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Graduation Project Report II

**Sustainable Solid Waste Management for Higher Educational Institutions,
An-Najah National University Main Cafeteria, Case Study**

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ABSTRACT

Solid waste is a growing concern, driven by population growth, urbanization, and the industrial revolution. Inadequate management leads to higher costs, environmental damage, and health risks. Integrating effective waste management systems is crucial for sustainable development.

This research explores solid waste management in higher educational institutions. It aims to implement waste reduction strategies, assess student awareness, analyze economic aspects, and ensure financial viability. The findings contribute to the development of sustainable waste management practices in this context, serving as a reference for other institutions.

This research focuses on the cafeteria of An-Najah National University, where solid waste was sorted into five main categories: glass, cardboard, plastic, metal, and organic material. Over a 15-day period, the weights of each waste type were measured, along with the mixed waste generated from the cafeteria. The average daily quantities were determined as 11.0 kg for separated waste and 152.0 kg for mixed waste, resulting in a separation rate of 6.7%.

To increase student awareness, a campaign was conducted, accompanied by a questionnaire to assess students' knowledge of solid waste management and related issues. Interviews were also conducted with key stakeholders, local traders, and the university's services department to gather data on unit prices for each waste type, university expenses, and project capital.

The collected data underwent analysis using Excel, economic models, and mathematical equations. This analysis determined the total quantities and calculated the potential revenue from selling each waste type, taking into account the capital cost, expenses, and savings. The equal payment series method was then applied, resulting in a projected present worth value of 396,400 NIS in five years, assuming the interest rate is 5%, indicating the project's high feasibility.

Based on the project results, recommendations are proposed for the university to consider, aiming to expand the initiative and revise relevant policies. This research contributes valuable insights to the development of a sustainable waste management strategy at An-Najah National University, and it serves as a potential model for other institutions seeking effective solutions to waste management challenges.

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LIST OF ABBREVIATIONS

C&D:	Construction and Demolition Waste
GDP:	Gross Domestic Product
GIS:	Geographic Information System
HEIs:	Higher Educational Institutions
ISWM:	Integrated Solid Waste Management
JSCs:	Joint Service Councils
MET:	Middle East Technical University
MWS:	Municipal Solid Waste
NGO:	Non-Governmental Organization
NSSWM:	National Strategy for Solid Waste Management
SDGs:	Sustainable Development Goals
SW:	Solid Waste
SWM:	Solid Waste Management
UJ:	University of Jordan
UNEP:	United Nations Environment Program
WCV:	Waste Collection Vehicles
WTE:	Waste-to-Energy

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1. INTRODUCTION

1.1 Definitions

The concept of waste is a relative concept (Soufan, 2012). In other words, what is considered a waste to one person may not be a waste to another person and what may be a waste to one country may not be a waste to another country.

In the Palestinian Environmental Law (1999), Solid Waste (SW) is broadly defined as any non-hazardous waste, or garbage, generated by different activities: domestic refuse including household organic trash, street sweepings, hospital and institutional garbage, commercial, agricultural, construction, industrial waste and the sludge generated by waste treatment plants.

According to Soufan (2012), SW may be organic and inorganic (recyclable and non-recyclable) materials produced by various activities of the society, which have lost their value to the first user. The components of SW differ from one community to another depending on the type and quantity of consumption of this community. Major types of solid waste are residential, industrial, commercial, institutional, construction and demolition, agricultural and nuclear waste.

All of these require proper management to mitigate the effect of solid waste on nature and mankind as well.

Management is the process of planning, organizing, directing, and controlling resources (people, finances, materials) to achieve an organization's goals and objectives (Mubark, 2010). It involves making decisions and taking actions that affect the performance of the organization and its ability to achieve its goals.

Effective management can lead to increased efficiency, productivity, and profitability for an organization. It also involves developing and maintaining relationships with stakeholders, including employees, customers, and shareholders.

This leads to a broad concept according to Wilson (1977) who defined that solid waste management refers to the collection, transportation, and disposal of solid waste materials. It includes the management of both residential and commercial waste, as well as industrial waste.

The goal of solid waste management is to reduce the negative impact of waste on the environment and public health. This can be achieved through a variety of methods such as recycling, composting, and landfilling.

Solid Waste Management is an interrelated system of appropriate technologies and mechanisms involved in the generation, collection, storage and processing, transfer and transport, and disposal of SW at the lowest possible cost and risk to the health of people and their environment (Soufan, 2012).

Proper solid waste management involves the proper collection and transportation of waste to a designated disposal site (Tayeh et al., 2021).

Landfills are the most common method of waste disposal, but they can have negative environmental impacts if not properly managed. Therefore, many communities are turning to alternatives such as recycling, composting, and waste-to-energy facilities. These methods can reduce the amount of waste sent to landfills and can also generate energy or other useful products (Tayeh et al., 2021).

A landfill is a method of waste disposal in which solid waste is placed in a designated area, typically a large hole in the ground, and is then covered with soil or other materials. Landfills are designed to contain and isolate waste from the environment, preventing the release of harmful pollutants (El-Kelani et al., 2017).

According to (WAFA, 2017), an illegal dumpsite is an area where waste is disposed of without the proper permits or regulations. This can happen in a variety of locations, including on public or private land, and can include a wide range of materials such as household trash, construction debris, hazardous waste, and more.

Illegal dumpsites are not only a violation of environmental laws and regulations, but they can also have severe negative impacts on the environment, public health, and the local community. Illegal dumpsites can cause a variety of problems, including:

- Contamination of soil and water with hazardous chemicals or pollutants.
- Attracting pests and wildlife, which can spread disease.
- Creating fire hazards and safety risks for people living or working nearby.
- Lowering property values and negatively impacting the aesthetics of the area.
- Being costly for the government and local authorities to clean up.

Illegal dumpsites are often discovered and dealt with by local authorities and Environmental Protection Agencies. (Thöni & Matar, 2019).

The solid waste is usually compacted and covered with a layer of soil each day. The waste is also periodically covered with a layer of clay or other materials to reduce odors and the attraction of pests (SWEEP, 2014).

Landfills are typically lined with clay or plastic to prevent pollutants from leaching into the ground and contaminating soil and groundwater.

To best understand and consider solutions related to waste management, a strategic plan should be taken place.

Based on (NSSWM, 2010-2014), a strategy can be defined as a road map that will guide the team and stakeholders to come up with appropriate solutions. Solid waste management comprises many steps such as gap analysis and engaging the interested groups and governments.

Baseline and gap analysis determine the current situation and how well the waste is being managed is central to developing a useful strategy.

The following steps are important for understanding the current local situation and identifying the gaps that need to be addressed:

- Compile related data available including information on waste generation, collection, transportation, disposal waste classification, and composition, if that is not available, surveys and sample studies may be needed.
- Waste Management policies need to be reviewed currently to understand the current waste management system and how the new way strategy is going to be interlinked with existing policies.
- Develop an understanding of the technical capacity and infrastructure available in the city or country, this technical capacity can be related to waste separation, collection, recycling, treatment, or disposal.
- Financial and human resources: financial and human resources will be needed to implement improved waste management practices to develop an understanding of the resources available, how is waste management currently funded and what technical skills are available.
- Considering community awareness and interest, the strategy will call for public participation in the planning and implementation of initiatives, people may be requested to separate their waste or use special waste bins. For this reason, it is important to

understand the level of awareness regarding waste management among members of the public and private sectors and the community.

- Engaging stakeholders (identify all interested groups): governments will have a leading role in developing any national waste management strategy and agencies with sectoral responsibilities like environment or health will play key roles, relevant stakeholders may fall into one of three categories, waste generators service providers and supporting entities, members of these categories can be found in the community private sectors, NGOs and civil society.

NGOs for example often have experience in working with communities at the grassroots level and can play an instrumental role in complementing the waste management Service provided by the government.

The general dimensions, scope, and goals should be decided early. The strategy should focus on preventing the generation of waste and phasing out the use of hazardous substances in the products, rather than simply managing what is generated.

Some of the major goals that could be presented are, for example, accelerating waste collection and 3Rs activities, stopping open burning and illegal dumpsites, activating the landfill capacity to the max, increasing local awareness, constructing a waste to energy facilities, and applying regular monitoring and penalties.

Based on UNEP (2015), the 3Rs in waste management refer to the principles of Reduce, Reuse, and Recycle. These principles aim to minimize the amount of waste that is produced and to make the most efficient use of resources by reducing, reusing, and recycling materials whenever possible.

Reducing the amount of waste produced can be achieved by using less material in the first place, designing products that last longer, or using less packaging, reusing materials can be done by finding new uses for them instead of throwing them away, and recycling involves turning materials into new products.

These principles are important for preserving natural resources, reducing pollution and greenhouse gas emissions, and conserving energy. A very useful technique to achieve that concept is composting and waste to energy.

Composting is a method of breaking down organic materials, such as food scraps and yard waste, into a nutrient-rich soil amendment known as compost. The process of composting is a

natural one that occurs in nature but can be accelerated by providing the right conditions (Sweep, 2014).

Composting typically involves mixing different types of organic materials, such as leaves, grass clippings, food scraps, and manure, in a pile or container. The mixture is then turned and aerated regularly to ensure that oxygen reaches all parts of the pile, and to help control the temperature and moisture levels.

Microorganisms, such as bacteria and fungi, break down the organic matter over time, and the process generates heat. As the microorganisms consume the organic matter, they convert it into a stable, humus-like material that can be used as a soil amendment.

Home composting is a great way to reduce the amount of waste sent to landfills and provides benefits to the environment and garden. Compost can be used as a soil amendment to improve soil structure, fertility, and water-holding capacity, and can also help reduce the need for chemical fertilizers. Composting can also reduce greenhouse gas emissions from landfills and save money on garbage disposal fees.

According to Tayeh et al. (2021), Waste-to-Energy (WTE) is a process of generating energy in the form of electricity or heat from the incineration of waste. This process involves the burning of various types of waste such as municipal solid waste, industrial waste, and sewage sludge in specially designed incineration facilities. The heat generated from the combustion process is used to produce steam, which in turn drives turbines to generate electricity.

The ash and other residue left over from the process can be used for construction and other industrial purposes. WTE is considered an alternative to traditional waste management techniques such as landfilling and can help to reduce the amount of waste sent to landfills, and also generates a source of renewable energy. However, it also has some disadvantages as well such as air pollution, and the potential for toxic ash.

The United Nations Environment Program (UNEP) is an agency of the United Nations that coordinates environmental activities and assists countries in implementing environmentally sound policies.

One of UNEP's main focuses is on promoting sustainable development, which is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs. This includes addressing issues such as climate change,

biodiversity loss, and pollution, as well as ensuring that economic growth is inclusive and sustainable (UNEP, 2015).

UNEP works to achieve this through a variety of initiatives and programs, such as its Global Environment Outlook, which provides regular assessments of the state of the environment, and its work on environmental education and capacity building.

Goal 12 of the United Nations' Sustainable Development Goals (SDGs) is to "Ensure Sustainable Consumption and Production Patterns".

The goal has several targets that aim to achieve this, including:

- Target 12.1: By 2030, implement the 10-year framework of programs on sustainable consumption and production, all countries taking action, with developed countries taking the lead, taking into account the development and capabilities of developing countries.
- Target 12.2: By 2030, achieve sustainable management and efficient use of natural resources.
- Target 12.3: By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses.
- Target 12.4: By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, by agreed international frameworks, and significantly reduce their release to air, water, and soil to minimize their adverse impacts on human health and the environment.
- Target 12.5: By 2030, substantially reduce waste generation through prevention, reduction, recycling, and reuse.
- Target 12.6: Encourage companies, especially large and transnational companies, to adopt sustainable practices and integrate sustainability information into their reporting cycle.

This goal is important because the way we currently consume and produce goods and services is not sustainable in the long term. It is causing negative impacts on the environment and human health, as well as contributing to climate change. By shifting towards sustainable consumption and production patterns, we can reduce these negative impacts, conserve natural resources, and promote economic growth that is inclusive and sustainable.

1.2 General Background

1.2.1 Addressing the Global Issue of Solid Waste

Solid waste management refers to the process of collecting, transporting, treating, and disposing of solid waste materials safely and efficiently. It includes a variety of activities such as waste reduction, recycling, composting, and safe disposal in landfills or incineration facilities.

There are several challenges facing solid waste management around the world, some of the major challenges include:

- **Increasing waste generation:** The world population is growing, and with it, the amount of waste is being produced. This is particularly true in urban areas, where population density and economic development are leading to higher rates of waste generation.
- **Limited disposal capacity:** Many countries, particularly in developing regions, have limited capacity for the safe and effective disposal of solid waste. This can lead to overburdened landfills, open dumping, and other unsafe disposal practices.
- **Lack of proper collection and transportation:** In many areas, particularly in developing countries, there is a lack of proper infrastructure for collecting and transporting waste to disposal sites. This can lead to litter, open dumping, and other unsanitary disposal practices.
- **Limited recycling and composting:** While recycling and composting can help to reduce the amount of waste that needs to be landfilled, these practices are often limited in many areas due to a lack of infrastructure, education, and incentives.
- **Environmental pollution:** Improper disposal of solid waste can lead to environmental pollution, including air and water pollution, as well as soil and groundwater contamination.
- **Public health concerns:** Unsanitary disposal practices can lead to public health concerns, including the spread of disease and exposure to toxic materials.
- **Climate change:** Solid waste management is a significant contributor to greenhouse gas emissions and climate change. Landfills are a major source of methane, a potent greenhouse gas.

Addressing these challenges requires a comprehensive approach that includes reducing waste at the source, increasing recycling and composting, improving collection and transportation infrastructure, and investing in safe and effective disposal methods. It also requires cooperation and coordination among government, private sector and civil society (Kaza et al., 2018).

Solid waste management is a global issue that is important to everyone worldwide. With more than 90% of waste dumped or burned openly in low-income countries, the poor and most vulnerable are disproportionately affected.

1.2.2. Projected Growth in Solid Waste Production

Countries are developing rapidly without adequate systems to manage the changing composition of citizens' waste. Cities are at the forefront of addressing global waste challenges, home to more than half of the world's population and producing more than 80% of the global GDP (Kaza et al., 2018).

