ANALYSIS OF THE PHYSICAL PROPERTIES OF SOLID WASTE FROM THREE DIFFERENT BUILDINGS.

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A Thesis Paper Submitted to the Department of Civil Engineering, Daffodil International University, in Partial Fulfillment of the Requirements for the Degree of **Bachelor of Science in Civil Engineering.**

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APPROVAL

Towards completing the partially fulfilled requirements of the Bachelor of Science in Civil Engineering degree. This notification certifies that the following students, who are listed below, completed their thesis work on "**Analysis of the physical properties of Solid Waste from three different buildings.**" under my direct supervision in the Department of Civil Engineering at Daffodil International University's Faculty of Engineering.

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This document asserts that, with the exception of sections explicitly citing the contributions of others, the design presented in the thesis report is the product of comprehensive research conducted by the authors under the guidance of Dr. Miah M. Hussainuzzaman, Associate Dean of the Faculty of Engineering and Associate Professor in the Department of Civil Engineering at Daffodil International University. This report has not been submitted to any other university or educational institution for a degree, diploma, or any other qualification.

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DEDICATION

Dedicated

To

Our Parents & All Teacher

ABSTRACT

This study examines the physical characteristics of solid waste—namely moisture content and bulk density—produced in three specific locations at Daffodil International University: the Civil Engineering Building (A1), Yunus Khan Scholar Garden 2 (A2), and Food Court 2 (A3). The study seeks to evaluate the impact of these physical factors on suitable disposal options and to propose location-specific waste management procedures. Waste samples were collected over a ten-day period and analyzed using normal laboratory protocols to ascertain moisture content using oven-drying methods and bulk density based on mass-to-volume ratios.

The results demonstrated considerable diversity among the three locations. A1 produced primarily dry, recyclable trash with an average moisture level of 12.7% and modest bulk density. A2 demonstrated the greatest moisture content (47.7%) and bulk density (194.7 kg/m^3), owing to the substantial quantity of food and organic waste. A3 generated heterogeneous trash characterized by intermediate moisture content and low density, indicative of the impact of food packaging and plastic use.

The research advocates for a zone-specific waste management strategy: recycling for dry academic trash, composting for organic residential waste, and integrated treatment for mixed commercial garbage. This research highlights the significance of defining physical waste characteristics to develop efficient, sustainable, and economical disposal systems in institutional environments. The results demonstrated considerable diversity in the physical composition of garbage and underscored the elevated moisture content as a constraining factor in conventional landfill and open dumping practices. This paper advocates for incineration as a feasible and energy-efficient method for garbage disposal, particularly appropriate for the regulated institutional setting of a university. Incineration provides a sustainable solution to waste management concerns in private institutions by optimizing energy recovery and minimizing landfill reliance. The paper closes with actionable recommendations for the implementation of an incineration-based system and advocates for regulatory assistance to guarantee environmental compliance and energy efficiency.

Keywords: Solid waste, moisture content, bulk density, waste disposal, university campus, composting, recycling, integrated waste management.

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CHAPTER 1

INTRODUCTION

1.1 Background

Solid waste management has emerged as a critical issue in urban and institutional environments due to rising population, consumer trends, and environmental repercussions. Universities, being microcosms of metropolitan settings, produce a varied array of garbage, including organic, plastic, paper, and electronic refuse. Effective waste management necessitates a comprehensive grasp of its physical and chemical characteristics to ascertain the most suitable disposal techniques. Moisture content and bulk density are crucial physical variables that impact waste management decisions.

The moisture content directly influences the appropriateness of trash for several treatment methods, including composting or incineration. Likewise, bulk density is an essential determinant of the efficacy of garbage transportation and the optimization of landfill area. This study aims to assess the moisture content and density of solid waste gathered from various sites inside the Daffodil International University campus to propose suitable disposal methods.

1.2 Problem Statement

Inadequate disposal of solid waste presents considerable environmental and health risks. The absence of a scientific foundation for trash segregation and disposal in private colleges sometimes leads to ineffective management techniques. This study examines waste qualities to develop disposal solutions suited to the individual features of various campus sites.

