازمة</b> <b>5. منظم للحرارة (ثيرموستات) للتحقق من درجة الحرارة داخل المقطورة</b> <b>6. وسيلة اتصال مناسبة</b>
			<b>طريق / مسار رحلة المركبة لديه الخصائص التالية:</b>
			- محدد مسبقا مع الأخذ بعين الاعتبار أقصر وأسرع طريق ممكنة
			- يتجنب السفر أو السير في الشوارع المزدحمة وحركة المرور الثقيلة

معالجة النفايات والتخلص منها:			
			- يتم جلب النفايات العادية إلى محطة نقل ويتم ضغطها
			- بعد الضغط، تذهب النفايات العادية إلى التخلص النهائي (المكب)
			- النفايات الطبية تذهب إلى معالجة محددة
			- بعد المعالجة، تذهب النفايات الطبية إلى التخلص النهائي (المكب)
			- معالجة النفايات المعدية كافية
			- [إدراج أسئلة أخرى ذات صلة]

## Appendix 6: Bethlehem healthcare facilities list

<b>Hospitals</b>	
BeitJala gov. Hospital	(General)
Al Yamama Hospital	(General)
Dr.Ahmad Maslamani Hospital	(General)
Ad Dibs Hospital	(Maternity)
Shephards Field Hospital	(Maternity)
Holy Family Hospital	(Maternity)
Caritas Baby Hospital	(Children)
Military Services Hospital	(Military)
Arab Society For Rehabilitation	(Rehabilitation)
Bethlehem Psychiatric Hospital	(Specialized)
<b>Primary Health Care</b>	
Bethlehem Health Directorate	(MOH)
Zaa'tara Health Directorate	(MOH)
Beit Sahour Health Directorate	(MOH)
Beit Fajjar Health Directorate	(MOH)
<b>UNRWA</b>	
UNRWA Aida Camp	(UN)

UNRWA Dheisheh Camp	(UN)
UNRWA Azza Camp	(UN)
<b>Other Health Care Facilities</b>	
Health Work committee (AdDaman)	
German Palestinian Medical Center	
Aida Health Center	
Al Sadaqah Medical Society	
Medicare Laboratories	
MedLab Laboratory	
BioLab Laboratory	
Odeh's Medical Laboratory	
Al Hayat Laboratory	
Future Medical Center	
Razan Center For Infertility	
Kahmashta Health Center	
Beit Sahour Specialized dental Center	
Arab Dental Center	
Massad Dental Clinic	
Cmodent Dental Clinic	

## **Appendix 7: Initiative**

This thesis proposes a groundbreaking initiative to establish a medical waste recycling factory in collaboration with Al-Quds University, aimed at addressing the critical issue of medical waste management in the Bethlehem Governorate. This project seeks to leverage the academic expertise and research capabilities of Al-Quds University to develop innovative and sustainable solutions for recycling medical waste generated by healthcare facilities. By implementing advanced recycling technologies, the factory will not only mitigate the environmental hazards associated with medical waste disposal but also create a model of best practices that can be replicated across the region. According to JSC data and reports the average of annual medical wastes quantities produced in 2021-2022 is 66 tons with an annual increase of 3%.

The establishment of this factory will bring numerous benefits to the Bethlehem Governorate. It will enhance public health and safety by reducing the risk of contamination and infection from improperly disposed medical waste. Additionally, indeed create new job opportunities and stimulate the local economy. The collaboration with Al-Quds University will ensure that the project is grounded in scientific research and innovation, fostering a culture of sustainability and environmental stewardship within the community. This initiative aligns with global efforts to promote green technologies and sustainable waste management practices, positioning Bethlehem as a leader in environmental responsibility. Additionally this project would turn the waste management costs into revenues that will in deed enhance the local economy of Bethlehem governorate.

## مبادرة

تقترح هذه الأطروحة مبادرة رائدة لإنشاء مصنع لإعادة تدوير النفايات الطبية بالتعاون مع جامعة القدس، بهدف تحسين عملية إدارة النفايات الطبية في محافظة بيت لحم. يسعى هذا المشروع إلى الاستفادة من الخبرة الأكاديمية والقدرات البحثية لجامعة القدس لتطوير حلول مبتكرة ومستدامة لإعادة تدوير النفايات الطبية الناتجة عن المؤسسات و المنشآت الطبية. من خلال تطبيق برامج إعادة التدوير المتقدمة، المصنع المقترح سيقفل من المخاطر البيئية المرتبطة بالتخلص من النفايات الطبية ، بالإضافة إلى خلق نموذجاً لأفضل الممارسات التي يمكن تطبيقها في جميع المدن الأخرى. بناءً على تقارير مجلس الخدمات المشترك لمنطقة الجنوب فإن معدل انتاج النفايات الطبية لسنة 2021 – 2022 يبلغ 66 طن بمعدل زيادة سنوية 3%.

سيعود إنشاء هذا المصنع بفوائد عديدة على محافظة بيت لحم، حيث سيعزز الصحة والسلامة العامة من خلال تقليل مخاطر التلوث والعدوى من النفايات الطبية التي يتم التخلص منها بشكل غير صحيح. بالإضافة إلى ذلك، خلق فرص عمل جديدة ودعم الاقتصاد المحلي. سيشجع التعاون مع جامعة القدس أن يركز المشروع على البحث العلمي والابتكار، مما يعزز ثقافة الاستدامة و المحافظة على البيئة داخل المجتمع. تتماشى هذه المبادرة مع الجهود العالمية لتعزيز التكنولوجيات الخضراء وممارسات الإدارة المستدامة للنفايات، مما يجعل بيت لحم رائدة في المسؤولية البيئية. بالإضافة إلى ذلك، سيحول هذا المشروع تكاليف إدارة النفايات إلى إيرادات من شأنها أن تعزز الاقتصاد المحلي لمحافظة بيت لحم.