“Because waste generation is expected to rise with increased economic development and population growth, lower-middle-income countries are likely to experience the most remarkable growth in waste production. Sub-Saharan Africa and South Asia are the fastest-growing regions, where total waste generation is expected to triple by 2050, accounting for 35% of the world's waste. The Middle East and North Africa region is expected to double waste generation by 2050” (Kaza et al., 2018).

“Upper middle-income and high-income countries collect almost all waste, and more than a third of waste in high-income countries is recovered through recycling and composting. Low-income countries collect about 48% of waste in cities but only 26% in rural areas, and only 4% is recycled. In all, 13.5% of the world's waste is recycled, and 5.5% is composted” (Kaza et al., 2018).

1.2.3. Minimizing Negative Impacts and Ensuring Safe Disposal of Solid Waste

The goal of solid waste management is to minimize the negative impacts of waste on the environment and public health, while also ensuring the safe and efficient disposal of waste materials.

Waste reduction can be achieved through source reduction, recycling, and composting. Recycling and composting can help to reduce the amount of waste that needs to be landfilled, while also conserving natural resources. Landfills and incineration facilities are used for the

safe disposal of remaining waste. Effective solid waste management also includes proper collection and transportation of waste materials to processing or disposal sites, as well as monitoring and regulation of these sites to ensure that they are operated in compliance with environmental standards (River, 2017).

1.2.4. Environmental Challenges in Palestine

Palestine is located in a region with a hot and arid climate, which has seen a rise in temperatures in recent decades. Despite having a low contribution to global emissions, it is one of the most affected countries by climate change. The country is facing various environmental challenges, such as limited resources, lack of control over its territory, and financial constraints.

These issues are compounded by water scarcity, pollution of water and land, desertification, and poor land management. Additionally, the Israeli occupation limits access to resources and hinders efforts to sustainably manage them, exacerbating the negative effects of climate change, particularly for the country's high population and poverty levels, and food insecurity.

1.2.5. Solid Waste Management in Palestine

Solid waste management in Palestine is also a major concern, facing issues such as a lack of legislation, data collection, and infrastructure, as well as restrictions imposed by the occupation on access to land and resources (United Nations, 2022).

Solid waste management in Palestine is a significant challenge due to a variety of factors, including ongoing conflict and limited resources. The majority of waste in Palestine is generated in urban areas, with the largest cities such as Jerusalem, Nablus, and Hebron producing the most waste.

Recycling and composting programs are limited in Palestine, with a majority of the waste being sent to landfills. However, many of these landfills are not properly managed and can lead to environmental pollution and public health concerns.

In recent years, there have been some efforts to improve solid waste management in Palestine, including the implementation of new technologies and the involvement of the private sector. However, the lack of a stable political and economic environment, lack of funding, and limited resources continue to hinder progress in this area (Thöni & Matar, 2019).

High population growth can be a major factor in environmental changes. Palestine's population is currently growing at a rate of 2.7% annually, with an estimated total of 5 million people in 2019, and a projection to reach 6.9 million by 2030.

“The population density is particularly high in Gaza and some areas of the West Bank, including East Jerusalem, where urbanization has taken place quickly without proper planning. This increase in population puts pressure on natural resources and infrastructure, for example, the amount of solid waste generated in Gaza is expected to rise to over 3,000 tons in 2030, from around 1,900 tons in 2015. Furthermore, population growth has led to an increase in land value, resulting in the sale of land for urban development and the expansion of buildings onto agricultural lands. Additionally, the expansion of settlements in the West Bank and East Jerusalem contributes to the strain on limited resources and increases the pollution of air, soil, and water” (Sellwood & Thummarukudyil, 2020).

In Palestine, solid waste is generated from a variety of sources, including households, commercial and industrial activities. The types of solid waste found in Palestine can be broadly categorized into the following categories:

- **Municipal Solid Waste (MSW):** This includes waste generated from households and other residential areas, such as food waste, paper, plastics, and other household items.
- **Construction and Demolition Waste (C&D):** This includes waste generated from construction and demolition activities, such as bricks, concrete, and other building materials.
- **Hazardous Waste:** This includes waste that can be harmful to human health or the environment, such as chemicals, batteries, and electronic waste.
- **Medical Waste:** This includes waste generated from healthcare facilities, such as sharps, medical equipment, and other materials that may be contaminated with infectious agents.
- **Industrial Waste:** This includes waste generated from industrial activities, such as manufacturing, mining, and agriculture.

The composition of solid waste in Palestine can vary depending on the location, population density, and economic activity. In general, the majority of waste is made up of organic materials, such as food waste and yard trimmings, with smaller amounts of paper, plastics, and other materials. It is important to note that the collection and management of solid waste in Palestine is facing several challenges, including lack of proper infrastructure, limited financial

resources, and the ongoing conflict which affects the access to the waste collection and disposal sites (Thöni & Matar, 2019).

Waste collection and disposal services in Palestine are provided by municipalities, with support from the government and international organizations. However, due to the ongoing conflict and limited resources, these services are often inadequate, leading to widespread litter and open dumping in many areas.

The Ministry of Local Government provides support to the Joint Service Councils (JSCs) in the West Bank and Gaza Strip to manage the collection and treatment of solid waste. The services of the twelve JSCs are available to 83% of Local Government Units in the West Bank and 74% of the population. In the West Bank, it is estimated that 2,622 tons of municipal waste are generated daily, with a per capita generation of 0.91 kg/day.

“The JSCs are responsible for collecting around 65% of this waste, while the remaining waste is managed by Local Government Units and the United Nations Relief and Works Agency for Palestine Refugees in the Near East. In Gaza, approximately 1,330 tons of solid waste are generated per day, with an average per capita generation of 0.7 kg/day” (United Nations, 2018). One JSC operates in the southern part of Gaza and manages to collect about 12% of the total solid waste in the area (Sellwood & Thummarukudyil, 2020).

A report by Cesvi in 2019 states that the Palestinian population in the occupied territory generates approximately 0.9 kg of solid waste per person per day, with rural areas generating less waste than urban areas. The amount of waste generated per person increases each year as a result of population growth and changes in lifestyle. However, the report also notes that in Gaza, despite an increase in population, the waste generation rate has decreased in recent years. Cesvi estimates that Israeli settlements in the West Bank generated around 1,200 tons of solid waste per day in 2017, which is equivalent to 1.9 kg per person per day.

The majority of the waste is organic matter (50%) but also includes materials like cardboard, glass, metals, paper, and plastics. Most of the waste comes from major cities. There are also often hazardous and industrial waste mixed in with the municipal solid waste and waste from Israeli settlements.

There are three main landfill sites in the West Bank: Zahrat al Finjan in the north, al Minya serving the south, and Jericho Sanitary Landfill for the Jericho area. In addition to these, there is a small landfill in North-West Jerusalem (Beit Anan) and one Israeli landfill (Tovlan in the

Jericho area) that takes waste from Israeli settlements. About 20% of the solid waste generated in the West Bank and Gaza is disposed of in random dumpsites.

The Israeli Civil Administration states that Al Minya treats waste from both Palestinians and Israeli settlements. In Gaza, the three sanitary landfills at Deir el Balah, Jahr al Deek, and Rafah are currently beyond capacity. Deir el Balah and Rafah landfill sites were replaced by a new site at Al Fukhari in South Gaza, which became operational in 2019 (Thöni & Matar, 2019).

Hazardous waste poses a significant risk to public health and the environment. The Environment Quality Authority has attempted to address this issue through the National Solid Waste Management Strategy, but limited resources and expertise have hindered their efforts. Medical waste is often mixed with regular municipal waste without proper treatment. Communities, municipalities, and village councils are facing difficulties in managing the cost of collecting, transporting, and disposing of waste. Currently, only about 1% of the waste generated in the occupied Palestinian territory is recycled and recovered, but this is expected to increase to 30% in 2022 with the implementation of the National Strategy for Solid Waste Management in Palestine (Sellwood & Thummarukudyil, 2020).

A 2019 report by Cesvi states that the Zahrat al Finjan landfill had reached almost its maximum capacity in 2018. The Al Minya sanitary landfill, which was initially designed to handle 630 tons per day, was receiving 1,100 tons per day by November 2018, including waste from southern governorates, Bethlehem (220 tons per day), Hebron (700 tons per day), East Jerusalem (115 tons per day), and settlements (65 tons per day). The report also highlights that managing the leachate at Al Minya is a challenge, as the only solution is through evaporation, and the treatment unit with an aeration tank is not in use, an odor repellent is sprayed regularly on the leachate ponds and the landfill to minimize the impact on nearby residents (Thöni & Matar, 2019).

The leachate ponds are at risk of overflowing during certain seasons and the amount of leachate being reduced is very low. The Jericho landfill was expected to reach capacity by mid-2019 and there is no possibility for expansion. Plans for a new landfill in the Rammun area in Area C are reportedly on hold, possibly due to opposition from local residents. “Uncontrolled dumping is common in the occupied Palestinian territory, particularly for construction and demolition debris, used tires, or agricultural waste. According to Cesvi, it is difficult to have an accurate list of all the uncontrolled dumpsites” (Thöni & Matar, 2019).

“However, in recent years, due to the opening of sanitary landfills and several rehabilitation efforts, many illegal dumpsites have been closed. In 2019, it was estimated that 343 tons per day in the West Bank and 443 tons per day in the Gaza Strip were disposed of in dumpsites” (Bigagli, 2020).

A significant amount of solid waste is disposed of in open, unregulated, and unsupervised areas and burning is the common method used to reduce the volume of waste in these dumpsites. However, this practice of burning waste in dispersed sites causes multiple sources of pollution (Sellwood & Thummarukudyil, 2020).

Overall, solid waste management in Palestine remains a major challenge, requiring significant investment and coordination among government, private sector, and civil society to improve the collection, transportation, treatment, and disposal of waste, and to prevent negative impacts on public health and the environment.

1.2.6. Solid Waste Management for Higher Education Institutions

Solid waste management systems in higher education institutions, such as colleges and universities, can vary depending on the size and resources of the institution. However, many institutions have implemented similar systems to address the collection, transportation, treatment, and disposal of solid waste.

- Recycling and composting programs: Many higher education institutions have implemented recycling and composting programs to reduce the amount of waste that needs to be landfilled. This can include recycling of materials such as paper, plastics, and metals, as well as composting of food waste and other organic materials.
- Collection and transportation: Higher education institutions typically have a system in place for the collection and transportation of waste to processing or disposal sites. This can include a combination of manual and mechanical collection methods, as well as specialized vehicles for transportation.
- Waste reduction: Many higher education institutions have implemented policies and programs to reduce waste at the source, such as reducing the use of single-use plastics, promoting energy efficiency, and encouraging the use of public transportation.
- Education and outreach: Higher education institutions often have programs in place to educate students and staff about solid waste management and the importance of reducing, reusing, and recycling.

- Research and innovation: Some higher education institutions have research centers and initiatives focused on solid waste management and sustainability. This can include developing new technologies for waste management, studying the environmental impacts of waste, and exploring alternative disposal methods.

Overall, solid waste management systems in higher education institutions are designed to reduce the amount of waste generated, promote recycling and composting, and ensure safe and effective disposal of waste materials. While many challenges exist in implementing effective solid waste management systems, universities have a unique opportunity to lead by example and be a model for the communities they serve (Al-Khatib et al., 2018).

1.2.7. Vision of Solid Waste Management for An-Najah National University

An-Najah National University is a public non-governmental university located in Nablus, Palestine. It is one of the largest and most prestigious universities in Palestine and is known for its academic excellence and research in a variety of fields, including engineering, medicine, business, and social sciences. An-Najah National University was founded in 1918 and has since grown to include more than 24,835 students and over 2,500 academic and administrative staff members.

The university offers undergraduate and graduate programs in a wide range of disciplines, and is known for its strong emphasis on research and community engagement. The university also has a number of research centers and institutes, including the Center for Environmental and Energy Research, which focuses on issues related to sustainable development, renewable energy, and environmental management. The university is also actively involved in community service and outreach, working with local organizations and government agencies to address important social and economic issues in the region (An-Najah National University, 2021).

As a large institution with a significant population of students and staff, it is likely that the university generates a significant amount of solid waste. It is common for universities to have a waste management plan in place to address the collection, transportation, treatment, and disposal of solid waste. This can include measures such as recycling and composting programs, as well as proper disposal of waste in landfills or incineration facilities.

It is likely that An-Najah National University also has policies in place to encourage waste reduction and promote sustainability on campus. This can include efforts such as reducing the use of single-use plastics, promoting energy efficiency, and encouraging the use of public

transportation. It is also possible that the university has research projects and initiatives related to solid waste management, particularly in the field of environmental engineering, civil engineering, and environmental science.

Solid waste management at An-Najah National University would involve implementing a system for collecting, transporting, and disposing of waste on campus. This could include separating recyclable materials from non-recyclable waste, implementing composting programs for organic waste, and properly disposing of hazardous materials. Additionally, educating students, faculty, and staff on proper waste management practices and encouraging participation in recycling and waste reduction initiatives can also be an important aspect of solid waste management at the university.

1.3 Objectives

1. Implementing Financially and Environmentally Responsible Waste Management Strategies:
 - Develop and implement waste reduction, recycling, and disposal strategies at An-Najah National University's cafeteria that promote financial efficiency and minimize environmental impact.

2. Quantifying Solid Waste Generation and Categorization:
 - Measure and categorize the quantities of solid waste generated in the cafeteria, including glass, cardboard, plastic, metal, and organic material, over a 15-day period.
 - Determine the proportion of mixed waste generated during the same period.

3. Enhancing Student Knowledge and Engagement in Waste Management:
 - Assess the level of student knowledge and awareness regarding solid waste management.
 - Design and execute a campaign aimed at increasing students' understanding and engagement in waste reduction practices.
 - Administer a questionnaire to measure the effectiveness of the campaign and gather insights on student attitudes towards waste management.