1.3 Objectives

Here are the thesis objectives:

1) To determine the moisture content and bulk density of solid waste collected from three different university locations.
2) To analyze the composition of waste by components and recommend appropriate waste disposal strategies based on physical properties.

1.4 Scope and Limitations

The study is confined to three areas within Daffodil International University: The Civil Engineering Building (A1), Yunus Khan Scholar Garden 2 (A2), and Food Court 2 (A3). The analysis is limited to physical parameters—moisture content and bulk density—and does not include chemical or biological waste properties.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Solid waste management (SWM) is a cornerstone of environmental sustainability—a fact increasingly evident in densely populated and institutional settings, such as university campuses. With rising consumption patterns, diverse waste compositions, and dwindling landfill capacities, efficient and sustainable waste management solutions are paramount. Waste generation has surged globally due to accelerating urbanization, industrial growth, and population increases. In response, innovative, energy-efficient waste treatment methods are being pursued worldwide.

This chapter presents a detailed and critical literature review of global and local SWM practices. It outlines waste treatment approaches and examines how waste's physical characteristics, particularly moisture content and density, affect treatment efficacy and potential energy recovery. Special emphasis is placed on transitioning toward energy-efficient and sustainable waste-to-energy (WtE) systems.

2.2 Global Perspective on Waste Management

Globally, solid waste management systems have evolved significantly over the last few decades. Developed countries have adopted advanced technologies, including incineration with energy recovery, anaerobic digestion, composting, and recycling. For instance, countries like Sweden, Germany, and Japan incinerate a substantial proportion of municipal solid waste (MSW) to generate electricity and district heating (Wilson et al., 2012).

Solid waste systems have undergone significant evolution globally over the past few decades. High-income nations have embraced technologically advanced systems—such as waste-to-energy incineration, anaerobic digestion, composting, and recycling—while many low-income nations continue relying on landfills and open dumping, beset by policy and financial barriers.

In contrast, many developing nations continue to rely heavily on landfilling, open dumping, and inadequate collection systems due to financial constraints, lack of policy enforcement, and low public awareness. This results in severe environmental pollution and greenhouse gas emissions (UNEP, 2018).

Effective solid waste management (SWM) is a vital issue for nations worldwide, driven by growing urban populations, increased consumption, and rising environmental awareness. The global approach to waste management varies significantly between high-income and low-income countries, based on economic capabilities, governance structures, technological advancements, and environmental priorities.

2.2.1 Developed Countries: Technological Integration and Circular Economy

In sophisticated nations like Sweden, Germany, Japan, and South Korea, waste management systems are meticulously organized, efficient, and reliant on advanced technology. These nations emphasize source reduction, segregation, recycling, and waste-to-energy (WtE) procedures.

- Sweden is a global leader in waste-to-energy incineration. Over 50% of its municipal solid waste is incinerated to generate electricity and district heating, with less than 1% ending up in landfills. The country even imports waste from other nations to fuel its incineration plants (Swedish Waste Management Association, 2020).
- Germany has a recycling rate of 60% attributable to the rigorous enforcement of the “Green Dot” system and enhanced producer responsibility legislation. Waste is segregated at the residential level, with only non-recyclable materials burnt at Waste-to-Energy facilities.
- Japan employs sophisticated incinerators fitted with pollution control mechanisms. garbage segregation is legally required, with several municipalities recognizing as many as 20 distinct garbage types. Organic waste undergoes composting or anaerobic digestion.

These nations adhere to the waste hierarchy principle: reduce, reuse, recycle, recover energy, and discard as a final option. Significantly, they also implement resource recovery and circular economic ideas, regarding trash not only as an issue but as a valuable asset.