4. Gathering Financial and Operational Data:
 - Conduct interviews with key stakeholders, local traders, and the university's services department to collect data on unit prices for each waste type, university expenses, and project capital.

5. Analyzing Data for Feasibility and Revenue Projection:
 - Analyze the collected data using Excel, economic models, and mathematical equations to evaluate the total quantities of waste generated and calculate the potential revenue from selling each waste type.
 - Assess the feasibility of the waste management project from both financial and environmental perspectives.

6. Projecting Financial Viability:
 - Utilize the equal payment series method to project the present worth value of the waste management project over a five-year period, assuming an interest rate of 5%.
 - Determine the financial viability of the project based on the projected present worth value and considering capital costs, expenses, and savings.

7. Proposing Recommendations for Expansion and Policy Revision:
 - Formulate recommendations based on the research findings to guide the expansion of the waste management initiative at An-Najah National University.
 - Propose revisions to relevant policies that promote improved waste management practices and financial efficiency.

8. Contributing Valuable Insights and Serving as a Model:
 - Contribute valuable insights to the field of waste management through the development and implementation of effective strategies.
 - Serve as a model for other institutions seeking to establish sustainable waste management practices by sharing research findings, recommendations, and lessons learned.

1.4 Literature Review

1.4.1 Solid Waste Management in Educational Institutions: The Case of The University of Jordan (Shadi Moqbel, 2018).

The study was done by an assistant professor at the civil engineering department including an estimation of the waste generation rate, characterization of the solid waste generated on the campus and its variation over four distinct periods during the academic calendar, regular semester, study break, summer semester and the month of Ramadan.

The study investigated the generation rate of solid waste and the characteristics of the entire stream of solid waste on the main campus of the University of Jordan and the variation in waste composition over the school academic calendar and main events. The measurements were done 3 times during the weekdays and limited to one regular semester.

The waste sorting during the monitoring campaign at the UJ campus used manual sorting at each of the 67 waste containers on campus. This method involved a sorting crew visiting each container within the university fence in rounds, emptying the entire content of the container on a designated plastic tarp, hand sorting the waste into specified buckets, weighing the assigned categories, and then returning the solid waste to the container before the solid waste collection vehicle came to take the waste away.

The manual sorting method is a traditional and commonly used method for waste sorting, which has the advantage of being able to identify and quantify a wide range of waste categories. However, it is a labor-intensive process and can be time-consuming.

For each study period except the study break, the content of every container was sorted and weighed at least three times to ensure accurate data collection. This approach helps to increase the reliability of the data and provides a comprehensive understanding of the waste generation patterns on the campus.

The manual sorting method used in this study can be useful in identifying the composition and characteristics of the solid waste generated at the campus and can be used to develop targeted and effective solid waste management strategies to reduce the amount of waste generated and improve the efficiency of waste collection and disposal.

The study showed that waste generated from the university campus reaches an average of 8113 kg/ day during the regular semester with a full enrolment of students.

The study projected waste generation will reach 4250 kg/day and 800 kg/day during the summer semester and the break, respectively.

The study presented that at least 87% of the waste stream from the university's main campus can be diverted from going to landfill. This amount can be recycled, reused, or used as an energy source.

The study revealed that the major recyclable components that have a significant presence are hot beverage cups, cardboard, plastic, paper, yard waste, and food waste.

The study results showed that the recycling program on campus is highly recommended but requires full-scale cooperation and careful handling.

It is noticeable that the study didn't mention any further information regarding the expenses the university pays to get rid of waste. Furthermore, it didn't come across the revenues expected from selling sorted waste to local companies to recycle it.

1.4.2 Integrated solid waste management strategy of a large campus: A comprehensive study on METU campus, Turkey (Bahçelioğlu et al., 2020)

This study aims to evaluate the effectiveness of current solid waste management strategies in METU Ankara, Turkey by utilizing various data collection methods such as monitoring of waste generation, site visits, compost experiments, interviews with waste management administrators, and surveys to understand the social behavior of students.

A year-long monitoring campaign conducted at the Middle East Technical University (METU) campus to estimate the spatial and temporal variations of solid waste generation amount is a valuable step in the planning of integrated solid waste management (ISWM).

The assessment of the solid waste generation rate provides important information on the amount of waste generated and can help identify areas of the campus where waste reduction and management efforts can be focused.

The results of the monitoring campaign indicated that the average domestic solid waste generation on the METU campus varies between 5.8 and 10.3 tons per day every week. This information, obtained from four audit periods, can be used to better understand the waste generation patterns on campus and develop strategies to reduce and manage the waste effectively.

For example, if the highest waste generation rate is found to be in the dining halls, efforts could be made to reduce food waste, encourage composting, and promote the recycling of food packaging materials.

Overall, the monitoring campaign provides valuable information that can be used to improve the effectiveness of solid waste management on the METU campus and contribute to a more sustainable environment.

The results of the study indicate that the average daily solid waste generation factor is 0.40 kg/day/cap and the total amount of waste generated varies between 5.8 and 10.3 tons/day weekly on the campus. The study also found that the total collected recyclable waste accounts for 13% of the total waste generated.

Based on the findings of the evaluation, strategies were developed to decrease the solid waste generation rate, increase the recyclable material collection rate, and initiate compost activities. These strategies include a combination of behavioral, structural, and managerial approaches.

This study is an evaluation (descriptive) of the previously used solid waste plan in the university, it studied the overall performance and awareness of the students and did not talk about the costs paid on waste collection and disposing of it and as well as the potential revenues of waste as a source for the university. it included a summary of previous studies as well.

1.4.3 Current Trends in Solid Waste Management in Higher Education Institutions. The Case of West Bank Region, Palestine (Al Khatib et al., 2018).

Field research was conducted in West Bank (Palestine) Higher Educational Institutions (HEIs) and its outcomes aim primarily to the identification of the current situation of SWM systems in the HEIs of Palestine, the negative and positive attitudes towards SWM, the extent to which the solid waste sector in Palestinians' HEIs connects and affects the municipal SWM system as well as the environment. Most importantly the primal outcomes that are the quantitative and qualitative data will constitute the foundations for the organization of a SWM strategy in Palestinian HEIs.

The first step was directed into taking a questioner which distributed over 10 HEIs, the questionnaire included the number of students and employees of their institution, the method of solid waste treatment (waste collection schemes, packaging, type and size of the used containers, etc.) and final disposal site.

It should be mentioned that in the questionnaire the waste streams were indicated (i.e., hazardous laboratory- waste, garden waste, food waste, and office activities resulting in waste).

The second step was following the questionnaire to quantify waste generated in the HEIs, so the net weight of all waste collection vehicles (WCV) involved in the waste collection from HEIs (before their entrance into the campus) was measured as well as the total weight of the WCV after the end of the waste collection (at the exit of the campus).

The data were collected for 10 HEIs (7 universities and 3 community colleges) for a period of 5 consecutive days. It must be noted that the days where the quantitative research took place are judged as regular days for HEI operation as there were no holidays, strikes, or any other reasons affecting the overall generation of waste of any type.

Following the quantification of waste, a waste characterization study was conducted since it constitutes an important element of the SWM plan. Random solid waste samples were taken from three different locations per each involved institution, academic and administrative buildings (including laboratories), gardens and corridors, and the community center (store, and cafeteria areas).

These places were selected to reflect the diversity of the domestic waste stream generated in any HEI campus, while construction waste was excluded, the samples were taken for 5 consecutive days to reflect the consumption pattern and ensure the representation of the waste stream. All of the samples were taken using the same-sized aluminum bin with a net weight of 2.5 kg and a volume of 50 liters.

The study resulted that the Palestinian Higher Education Institutions were generating approximately 34 tons of solid waste per day - an average per capita generation of 0.51kg.

Overall, out of the 10 Higher Education Institutions involved in the research, only 25% were practicing waste separation at the source, 25% were implementing awareness-raising programs on solid waste management and 50% of the source separation of hazardous waste generated was performed.

Following the results of these studies, it can be concluded that each educational institution is a special case of study, and adopting a zero-waste policy among educational institutions is achievable but requires full-scale cooperation.

2. METHODOLOGY

1. **Study Design:** The research adopts a descriptive and analytical approach to investigate sustainable solid waste management at An-Najah National University. The study focuses specifically on the cafeteria, which serves as a representative area for waste generation on campus. The methodology encompasses data collection, analysis, and evaluation to achieve the research objectives.
2. **Data Collection:**
 - a) **Waste Characterization:** A 15-day waste characterization study is conducted to determine the quantities and categories of solid waste generated in the cafeteria. The waste is sorted into five main categories: glass, cardboard, plastic, metal, and organic material. The weights of each waste type are measured separately, along with the mixed waste generated from the cafeteria.
 - b) **Student Questionnaire:** A questionnaire is developed and administered to students to assess their knowledge and awareness of solid waste management and related issues. The questionnaire aims to gather data on students' understanding, practices, and attitudes towards waste reduction and recycling.
3. **Interviews:** Interviews are conducted with key stakeholders, including local traders, the university's services department, and relevant administrative staff. These interviews aim to gather data on unit prices for each waste type, university expenses related to waste management, and project capital requirements. The interviews also provide insights into the organizational, technical, environmental, and financial aspects of waste management at the university.
4. **Data Analysis:**
 - a) **Waste Quantification:** The collected data from the waste characterization study is analyzed to determine the average daily quantities of separated waste and mixed waste generated in the cafeteria. The separation rate is calculated as the percentage of separated waste in relation to the total waste generated.
 - b) **Student Questionnaire Analysis:** The data gathered from the student questionnaire is analyzed to assess the level of knowledge, awareness, and engagement of students in solid waste management practices.
 - c) **Interview Data Analysis:** The data obtained from interviews with stakeholders is analyzed to determine unit prices for waste types, university expenses, and project capital requirements.

5. **Financial Analysis:** The collected data, including waste quantities, unit prices, expenses, and capital requirements, are utilized in financial analysis. This analysis involves the application of Excel, economic models, and mathematical equations to determine the potential revenue from selling each waste type. The equal payment series method is employed to project the present worth value of the waste management project over a five-year period, assuming an interest rate of 5%.
6. **Recommendations:** Based on the research findings and analysis, recommendations are proposed for the university to enhance its waste management practices. These recommendations aim to expand the waste reduction, recycling, and disposal initiatives and suggest revisions to relevant policies. The recommendations are developed to align with sustainable development principles and promote environmental responsibility.
7. **Limitations:** The research acknowledges certain limitations, including the focus on a specific area (the cafeteria) as a representation of waste generation on campus. The research may not capture the entire scope of waste management practices at the university. Additionally, the findings and recommendations are context-specific to An-Najah National University and may require adaptation for implementation in other settings.
8. **Ethical Considerations:** The research adheres to ethical guidelines, ensuring the confidentiality and anonymity of participants in data collection. Informed consent is obtained from participants, and the research complies with ethical standards for research involving human subjects.
9. **Validity and Reliability:** Measures are taken to ensure the validity and reliability of the data collected. The waste characterization study employs rigorous sorting and weighing methods to obtain accurate waste quantities. The questionnaire is designed using established measures and validated instruments, and measures are taken to enhance response validity. The interview process follows a structured approach to ensure consistency and reliability of data collection.

3. DATA COLLECTION

In order to conduct a comprehensive study on sustainable solid waste management, the focus of this research project was directed towards the cafeteria facilities at An-Najah National University. This specific area was chosen due to its significant contribution to the overall generation of solid waste within the university premises. The primary objective was to determine the precise quantities of each type of solid waste produced in this cafeteria.

To facilitate the collection of accurate data, five containers were strategically placed, each with a volume capacity of 75 liters. These containers were specifically allocated for the segregation of five distinct categories of solid waste, namely glass, metal, cardboard, plastic, and organic materials. This approach ensured the systematic categorization of waste, allowing for efficient measurement and analysis.

The data collection period spanned a total of 15 working days. Although this duration may seem relatively short, it was chosen considering several factors that impacted the availability of data. For instance, the semester during which the data was collected witnessed numerous strike days, which constrained the overall number of working days available for the study. Additionally, the holy month of Ramadan followed directly after the 15-day collection period, during which the cafeteria remained closed. These circumstances necessitated the selection of a shorter timeframe for data collection.

To encourage active participation from students, a dedicated campaign was launched to raise awareness about the research study. This campaign utilized various social media platforms and targeted relevant student groups, urging them to actively cooperate in the separation of solid waste. The aim of this initiative was to foster a sense of responsibility among the student body and garner their support in implementing sustainable waste management practices.

During the commencement of the quantity surveying, the research team received valuable technical assistance from the dedicated cafeteria services staff. Their cooperation was instrumental in ensuring a smooth initiation of the data collection process. However, as the surveying progressed, the team took on the responsibility independently until its conclusion.

Upon the completion of the designated working days, the team proceeded to measure the weight of each solid waste container. To accomplish this, a hand weight scale was utilized, guaranteeing accurate measurements for further analysis. In addition to tracking the individual categories of solid waste, the team also sought to determine the weight of the mixed solid waste.

To achieve this, regular weighing intervals were established, typically occurring approximately every two hours.

To account for the mixed solid waste, containers specifically designated for its collection were strategically placed both indoors and outdoors of the cafeteria premises. This meticulous arrangement ensured the inclusion of all relevant waste generated within the cafeteria's vicinity. By periodically weighing these mixed waste containers, the research team gained valuable insights into the overall composition and weight of the combined waste stream.

The diligent implementation of these weighing procedures and the inclusion of mixed waste measurements bolstered the comprehensiveness of the data collection process. These efforts allowed for a more comprehensive analysis of the cafeteria's waste management practices and offered insights into the potential areas of improvement regarding waste segregation and reduction.

By adopting a meticulous approach to data collection and incorporating various weighing techniques, the research team successfully captured a detailed snapshot of the solid waste generated within the cafeteria of An-Najah National University. These findings serve as a valuable foundation for further analysis and the formulation of effective strategies for sustainable solid waste management.

In addition to the quantity surveying efforts, a questionnaire was meticulously developed to gauge the level of awareness regarding solid waste management among the student population at An-Najah National University. This questionnaire comprised a series of multiple-choice and open-ended questions, designed to gather comprehensive insights into students' knowledge and practices concerning sustainable waste management.