2.2.2 Developing Countries: Informality, Challenges, and Opportunities

Conversely, emerging nations encounter several obstacles in attaining efficient waste management. Countries such as India, Bangladesh, Nigeria, and the Philippines have challenges including:

- Inadequate waste collection and transportation
- Unregulated open dumping practices
- Limited recycling infrastructure
- Insufficient public awareness and policy enforcement

India produces more than 150,000 metric **tons** of municipal solid trash per day. A significant amount of material is unsegregated and ultimately deposited in unregulated landfills or open dumps, resulting in leachate pollution and methane emissions. Nevertheless, cities such as Pune and Indore have demonstrated that **decentralized** waste segregation and public-private partnerships may enhance collection efficiency and recycling.

Bangladesh, **characterized** by fast **urbanization** and population expansion, is producing escalating quantities of solid garbage, frequently without a proportional enhancement in management capabilities. Dhaka, for instance, is deficient in sufficient sanitary landfills and continues to depend on open dumping and informal **laborers** for waste segregation. The incorporation of informal garbage collectors into official recycling systems is restricted yet has considerable promise.

Nigeria and other Sub-Saharan African nations have analogous challenges, with fewer than 30% of solid trash being legally collected, while the remainder is either disposed of in water bodies or incinerated in open air, exacerbating air pollution and posing public health hazards (UN-Habitat, 2021).

2.2.3 Informal Sector's Contribution

In several low- and middle-income nations, the informal sector is crucial in garbage recycling and resource recovery. Informal garbage collectors gather, categorize, and sell recyclables, including plastics, paper, and metals, sometimes under inadequate health and safety circumstances. Their contribution, albeit underestimated, alleviates landfill strain and enhances the recycling rate.

Wilson et al. (2009) asserted that incorporating the informal sector into official waste management systems can enhance efficiency, decrease costs, and promote social fairness.

In many lower-income nations, the informal sector is a key recycling engine. Informal collectors recover significant quantities of recyclables like plastics, paper, and metals under hazardous conditions. Research (Wilson et al., 2009) finds that their integration into formal systems can improve collection efficacy, cut costs, and enhance social equity. However, challenges like health risks and lack of recognition remain.

2.2.4 Emerging Trends and Global Commitments

There is a growing global alignment with the United Nations Sustainable Development Goals (SDGs), especially Goal 11 (Sustainable Cities and Communities) and Goal 12 (Responsible Consumption and Production). Countries are investing in:

- Smart waste management utilizing IoT and GIS technologies
- Decentralized composting facilities
- Public-private partnerships in waste-to-energy (WtE) initiatives • Bans and reduction strategies for plastics
- Circular economic frameworks

International initiatives like the Global Waste Management Outlook (UNEP, 2018) and The Global Methane Pledge are urging nations to adopt more sustainable waste management techniques.

Global priorities are increasingly shaped by sustainable development and climate imperatives:

- UN Sustainable Development Goals (SDGs): Notably Goal 11 (sustainable cities) and Goal 12 (responsible production and consumption).

- Smart waste management: Deployment of IoT sensors for bins and GIS for route optimization.

- Decentralized composting: Community- and campus-level installations.
- Waste-to-energy partnerships: Focus on energy recovery systems.
- Plastic bags and single-use policies: Regulatory restrictions gaining traction.
- Circular economy frameworks: Emphasize material reuse, resource recovery, and reduced virgin extraction.
- Global initiatives: The Global Waste Management Outlook (UNEP, 2018) and the Global Methane Pledge promote the best practices and decarbonizing waste systems.

International support has spurred investments in sustainable, scalable SWM technologies in systems ranging from communal to municipal and institutional.

2.3 Waste Management in Bangladesh and University Campuses

In Bangladesh, waste management continues to be a concern, especially in urban and institutional environments. The nation produces over 23,688 tons of solid trash per day (BBS, 2021), with Dhaka contributing nearly 6,000 tons per day. Nonetheless, just around 50% gets collected, and fewer than 10% is processed or recycled.

Universities, being microcosms of urban environments, produce a variety of garbage, including paper, food, plastic, and dangerous laboratory items. Research (Islam et al., 2016; Ahmed et al., 2020) indicates that most Bangladeshi institutions do not possess organized waste segregation or disposal systems. Open dumping and uncontrolled incineration are frequently employed, resulting in environmental deterioration.