To ensure a representative sample that encompassed diverse academic disciplines and years of study, a systematic sampling method was employed. This approach aimed to maintain an equitable distribution of participants from both genders throughout the survey. By including a diverse range of respondents, the research aimed to capture a holistic perspective on the awareness and attitudes towards solid waste management within the university community.

The survey was conducted in two distinct stages to enhance the reliability and validity of the obtained results. In the first stage, a total of 100 face-to-face interviews were conducted with selected participants. This approach allowed for direct engagement, enabling in-depth

discussions and the opportunity to clarify any ambiguities in responses. The face-to-face interviews ensured a higher level of accuracy and enriched the quality of the data obtained.

Following the completion of the initial stage, the second stage involved the distribution of the questionnaire on various social media platforms widely utilized by the student body. This method aimed to reach a larger audience and gather a more diverse range of responses. The use of social media platforms facilitated the convenient participation of a significant number of students, providing them with an accessible means to contribute to the research study.

By incorporating both face-to-face interviews and the online dissemination of the questionnaire, the research team ensured a comprehensive approach to data collection. This combination of methods allowed for a deeper understanding of students' perspectives, attitudes, and knowledge regarding solid waste management practices. The diverse sampling method further strengthened the validity and generalizability of the findings, enabling a more robust analysis and the formulation of effective recommendations for sustainable waste management initiatives at An-Najah National University.

In order to gather comprehensive insights and obtain valuable information for the research project, interviews were conducted with various key stakeholders in the solid waste sector. These interviews involved individuals holding official positions within the Nablus and Tukaram municipalities, technical personnel working at Zahret Al-Finjan and Al-Monia landfills, local market solid waste traders, as well as employees from the general services department of An-Najah National University.

Engaging with these individuals offered a multifaceted understanding of solid waste management practices, policies, and challenges. The officials from the municipalities provided crucial insights into the regulations and strategies implemented at the local level to address solid waste management. Their expertise shed light on the initiatives undertaken to ensure proper waste collection, transportation, and disposal within the respective jurisdictions.

The technical professionals, including engineers from Zahret Al-Finjan and Al-Monia landfills, offered valuable knowledge regarding waste treatment and disposal methods. Their expertise contributed to the understanding of the operational aspects of landfills, waste sorting techniques, and potential environmental implications. Such insights allowed for a comprehensive evaluation of the current solid waste management infrastructure in the region.

Engaging with local market solid waste traders offered valuable perspectives on the economic aspects of waste management. These individuals provided insights into the dynamics of waste recycling, the market demand for specific types of recyclable materials, and the associated costs and benefits. Understanding the commercial aspects of waste management contributed to the overall analysis of the feasibility and economic viability of sustainable waste management practices.

Furthermore, interviews with employees from the general services department of An-Najah National University provided an internal perspective on the university's current waste management practices. These individuals shared valuable information regarding waste collection and disposal within the university premises, existing challenges, and potential opportunities for improvement. Their contributions allowed for a comprehensive understanding of the specific solid waste management context within the university setting.

Through these interviews, the research project gained access to a wealth of important information. Insights from these key stakeholders provided a holistic view of the solid waste management landscape, including technical, regulatory, economic, and operational aspects. The information collected from these interviews also facilitated a cost analysis of solid waste management, enabling a comprehensive evaluation of the financial implications associated with different waste management approaches.

By incorporating the perspectives and expertise of these various stakeholders, the research project aimed to formulate recommendations and strategies that align with the realities of the solid waste sector. The insights obtained from these interviews enriched the overall understanding of sustainable solid waste management practices and contributed to the development of a comprehensive framework for An-Najah National University's waste management system.

As per the information provided by the General Services Department of An-Najah National University, the campus is equipped with four large containers for solid waste disposal. One of these containers has a capacity of 20 cubic meters, while the remaining three containers have a capacity of 10 cubic meters each. These containers are emptied three times a week as part of the waste management routine.

The average cost associated with the disposal of the waste from these containers is approximately 200 NIS per disposal cycle. It is important to note that this cost includes the expenses related to transportation and proper disposal of the collected waste. The disposal

frequency of three times per week ensures that the waste generated within the university campus is promptly and effectively managed, contributing to a clean and well-maintained environment.

This information from the General Services Department sheds light on the infrastructure and operational aspects of solid waste management at An-Najah National University. Understanding the disposal capacity and frequency, as well as the associated costs, is crucial for assessing the efficiency and effectiveness of the waste management system. By considering these factors, recommendations can be made to optimize waste collection schedules, improve cost-effectiveness, and enhance overall sustainability efforts on campus.

In the process of data collection, an important aspect considered was the assessment of costs associated with solid waste management. Various cost factors were gathered, which are integral to understanding the economic implications of different waste materials. These cost data points provide valuable insights into the financial aspects of sustainable solid waste management practices. The following are the specific cost details for different waste categories:

- **Metal Cans:** To determine the cost associated with metal cans, information was obtained from a local trader in Eastern Nablus. It was revealed that every 100 metal cans, such as those used for coke and other drinks, amounted to 20 NIS. By averaging the weight of empty cans, which is approximately 15 grams, it was inferred that every 1 ton of metal cans generated would yield 13,350 NIS. This cost estimation includes transportation expenses.
- **Glass Waste:** For the assessment of glass waste costs, a local trader in Eastern Nablus provided valuable input. According to their insights, every 1 ton of glass waste amounted to 800 NIS, which includes transportation costs.
- **Cardboard Waste:** The Tukaram municipality provided the information that for every 1 ton of cardboard waste, a payment of 100 NIS would be made.
- **Plastic Bottles:** To determine the cost associated with plastic bottles, it was found that every 100 bottles of plastic equated to 15 NIS. By averaging the weight of empty bottles, approximately 25 grams, it was concluded that every 1 ton of plastic bottles would generate 6,000 NIS, inclusive of transportation expenses.
- **Organic Waste:** Through the data collection process, it was determined that there is no established price for selling organic waste as raw materials. As such, it was inferred that organic waste does not have a direct monetary value in terms of its sale or recycling potential.

The inclusion of these cost assessments provides crucial insights into the economic considerations associated with solid waste management. Understanding the financial implications of different waste materials allows for a comprehensive evaluation of the feasibility and potential revenue streams associated with sustainable waste management practices. This data enhances the research project's ability to make informed recommendations and formulate strategies that align with both environmental sustainability and financial viability.

Based on the comprehensive data collected from local traders, valuable information regarding waste management infrastructure and associated costs has been obtained. The following details were provided:

- **Integration of Large Fully Final Container:** As part of the waste management plan, a large fully integrated container is proposed for the cafeteria. This container is designed to accommodate five smaller containers, each with a capacity of 120 liters, representing the different waste categories identified earlier. The estimated cost of this container is approximately 1000 NIS. Its purpose is to streamline waste sorting and collection within the cafeteria area, promoting efficient waste management practices.
- **Outdoor Large Steel Container:** In addition to the integrated container in the cafeteria, an outdoor large steel container is recommended with a substantial capacity of 10 cubic meters. This container, primarily intended for bulk waste disposal, is estimated to cost around 5000 NIS. Its larger size enables efficient collection and containment of waste generated in outdoor areas of the university campus.

Depreciation rates were determined for the outdoor large container (10% over 10 years) and the indoor integrated container (20% over 5 years), influencing asset management and financial planning.

Expected Lifespan of Containers: The proposed containers, both the integrated container and the outdoor large steel container, are designed to have an expected lifespan of 5 years. This timeframe accounts for their durability and functionality in supporting the waste management efforts over a significant period.

Annual Maintenance Costs: It is crucial to consider the maintenance aspect of the waste management infrastructure. The annual maintenance costs associated with all the containers, including both the integrated and outdoor containers, are estimated to be approximately 5,000

NIS. This covers routine inspections, repairs, and upkeep of the containers to ensure their optimal performance and longevity.

Trash Bag Expenses: A significant consideration in waste management is the cost of trash bags used for waste collection. The annual expenditure on trash bags is estimated to be around 10,000 NIS. This cost encompasses the procurement of sufficient quantities of high-quality, durable bags necessary for efficient waste containment and transportation.

During the comprehensive analysis of operational costs, an intriguing finding emerged, revealing that the average salary allocated to cleaning and service labor at An-Najah National University stood at a notable amount of 2500 NIS. This insightful revelation sheds light on the financial investments made in sustaining an efficient waste management system while upholding the cleanliness and well-being of the university environment.

To assess the financial viability of the project, a rate of return of 5% has been assumed. This rate of return allows for the evaluation of the project's potential profitability and compares it to alternative investment opportunities.

By incorporating these cost-related aspects into the research, a comprehensive understanding of the financial implications of the proposed waste management infrastructure is gained. This information provides a foundation for conducting a thorough cost-benefit analysis and helps in making informed decisions regarding the feasibility and long-term sustainability of the solid waste management project.

4. DATA ANALYSIS

4.1 Questionnaire Analysis

Initially, a questionnaire was developed consisting of multiple questions to assess the degree of awareness about solid waste management among university students. To ensure equal representation of both genders across various academic disciplines and years, a consistent sampling method was employed. The survey was carried out in two stages. The first stage involved conducting 100 face-to-face interviews to obtain accurate results. In the second stage, the questionnaire was disseminated on various social media platforms utilized by the students. The outcomes of both stages were in agreement, as indicated below:

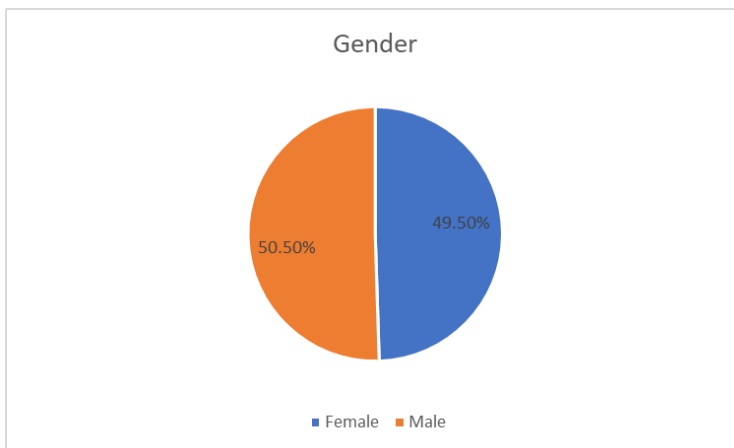


Figure 1. Gender

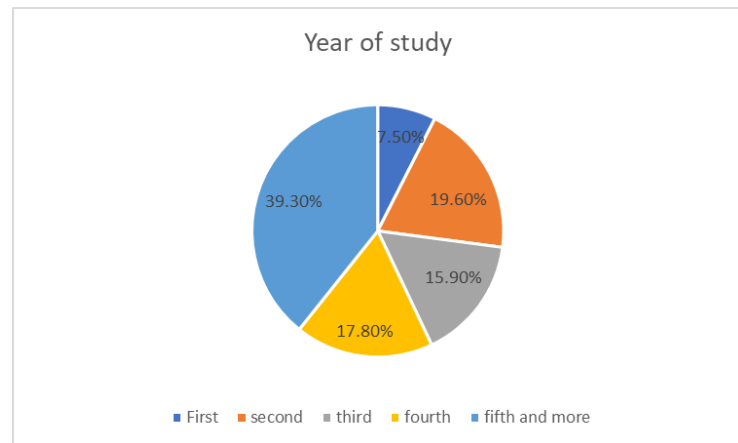


Figure 2. Academic Year

Firstly, the survey investigated whether the respondents considered solid waste to be a pressing concern, with a majority indicating that they faced waste-related difficulties in their surroundings. Following this, the participants were asked about their familiarity with the concept of solid waste management. The results were varied, with a significant proportion having moderate knowledge and only a minority demonstrating a superior understanding.



Figure 4. Familiarity with the concept of solid waste management

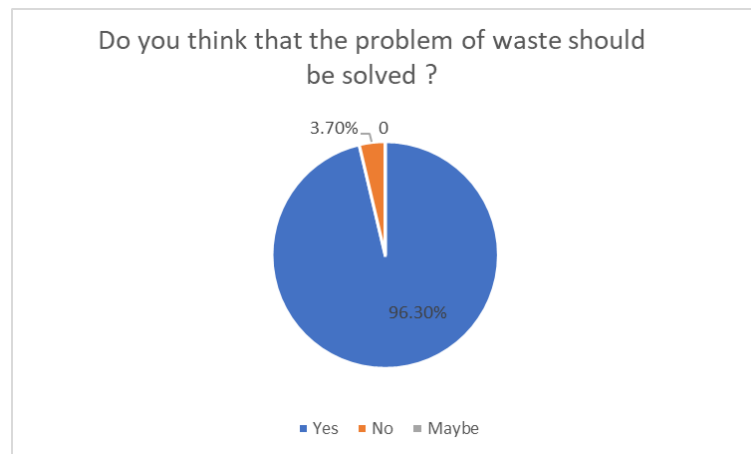


Figure 3. Importance of solving solid waste issues

Subsequently, the survey investigated the level of awareness among participants regarding the sustainable development goals that An-Najah University has adopted, revealing a mix of affirmative, negative, and uncertain responses. Following this, participants were asked about their comprehension of waste classification principles, with the majority indicating a positive understanding. Subsequently, the survey investigated the level of awareness among participants regarding the sustainable development goals that An-Najah University has adopted, revealing a mix of affirmative, negative, and uncertain responses. Following this, participants were asked about their comprehension of waste classification principles, with the majority indicating a positive understanding.

Have you ever heard about SDGs?

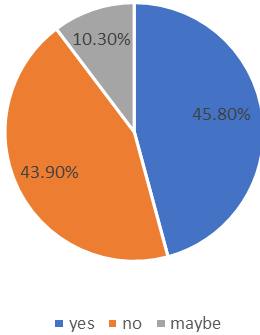


Figure 6. Knowledge of SDGs

Do you know the concept of waste separation?