2.3.1 National Context

Bangladesh generates roughly 23,688 tonnes of solid waste daily (BBS, 2021), with Dhaka alone contributing around 6,000 tonnes. Yet, only about 50% undergoes official collection, and less than 10% undergoes formal processing or recycling. Informal dumping remains common, as does burning—especially in peri-urban fringe zones.

2.3.2 Institutional Settings: University Campuses

Universities mirror urban societies: diverse campus trash streams—comprising paper, food waste, plastics, and laboratory chemicals—are typical. Studies by (Islam et al.,2016) and (Ahmed et al. ,2020) found that most Bangladeshi universities lack formalized segregation and disposal systems. Open dumping and indiscriminate burning, which cause soil, water, and air contamination, are widespread.

Current SWM at Bangladeshi campuses follows linear, “take-make-dispose” models. Low awareness among stakeholders exacerbates the issue. However, opportunities exist: academic environments are ideal for demonstrative SWM models and for exploring resource recovery systems such as composting, anaerobic digestion, and WtE.

2.4 Classification of Solid Waste

Solid waste can be classified based on source and composition:

1. **Biodegradable Waste:** Food scraps, tissue paper, garden waste.
2. **Recyclable Waste:** Plastic, paper, glass, metal.
3. **Inert Waste:** Construction debris, ash.
4. **Hazardous Waste:** Batteries, chemicals, electronic waste.

University-generated waste generally falls into biodegradable and recyclable categories, with a potential for energy conversion and material recovery.

2.5 Types of Waste Management Systems

Several waste management systems are used worldwide, each with distinct operational mechanisms and environmental impacts:

2.5.1 Landfilling

- It is predominantly observed in low- and middle-income nations.
- Cost-effective yet detrimental to the environment owing to methane emissions and groundwater pollution.
- Not energy-recapturing.

Figure 2.1: Landfills in ASEAN Countries

2.5.2 Composting

- Transforms organic waste into nutrient-dense compost.
- Suitable for food and garden refuse.
- Optimal moisture content for efficient composting is 50–60% (Tchobanoglous et al., 1993).

Figure 2.2: Making and Using Compost in the Garden

2.5.3 Recycling

- Entails the categorization and reprocessing of materials such as plastics, paper, and metals.
- Necessitates public engagement and the provision of clean, dry recyclables for optimal efficacy.

Figure 2.3: Plastics recycles.

2.5.4 Anaerobic Digestion

- A biochemical process that decomposes organic waste anaerobically.
- Generates biogas (methane) and digestate.
- Effective with elevated moisture content (>65%).