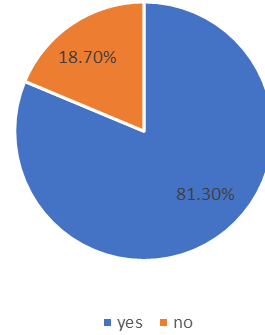


Figure 5. Knowledge of solid waste sorting

The survey also sought to determine their familiarity with waste reduction techniques, and while a small proportion of respondents showed both knowledge and interest in reducing waste, the majority showed minimal interest or concern.

Do you know how the waste can be reduced?

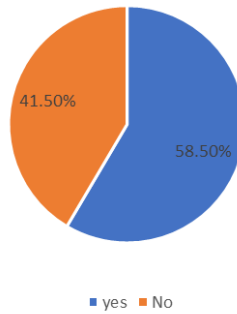


Figure 7. Participants' familiarity with waste reduction techniques

The participants were asked about their knowledge regarding the disposal destination of waste subsequent to collection. The majority of respondents disclosed that waste is conveyed to landfills, while some were split between recycling and incineration as disposal options. In order to assess their level of environmental awareness, the survey included questions regarding the participants' understanding of the negative consequences of solid waste disposal. The

participants' responses demonstrated their awareness of the issue, with several citing global warming and groundwater contamination as examples to illustrate their knowledge.

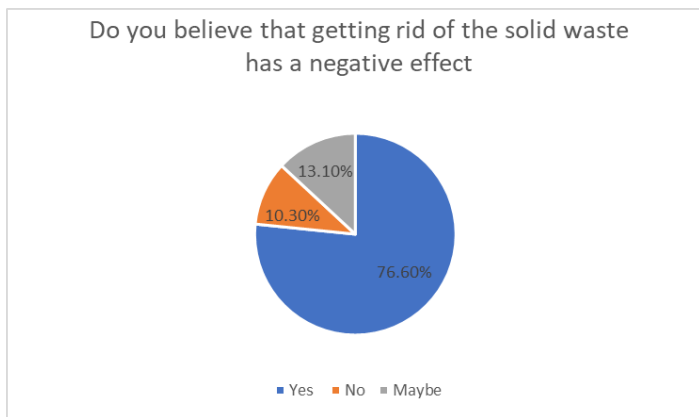


Figure 9. Understanding of the negative consequences of solid waste disposal

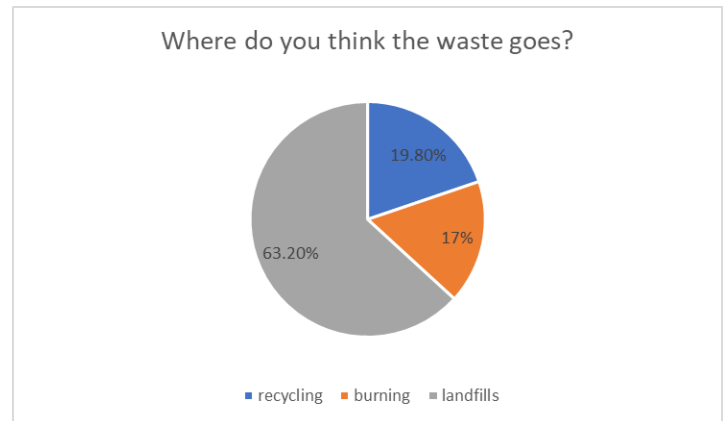


Figure 8. the disposal destination of waste subsequent to collection

The survey included questions about participants' attitudes towards waste sorting, with the majority indicating a willingness to participate. However, participants reported that the lack of support, incentives, and programs for waste sorting discouraged their involvement, as the sorted waste was often not properly disposed of. The survey also inquired about participants' recycling habits, with a majority stating that they did not engage in recycling due to limited knowledge on the topic.

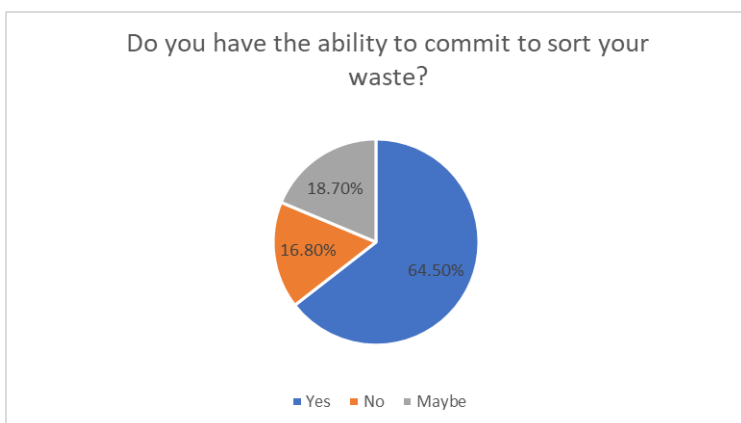


Figure 10. Participants' attitudes towards waste sorting

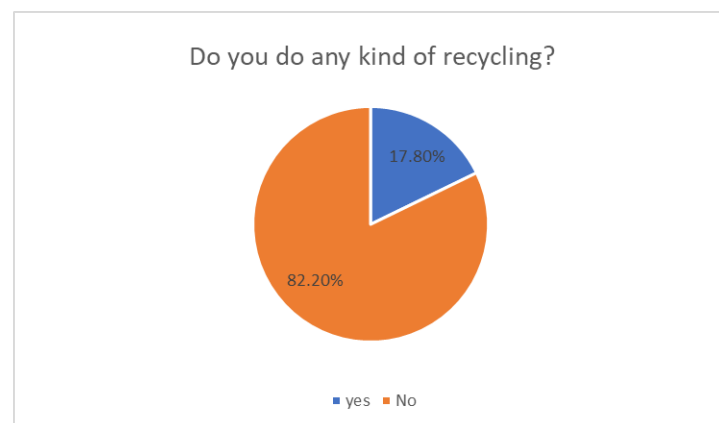


Figure 11. Participants' recycling habits

At the outset, participants were asked about their inclination towards using recycled products. The majority responded positively, while a minority had a negative view. A significant number indicated that their decision would depend on the quality of the product. After that, they were asked about their familiarity with using recycled items, such as plastic and cardboard cups. The majority confirmed their awareness of such products, but some were surprised and stated that they were unaware. Moreover, a few participants mentioned that they had stopped using certain products upon becoming aware of the issue.

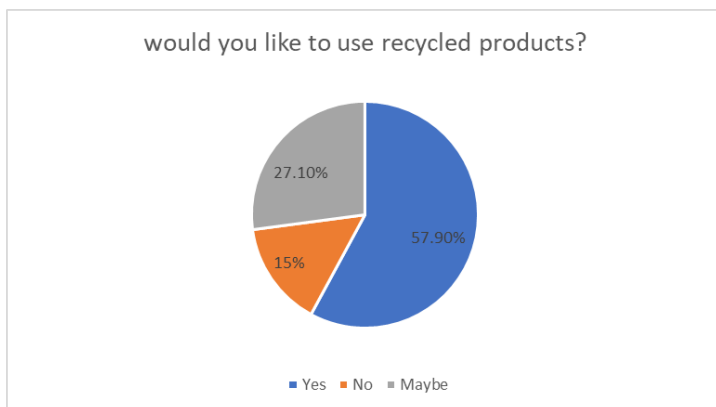


Figure 13. Inclination towards using recycled products

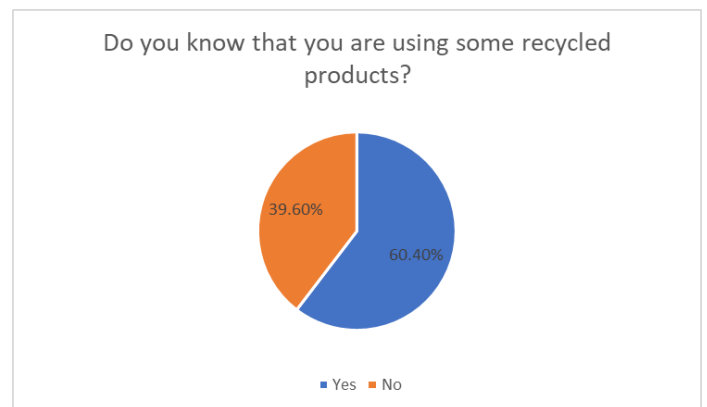


Figure 12. Participants' familiarity with using recycled items

In Palestine, the daily per capita waste production averages at 0.9 Kg. Participants were asked to estimate their daily per capita waste production, with responses ranging mostly from 0.5 to 1 Kg. However, a minority of participants believed their waste production to be less than 0.5 Kg or more than 1 Kg.

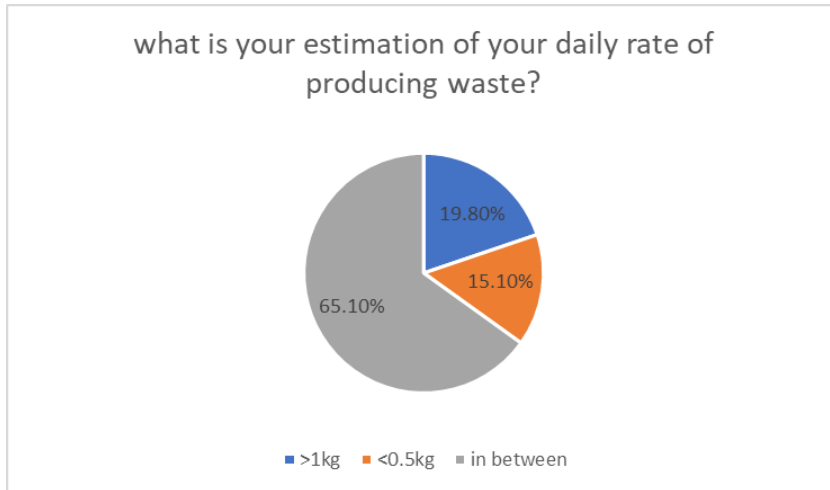


Figure 14. Participants' estimation of their daily per capita waste production

Additionally, participants were queried about their responsibility as university students to manage waste. The majority recognized their obligation to properly dispose of waste, emphasizing the significance of doing so to support the cleaning staff and uphold the campus's cleanliness and aesthetic appeal.

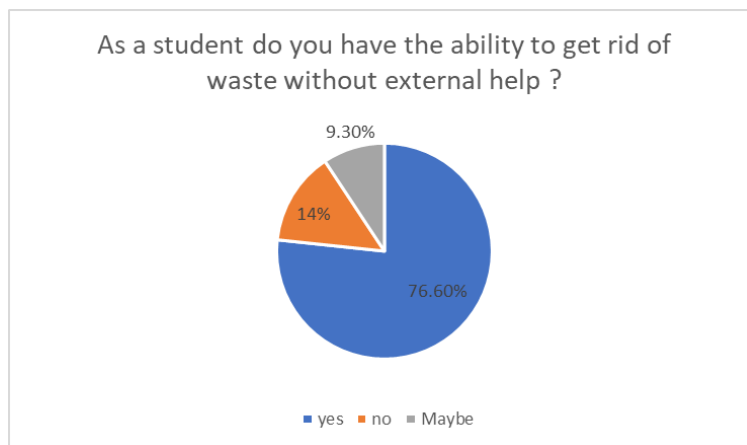


Figure 15. Participants' responsibility as university students to manage waste

To investigate the consumption habits of students in the cafeteria, an inquiry was conducted to determine the predominant materials used. The findings revealed that plastic, paper, and cardboard were the most frequently used materials, as illustrated in the figure.

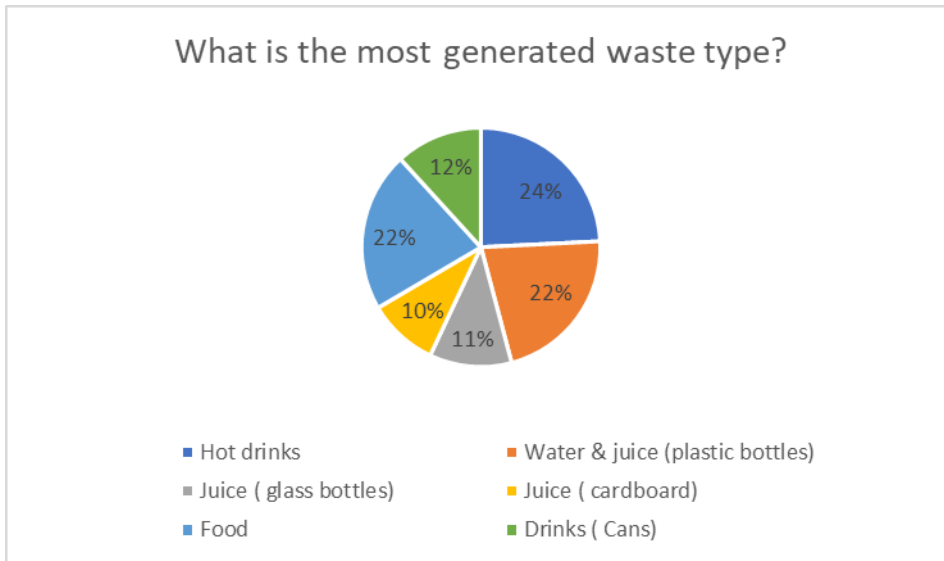


Figure 16. The most frequently used materials in cafeteria

In order to assess the cleanliness of the cafeteria, opinions were solicited from respondents regarding their overall perception. A considerable number of respondents viewed the cafeteria as being moderately clean. However, a group of respondents were divided in their assessment, with some labeling it as clean while others labeled it as unclean based on specific behaviors or scenes.

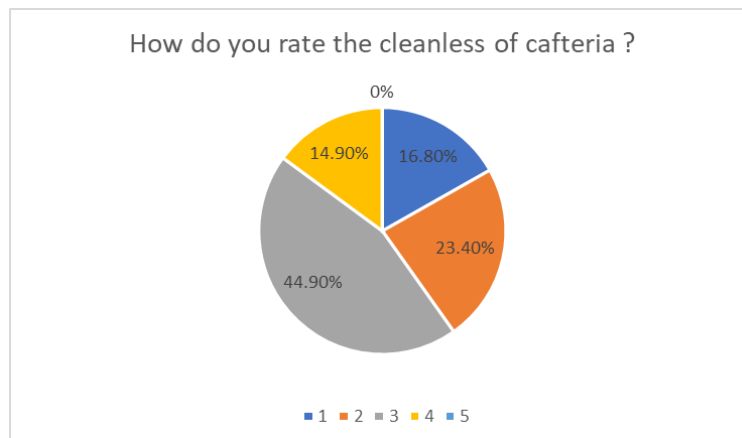


Figure 17. The cleanliness of the cafeteria

As a starting point for our initiative, we inquired about their willingness to sort their waste and dispose of each type in its respective container. The majority showed a strong willingness to participate, with equal percentages agreeing and strongly agreeing. Only a small percentage refused to sort out their waste.

The survey included questions regarding respondents' support for the implementation of sorting containers in various areas of the university. The majority expressed strong agreement with the need for these containers, citing their ability to increase awareness among students and the wider community and promote similar initiatives beyond the university.

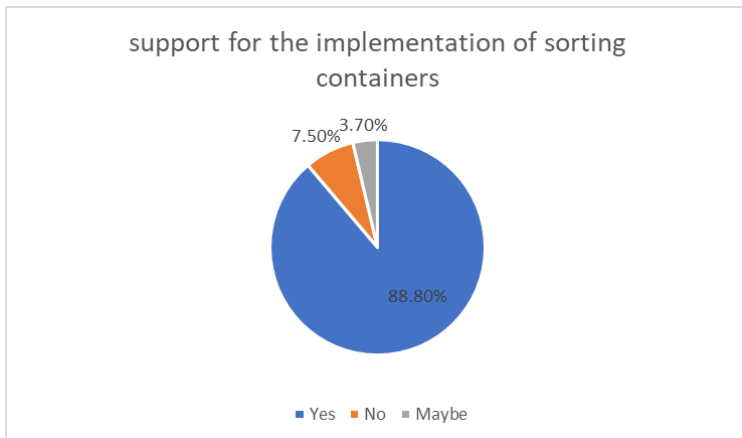


Figure 18. Respondents' support for the implementation of sorting containers in various areas of the university

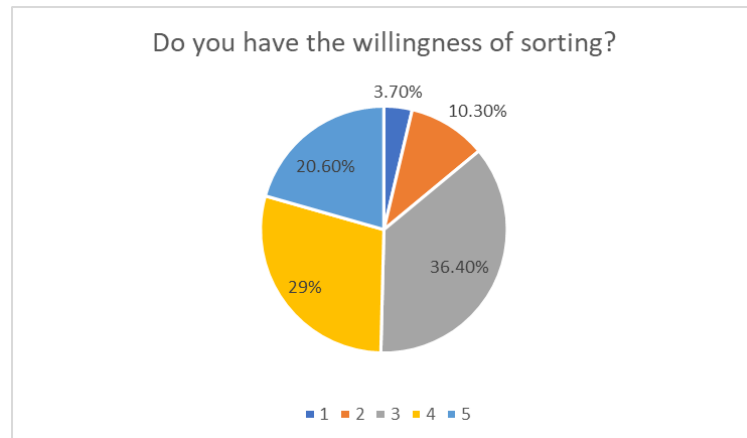


Figure 19. Respondents' willingness of sorting

Furthermore, it was found that a significant proportion of participants held the belief that the adoption of sustainability initiatives, such as waste recycling or the sale of sorted waste, could yield financial gains for the university, albeit modest, while also generating positive environmental outcomes over an extended period.

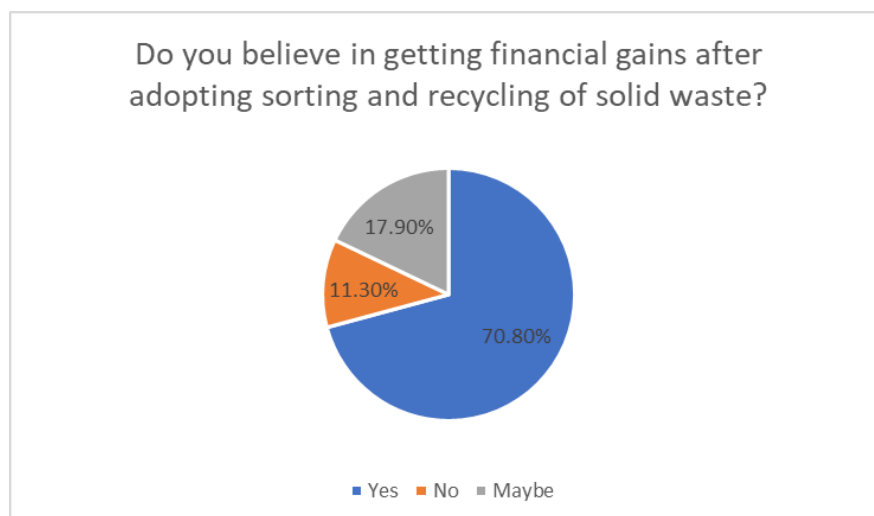


Figure 20. Participants belief in getting financial gains after adopting sorting and recycling of solid waste

The majority of surveyed university students demonstrate an understanding of the significance of proper waste management and express willingness to take part in waste sorting initiatives. However, the absence of incentives, strategies, and benefits for waste reduction and sorting, coupled with insufficient knowledge about recycling, deters students from engaging in such activities. Addressing these concerns and providing educational resources is crucial in encouraging students to participate in waste reduction and recycling initiatives. In addition, the survey highlights the necessity of implementing initiatives within the university, such as the installation of sorting containers, to promote environmental awareness and create a positive impact on the university community and beyond. Overall, the survey presents valuable insights that can inform the development of effective waste management and recycling programs at the university level.

4.2 Quantity Surveying Analysis

4.2.1 Mixed waste quantity surveying

The weight of mixed waste containers in the university cafeteria was measured over a period of fifteen days, and the resulting data was analyzed to determine the average quantity of waste generated per day.

The findings indicated that the daily average amount of mixed waste generated in the cafeteria was 152.0 Kg/day, thereby highlighting the magnitude of waste production in this particular setting. The data collected offers valuable insights into the nature and volume of waste produced in the cafeteria, which can inform the development of effective waste management strategies. By obtaining a better understanding of the waste generation patterns in this setting, it may be possible to identify areas where waste reduction and recycling initiatives can be implemented to minimize the environmental impact of this waste.

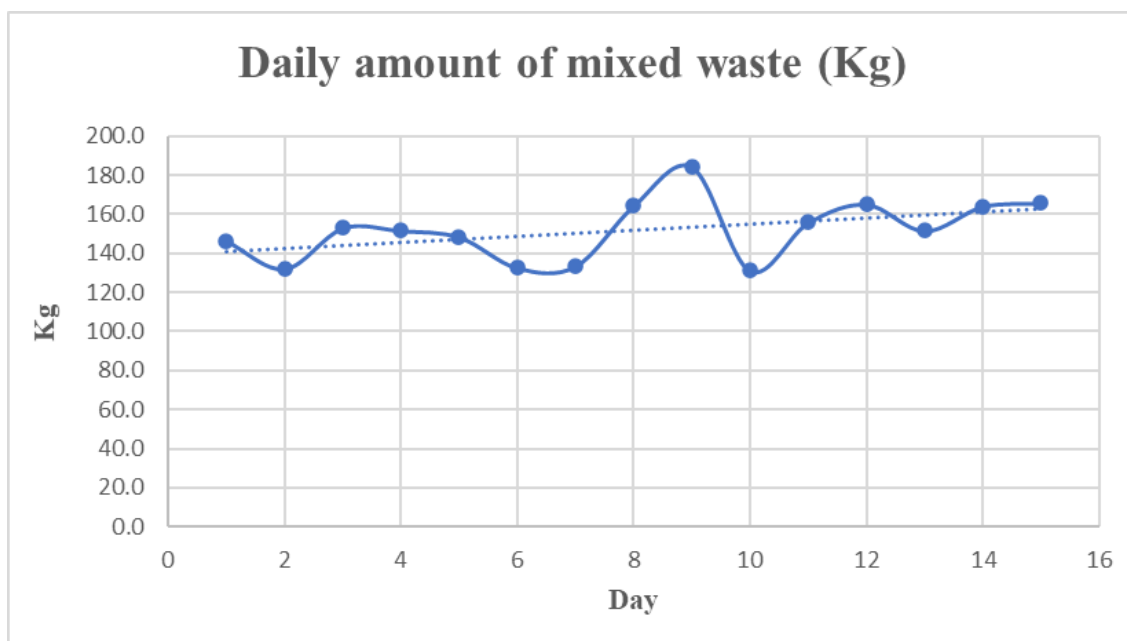


Figure 21. Trend line of daily amount of mixed waste

Table 1. Quantity of mixed waste in Kg

	Quantity of mixed waste (Kg)														
	day 1	day 2	day 3	day 4	day 5	day 6	day 7	day 8	day 9	day 10	day 11	day 12	day 13	day 14	day 15
	11.6	8.1	13.4	9.3	12.1	8.6	10.8	7.5	7.8	7.1	9.5	11.8	10.5	13.2	12.8
	12.3	11.6	7.7	13.1	8.6	13.4	8.6	9.2	9.1	9.8	7.2	6.7	15.1	8.3	10.9
	9.1	10.0	9.0	7.1	10.1	11.0	9.5	12.8	12.6	12.1	13.7	15.2	10.2	11.6	13.6
	9.2	13.0	5.1	10.3	11.0	9.6	12.5	10.5	10.2	13.2	12.8	9.3	14.3	6.5	8.9
	12.3	7.4	14.2	8.7	5.7	12.3	13.8	13.3	13.6	10.8	10.1	7.6	12.1	14.7	11.7
	6.6	9.5	6.8	11.2	7.8	10.5	6.9	8.6	8.7	8.3	11.3	13.1	9.1	15.8	6.2
	7.8	11.3	8.3	7.5	7.9	7.5	7.6	11.7	11.5	11.6	8.8	8.6	6.8	8.1	14.3
	8.4	13.0	12.0	7.3	11.3	7.4	6.0	6.2	6.8	6.5	14.5	10.4	13.6	13.1	15.4
	10.6	12.1	11.6	9.4	13.5	8.0	11.3	14.2	14.3	14.7	6.6	9.2	7.1	7.2	8.4
	14.1	9.9	9.7	10.2	9.2	7.0	9.8	15.4	15.1	15.8	10.6	14.6	8.7	9.5	13.9
	12.1	8.8	10.8	10.0	13.6	10.2	9.1	14.2	16.7	8.1	13.8	7.3	7.8	12.1	10.6
	13.2	7.0	8.6	12.0	8.9	8.7	7.6	8.8	12.8	13.1	6.6	8.6	14.5	13.2	7.1
	10.8	10.3	9.5	8.4	11.7	11.2	10.2	8.3	10.9		10.3	9.5	15.6	10.8	9.3
	8.3		12.5	11.0	6.2	7.2	9.7	12.0	13.6		8.7	12.5	6.1	8.3	12.4
			13.8	7.8	10.8			11.6	8.9		11.2	13.8		11.6	10.3
				8.2					11.7			6.9			
Summation (Kg)	146.4	132.1	153.0	151.6	148.4	132.5	133.4	164.3	184.3	131.1	155.7	165.1	151.5	164.0	165.8
Total quantity (Kg)	2279.3														
Average Kg per day	152.0														

4.2.2 Separated waste quantity surveying

To determine the proportions and quantities of different waste categories in the university cafeteria, a methodical approach was adopted. First, the waste was observed and the cafeteria administrator was consulted to identify the most frequently consumed items. Based on this information, the waste was separated into five main categories: glass, metal, cardboard, plastic, and organic. Over a period of 15 days, separate containers were provided for each category and the weight of the waste in each container was measured at the end of each day. After gathering the data, adjustments were made, and the information was analyzed.

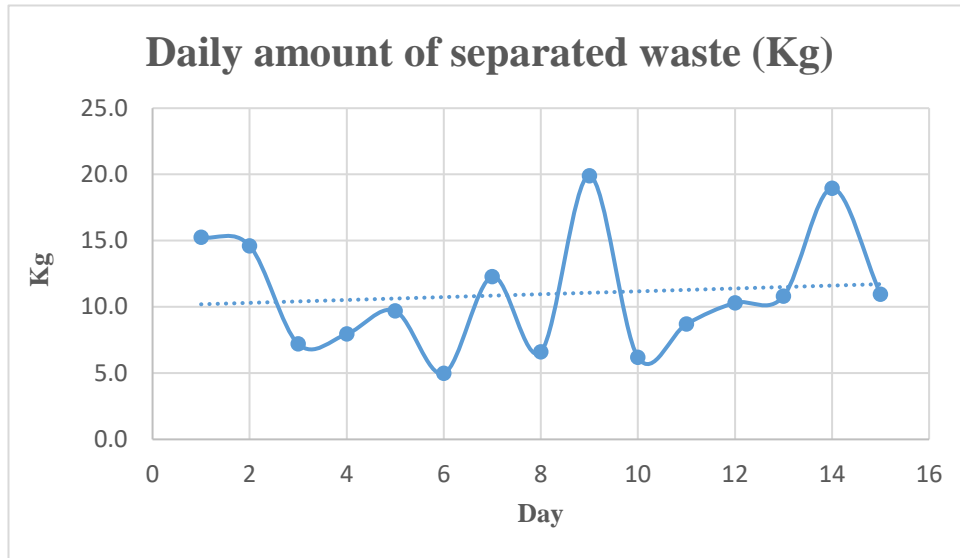


Figure 22. Trendline of daily amount of separated waste

Table 2. Quantity of separated waste in Kg

Day	Quantity of separated waste (Kg)					Total quantity (Kg)	
	Glass	Cardboard	Metal	Organic	Plastic		
1	2.7	4.2	1.1	2.3	5.0	15.3	
2	2.7	3.8	1.7	4.9	1.5	14.6	
3	1.4	1.7	0.7	2.3	1.2	7.2	
4	0.9	2.5	0.9	1.4	2.3	8.0	
5	3.5	3.2	1.1	1.5	0.4	9.7	
6	0.3	0.4	2.4	1.5	0.4	5.0	
7	2.1	3.8	1.2	3.1	2.1	12.3	
8	0.8	0.8	2.1	2.6	0.3	6.6	
9	5.0	4.8	3.6	5.4	1.1	19.9	
10	1.2	2.4	1.2	1.0	0.4	6.2	
11	1.6	1.6	1.4	1.9	2.2	8.7	
12	2.0	2.7	1.6	2.5	1.5	10.3	
13	2.7	1.7	2.0	2.3	2.1	10.8	
14	9.4	2.5	2.4	2.2	2.4	18.9	
15	2.6	2.6	1.7	2.5	1.6	11.0	
Toatal quantity (Kg)		38.8	38.6	25.0	37.3	24.6	164.4
Average Kg per day		2.6	2.6	1.7	2.5	1.6	11.0
Percentage of each separated type		23.5%	23.4%	15.1%	22.6%	14.9%	99.6%
Predicted quantity for every waste type for a semester (Kg)		207.1	205.9	133.2	199.1	131.3	876.6
Predicted quantity of waste type for a semester if the total amount was seperated (Kg)		3067.1	3049.8	1972.0	2949.2	1944.7	12982.8
Percentage of separation		6.7%					

The results revealed that the average percentages of the different waste categories were 23.5% for glass, 23.4% for cardboard, 15.1% for metal, 14.9% for plastic, and 22.6% for organic. Furthermore, by applying mathematical equations to the data, it was determined that the average daily quantity of waste generated in the university cafeteria was 11.0 kg per day and that the percentage of separation is 6.7%. This systematic approach to waste analysis provides valuable information for the development of effective waste management and reduction strategies.