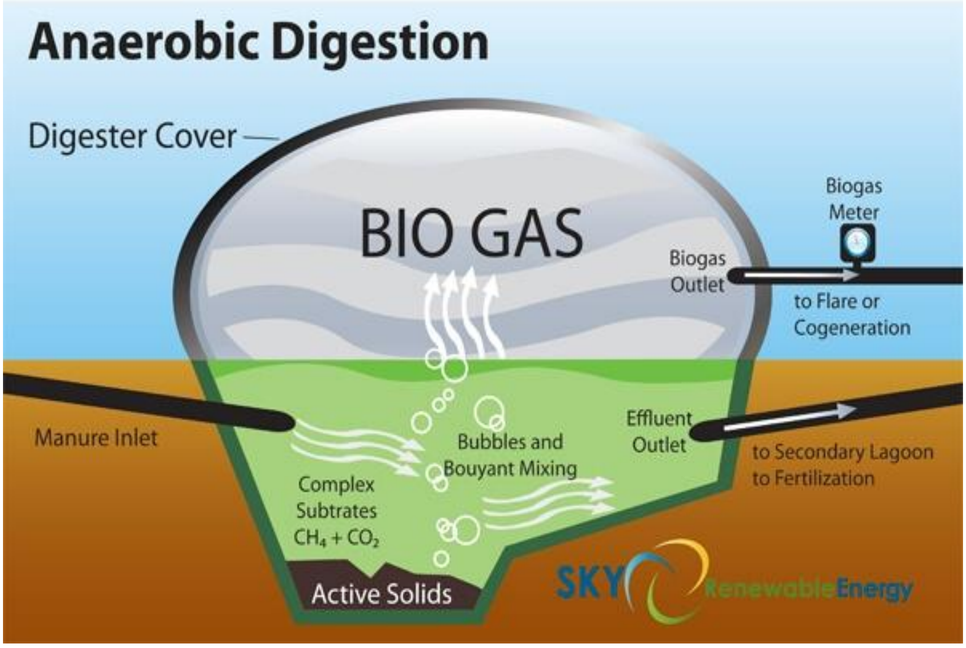

Figure 2.4: Anaerobic Digestions

2.5.5 Incineration

- Combustion of garbage at elevated temperatures to diminish volume and generate heat or power.
- Energy recovery is contingent upon calorific value, which is affected by moisture content and density.
- Countries such as Denmark and Japan generate 20–30% of their urban energy requirements from burned trash (OECD, 2020).

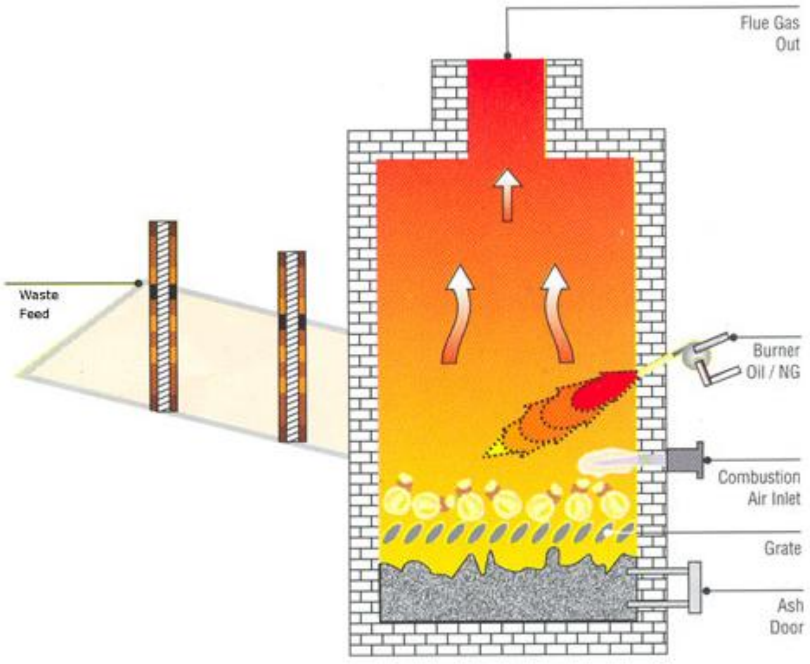

Figure 2.5: A Schematic of Solids Waste Incinerator

2.6 Role of Moisture Content and Density in Waste Management

2.6.1 Moisture Content

The moisture content substantially influences the efficacy of thermal treatment procedures. Elevated moisture content diminishes the calorific value of waste.

- Augment the energy input required for drying during incineration.
- Diminish combustion efficiency and elevate emissions.
- The optimal moisture percentage for incineration is below 30%, but composting and anaerobic digestion are enhanced by elevated moisture levels.

2.6.2 Density

The density influences collection, transportation, and treatment processes.

- High-density garbage facilitates transportation and storage.
- Low-density garbage, such as plastic, consumes greater volume and diminishes transportation efficiency.

- Energy content is negatively correlated with density in instances of high-moisture biodegradable waste.

Consequently, comprehending their physical features aids in selecting suitable waste disposal and energy recovery techniques.

2.7 Energy-Efficient Waste Management Systems

Contemporary waste management must prioritize both disposal and resource recovery. Energy-efficient systems encompass: • trash-to-Energy (WtE) incineration: Transforms high-calorific trash into power.