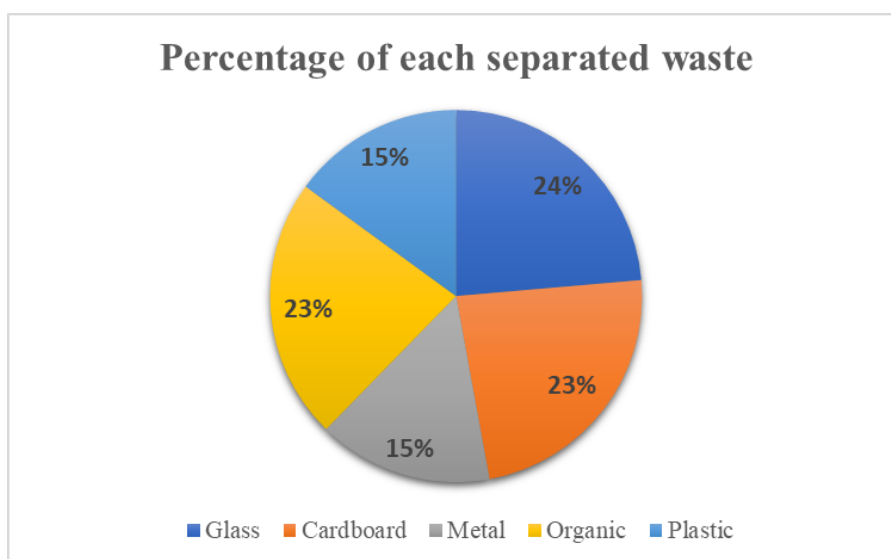


Figure 23. Percentage of each separated waste

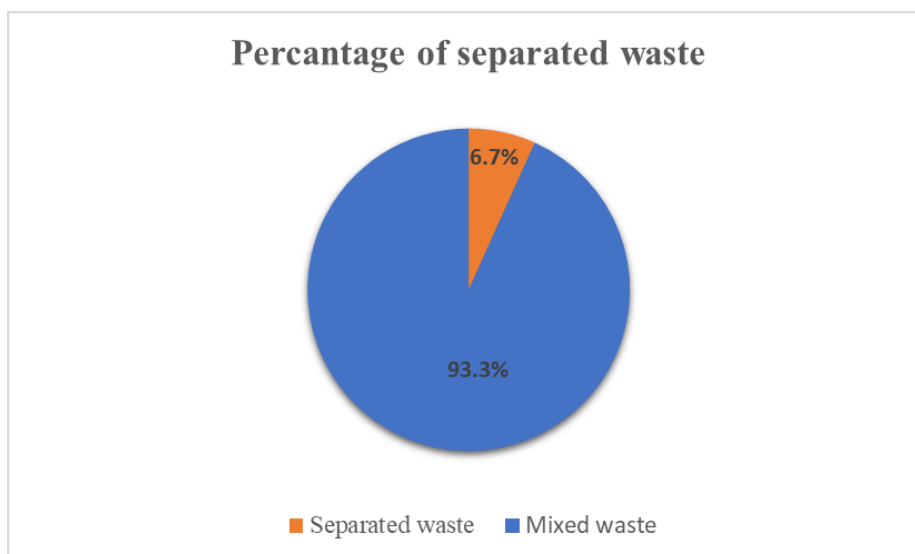


Figure 24. Percentage of separated waste to mixed waste

4.2.3 Prediction of waste quantities for a semester

To predict the quantity of waste generated during a semester, an estimation was made based on the assumption that the semester would consist of 80 working days. The quantity per day for each waste category was then determined and multiplied by the total number of working days to arrive at an estimated quantity of waste for the semester. The results of this analysis showed that an estimated 207.1 Kg of glass waste, 205.9 Kg of cardboard waste, 133.2 Kg of metal waste, 131.3 Kg of plastic waste, and 199.1 Kg of organic waste would be generated, resulting in a total of 1195.4 Kg of waste.

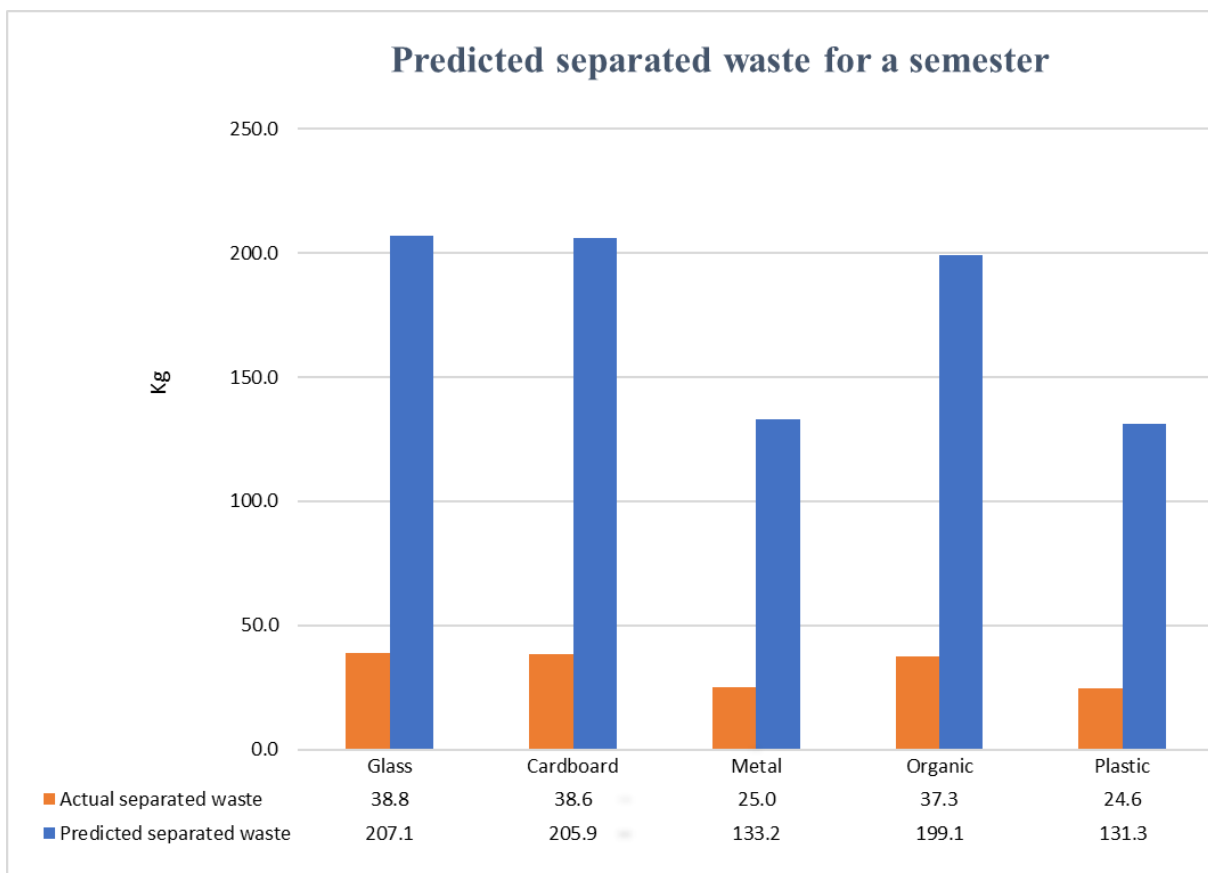


Figure 25. Comparison between actual separated waste and predicted separated waste

4.2.4 Projection of semester waste amounts assuming complete waste separation

Furthermore, an additional estimation was made to predict the quantity of waste for each waste type for the semester. It was assumed that the total amount of waste generated from mixed and separated waste sources would be collected in the separation container. The analysis showed that an estimated 3067.1 Kg of glass waste, 3049.8 Kg of cardboard waste, 1972.0 Kg of metal waste, 1944.7 Kg of plastic waste, and 2949.2 Kg of organic waste would be generated, resulting in a total of 12982.8 Kg of waste for the semester. By estimating the quantity of waste generated for each waste type, it becomes easier to develop and implement effective waste management strategies to promote sustainability.

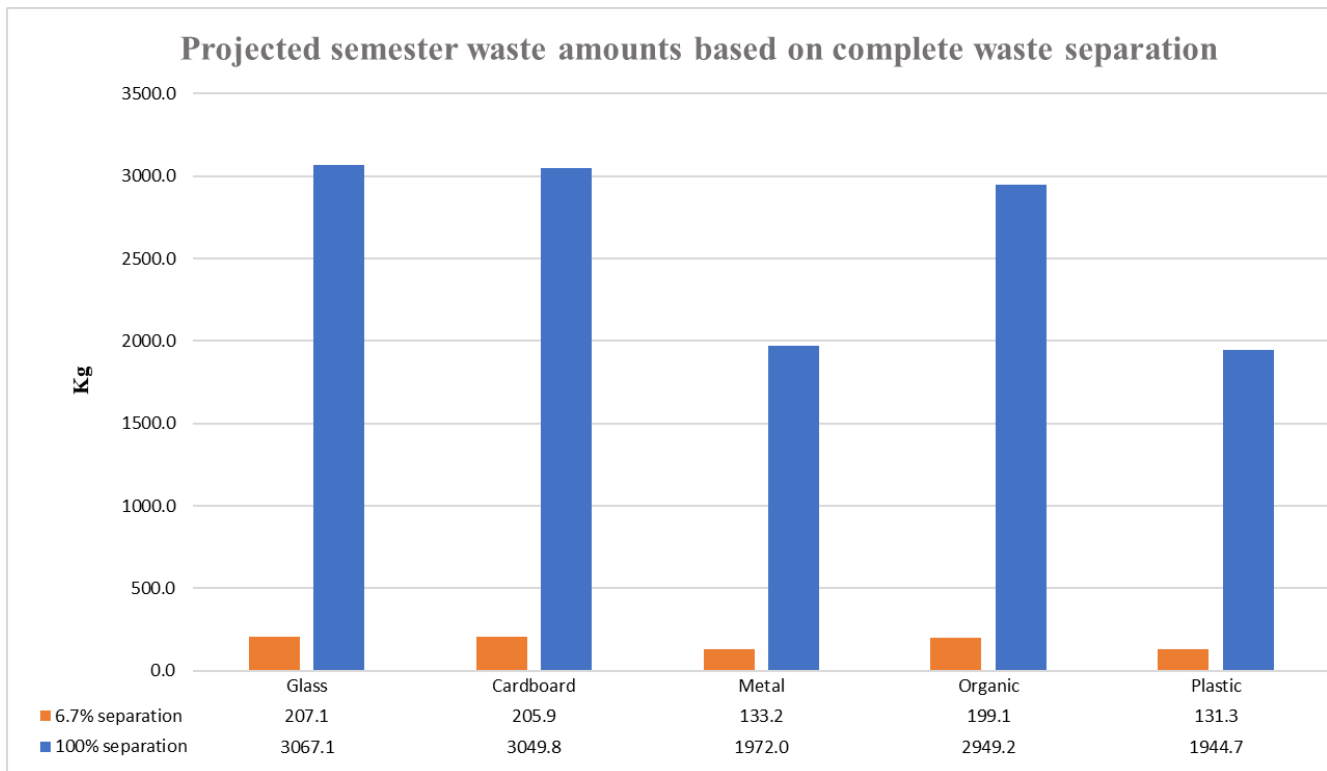


Figure 26. Comparison between 6.7% separation waste quantities and 100% projected separation quantities

4.2.5 Revenue estimation

A detailed analysis of revenue generation from waste recycling has been conducted. By multiplying the quantities of waste with the respective unit prices obtained from the local market, the expected revenue for a semester has been projected. The findings indicate that the anticipated revenue for glass, cardboard, metal, and plastic stands at 2480 NIS, 300 NIS, 26700 NIS, and 11400 NIS, respectively. Notably, no revenue is projected for organic waste. Consequently, the total revenue projected for a semester amounts to 40880 NIS. Furthermore, considering the academic year consisting of two semesters and a summer semester (equivalent to 2.5 semesters), the expected revenue for the entire year reaches 102200 NIS.

The obtained revenue figures provide valuable insights into the potential financial gains of waste recycling initiatives at An-Najah National University. It is noteworthy that the revenue generated from recycling varies across different waste categories, with metals yielding the highest return, followed by plastics, glass, and cardboard. However, it is important to emphasize that the absence of revenue projection for organic waste suggests the need for alternative waste management strategies, such as composting or utilization for energy generation, to unlock potential economic benefits. By leveraging these findings, the university can make informed decisions to optimize waste management practices, enhance sustainability efforts, and potentially allocate generated revenue towards further environmental initiatives on campus.

Table 3. Expected Revenue

Revenue					
Waste category	Glass	Cardboard	Metal	Organic	Plastic
Total quantity (ton) for a semester	3.1	3.0	2.0	2.9	1.9
Price/ton (NIS/ton)	800	100	13,350	0	6,000
Revenue (NIS)	2,480	300	26,700	0	11,400
Grand Total for a semester (NIS)					40,880
Grand Total for a year (NIS)					102,200

4.2.6 Initial capital cost estimation

A thorough assessment of the initial capital cost has been carried out; the findings revealed a requirement for the installation of 11 indoor integrated containers to replace the existing ones. By multiplying this quantity with the corresponding market price, the estimated total cost for these containers amounts to 11000 NIS. Additionally, it was identified that the project necessitates the addition of 4 outdoor containers. After multiplying this quantity with the relevant market price, the projected total cost for these containers reaches 20000 NIS. Consequently, the cumulative capital cost for the project is determined to be 31000 NIS.

Table 4. Initial capital cost

Initial Capital Cost			
Item name	Quantity	Price/unit (NIS)	Total (NIS)
Indoor intergated container	11	1,000	11,000
Outdoor large container	4	5,000	20,000
Grand Total (NIS)			31,000

4.2.7 Potential savings

An evaluation of the potential savings has been conducted. The estimated savings are derived from the cost of waste disposal, taking into consideration the deduction of the cost associated with organic waste disposal. According to information gathered from the services administrative staff, the cost of waste disposal is determined to be 250 NIS per occurrence. Considering that waste is disposed of three times a week, the cost is multiplied by 3. Additionally, factoring in the duration of 16 weeks for each semester and a total of 2.5 semesters, the calculation is performed. Based on the percentage breakdown of different waste types and deducting the proportionate share of organic waste (multiplied by 0.774), the total estimated savings per year amount to 23,220 NIS.

These projected savings reflect the potential cost reductions that can be achieved through efficient waste management practices. By implementing sustainable waste disposal strategies and reducing the amount of waste requiring external disposal, An-Najah National University can significantly minimize the associated expenses. The substantial annual savings of 23,220 NIS serve as an incentive for the university to prioritize sustainable waste management, further reinforcing its commitment to environmental responsibility and financial efficiency.

Table 5. Savings

Savings	
Waste disposal cost for a semester (NIS)	9,288
Waste disposal cost for a year (NIS)	23,220

4.2.8 Expenses estimation

In terms of expenses, various factors have been taken into account in the research project on sustainable Solid Waste Management at An-Najah National University. These anticipated expenses encompass different aspects, as outlined below:

1. Trash bags: The estimated expenditure for trash bags over a year is approximately 10,000 NIS. This cost is associated with procuring an adequate supply of bags to facilitate waste collection and disposal processes.
2. Annual allocation for direct labor cost: Assuming a salary of 2500 NIS for each employee, the calculation involves considering an additional 1 hour of work per day, which accounts for 1/8th of their daily salary. By multiplying this amount by 12 months and considering 2 employees, the total annual labor cost is projected to be 7500 NIS.
3. Depreciation of outdoor large containers: The depreciation rate for the outdoor large containers, set at 10%, is applied to their initial cost of 5000 NIS. With a total of 4 containers, the projected annual depreciation cost is estimated to be 2000 NIS.

4. Depreciation of indoor integrated containers: The indoor integrated containers, with a depreciation rate of 20%, are valued at 11,000 NIS. Multiplying this cost by the depreciation rate yields an estimated annual depreciation cost of 2200 NIS.
5. Annual maintenance: An expected expense of 5000 NIS has been allocated for annual maintenance activities, ensuring the proper functioning and upkeep of the waste management infrastructure.

Combining these expense components, the total projected expenses amount to 26,700 NIS. These calculations provide valuable insights into the financial obligations associated with implementing sustainable waste management practices at An-Najah National University. By considering and budgeting for these expenses, the university can effectively allocate resources and ensure the smooth operation of its waste management systems while maintaining a commitment to sustainability.

Table 6. Expenses

Expenses	
Trash bag expenses for a year	10,000
Annual allocation for direct labor cost	7,500
Depreciation of outdoor large container for 10 years	2,000
Depreciation of indoor integrated container for 5 years	2,200
Annual maintenance expenses	5,000
Total for a year (NIS)	26,700

4.2.9 Project's feasibility estimation

To apply the present worth analysis based on the given data, we can use the following equation:

$$P = A * [(1 + i)^n - 1] / [i * (1 + i)^n] - \text{Capital cost}$$

Where: P is the present worth value A is the net annual cash flow (revenue - expenses + savings)
i is the interest rate or rate of return n is the number of years

Using the provided values: A = 98,720 NIS (Revenue - expenses + savings) Capital Cost = 31,000 NIS i = 5% (0.05) n = 5 years

Let's calculate the present worth value (P):

$$P = 98,720 * [(1 + 0.05)^5 - 1] / [0.05 * (1 + 0.05)^5] - 31,000$$

P is approximately equal to 396,400 NIS

Table 7. Project's feasibility

Brief Project Feasibility	
Initial Capital (NIS)	31,000
Revenue (NIS)	102,200
Savings (NIS)	23,220
Expenses (NIS)	26,700
Interest Rate	5%
Lifespan Cycle	5
Present Worth Value (NIS)	396,400

4.2.10 Project's environmental assessment

According to Rabl et al. (2008), the study estimated the environmental damage cost associated with solid waste to be 45 NIS per ton.

Based on the provided information, the total environmental damage cost. Assuming a waste generation of 32.5 tons annually, the cumulative environmental and health damage cost is determined by multiplying the waste generation (32.5 tons) by the environmental and health damage cost per ton (45 NIS).

Thus, the total environmental damage cost amounts to 1462.5 NIS.

5. RESULTS AND FINIDINGS

5.1 Questionnaire Findings

The questionnaire analysis provided valuable insights into the awareness, attitudes, and behaviors of university students towards solid waste management. Respondents acknowledged solid waste as a pressing concern, with a majority facing waste-related difficulties in their surroundings. However, only a minority demonstrated a superior understanding of waste management concepts, while a significant proportion had moderate knowledge.

Participants showed a positive comprehension of waste classification principles and a willingness to participate in waste sorting. However, the lack of incentives, methods, or benefits for waste classification made them less likely to engage in sorting activities. Waste reduction techniques and recycling practices received limited interest or concern among the majority of participants.

The survey revealed that the disposal destination of waste after collection was primarily landfills according to the majority of respondents. This indicates the need for better communication and education on proper waste disposal methods, such as recycling and incineration.

The cafeteria's waste separation rate was found to be 6.7%, indicating room for improvement in waste sorting practices. While students expressed willingness to sort their waste, the lack of support, incentives, and proper disposal methods discouraged their involvement.

Positive attitudes towards using recycled products were observed among the participants, although limited knowledge hindered their adoption. Educational campaigns and resources are necessary to promote the availability and benefits of recycled items and increase their usage.

Participants recognized their responsibility as university students to properly dispose of waste, supporting the cleaning staff and upholding the campus's cleanliness and aesthetic appeal.

In conclusion, the questionnaire analysis highlights the need for addressing knowledge gaps, providing incentives, and improving waste management infrastructure. It is essential to

promote awareness, increase waste separation rates, and foster a culture of sustainable practices among university students. By implementing effective waste management strategies, the university can contribute to pollution reduction, resource conservation, and improved health outcomes in alignment with sustainable development goals.

5.2 Economical Aspects

After conducting a thorough data analysis, the results revealed significant insights regarding the economic aspects of the project. The projected revenue from the implementation of the waste management system is estimated to be 102,200 NIS annually. This revenue is derived from the sale of various waste types, such as glass, cardboard, plastic, and metal. The exclusion of organic waste from the selling aspect of the research was justified by the absence of a local market price for organic waste and the logistical constraints associated with implementing a composting program, including the need for dedicated space and expertise. Considering these factors, focusing on waste streams with established market demand and economic potential was a more practical approach for the research. By excluding organic waste, the project could realistically assess the financial aspects and prioritize waste streams with immediate economic viability.

Additionally, the analysis indicated potential savings of 23,300 NIS, resulting from reduced waste disposal costs and improved operational efficiency.

The expected revenue of 102,200 NIS is a promising outcome, indicating the potential for financial growth and sustainability. This revenue stream can be further enhanced through the implementation of marketing strategies, exploring new markets for waste materials, and establishing partnerships with recycling companies.

Moreover, the projected savings of 23,300 NIS demonstrate the project's cost-effectiveness. By implementing effective waste management practices, the university can significantly reduce waste disposal expenses, optimize resource utilization, and minimize environmental impact. These savings can be redirected towards other initiatives or reinvested in further enhancing the waste management system.

To evaluate the project's economic feasibility, a present worth analysis was applied. The present worth value of the project was calculated to be 396,400 NIS. This analysis takes into account the project's capital cost, expenses, and potential revenue over a specified time frame. An interest rate of 5% was used to determine the present value of future cash flows associated with the project.

A positive present worth value suggests that the project has the potential to generate a favorable return on investment over its lifespan of 5 years. It indicates that the project is financially feasible and has the potential to provide a net positive cash flow.

However, it's important to consider other factors such as potential risks, market conditions, and non-financial aspects before making a final conclusion about the project's feasibility. Additionally, consulting with experts or conducting a more detailed analysis can provide a comprehensive evaluation of the project's viability.

In conclusion, the data analysis revealed promising results in terms of the project's economic aspects, excluding organic waste from revenue calculations. The projected revenue and savings confirm its financial feasibility and cost-effectiveness. These findings support the rationale for implementing the waste management strategy and provide valuable insights for decision-making and policy revisions.

5.3 Environmental Aspects

The results of the study reveal a crucial environmental aspect: the total environmental and health damage cost, which amounts to 1462.5 NIS. This cost serves as an economic measure of the environmental impacts caused by inadequate waste management practices, including pollution, resource depletion, and ecosystem degradation. These findings highlight the significance of responsible waste management in addressing environmental concerns.

Responsible waste management practices play a vital role in reducing pollution, conserving resources, and improving overall health outcomes. By implementing sustainable waste management strategies, such as waste reduction, recycling, and proper disposal, it becomes possible to minimize environmental harm and achieve the goals of sustainable development. These practices align with the principles of a circular economy, emphasizing responsible resource management and promoting long-term environmental sustainability.

The financial implications of inefficient waste management practices cannot be overlooked. Ineffective management not only results in environmental damage but also imposes a significant financial burden on the municipality. By prioritizing sustainable waste management approaches, the municipality can alleviate this burden and enhance cost-effectiveness.

The study underscores the importance of adopting comprehensive and sustainable waste management strategies. By emphasizing waste reduction, promoting recycling initiatives, and ensuring proper disposal methods, it is possible to mitigate environmental damage and achieve long-term sustainability. Implementing these measures not only benefits the environment but also contributes to the well-being of the community by safeguarding public health and preserving valuable resources.

In conclusion, the findings of this study highlight the environmental significance of responsible waste management practices. The economic valuation of the environmental and health damage costs serves as a reminder of the consequences of inadequate waste management. By embracing sustainable waste management strategies, it becomes possible to reduce pollution, conserve resources, and improve overall environmental and health outcomes. These results emphasize the need for collective efforts to prioritize sustainable waste management, ensuring a healthier and more sustainable future for communities and the environment.

6. CONCLUSIONS AND RECOMMENDATIONS

Based on the comprehensive research conducted on sustainable solid waste management at An-Najah National University, the following key recommendations have been identified to guide the university in prioritizing sustainability, environmental considerations, and economic aspects in their waste management practices:

1. Implement a robust waste separation program across the campus, including the cafeteria and other relevant areas, with clear guidelines for proper waste sorting and disposal, emphasizing the separate collection of recyclable materials.
2. Establish a comprehensive recycling program with accessible recycling bins for different types of waste materials, collaborating with local recycling traders for proper collection, processing, and recycling.
3. Invest in suitable containers, collection systems, and disposal facilities designed for different waste categories, strategically placing them to optimize waste collection efficiency and promote adherence to waste separation practices.
4. Foster partnerships and collaboration with local authorities, waste management companies, and stakeholders to facilitate knowledge sharing, access to expertise, and potential funding opportunities, enabling the adoption of best practices and exploration of economic benefits.
5. Promote awareness and education through the incorporation of waste management and environmental education into the university curriculum, organizing awareness campaigns, workshops, seminars, and involving students in social works courses and competitions with prizes.
6. Conduct a detailed cost-benefit analysis to ensure the long-term feasibility and economic viability of the solid waste management project, considering investment costs, operational expenses, potential revenue streams, cost savings, and environmental benefits.
7. Introduce composting systems to manage organic waste effectively, establishing designated areas or facilities for composting and utilizing the compost for campus landscaping or community gardens.

8. Prioritize sustainable procurement practices by including sustainability criteria in procurement policies, favoring products with minimal packaging, recyclable materials, and reduced environmental impact.
9. Continuously monitor and evaluate waste management practices through the establishment of performance metrics and regular waste audits to track progress, identify areas for improvement, and inform decision-making.
10. Support research and innovation in waste management technologies and practices by establishing a dedicated research center or collaborating with external research institutions, exploring emerging technologies and strategies for waste-to-energy conversion, advanced recycling, and waste reduction.

In conclusion, by implementing these recommendations, An-Najah National University can make significant strides in sustainable solid waste management, reducing its environmental footprint, promoting responsible waste disposal, and contributing to the well-being of the campus and the surrounding community. These recommendations align with global sustainability goals and demonstrate the university's commitment to environmental stewardship. It is essential for the university to take proactive measures, engage stakeholders, invest in infrastructure, and foster awareness and education to ensure the long-term success of their sustainable waste management initiatives, setting an example for other institutions and making a lasting impact on environmental preservation for future generations.

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