- Biogas Production: Efficient for moist organic refuse.
- Refuse-Derived Fuel (RDF): Waste is converted into a high-energy pellet fuel utilized in cement or power facilities.

Energy recovery technologies diminish reliance on landfills and enhance the circular economy. In academic environments, this may result in reduced energy expenses and heightened environmental consciousness among students.

2.8 Overview of Literature Deficiencies

Although several studies have examined the composition and amount of university garbage (Alam & Hossain, 2019; Rahman et al., 2022), few have incorporated chemical energy analysis alongside physical attributes such as moisture and density. There are even fewer studies in Bangladesh that have examined energy recovery techniques, such as incineration, in relation to university garbage. This thesis seeks to fill that gap.

CHAPTER 3

METHODOLOGY

3.1 General

This chapter delineates the protocols for waste sampling, moisture content and density measurement, and assessment of the energy content of the collected waste materials. The approach combines field sampling, laboratory analysis, and theoretical calculations to measure the physical and calorific characteristics of trash.

3.2 Methodology

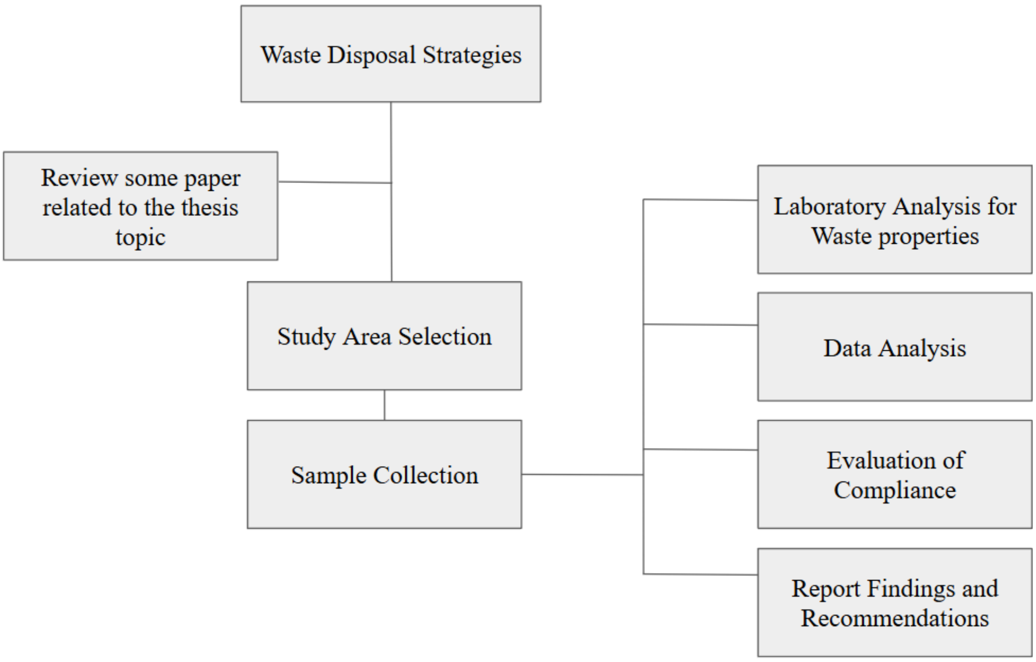

Figure 3.1: Methodology of this thesis.

3.3 Study Area Description

The study was conducted within a Daffodil International University campus, focusing on three distinct zones characterized by different waste generation patterns:

- **A1: Civil Engineering Building** – Represents academic waste primarily composed of paper, tissue, and minor plastic waste.

- **A2: Yunus Khan Scholar Garden 2** – A residential area where food waste, polythene, and organic-rich materials dominate.

- **A3: Food Court 2** – A commercial space generating a mix of food residues and plastic containers.

These locations were selected to represent the major waste-generating sectors of the university: academic, residential, and commercial.

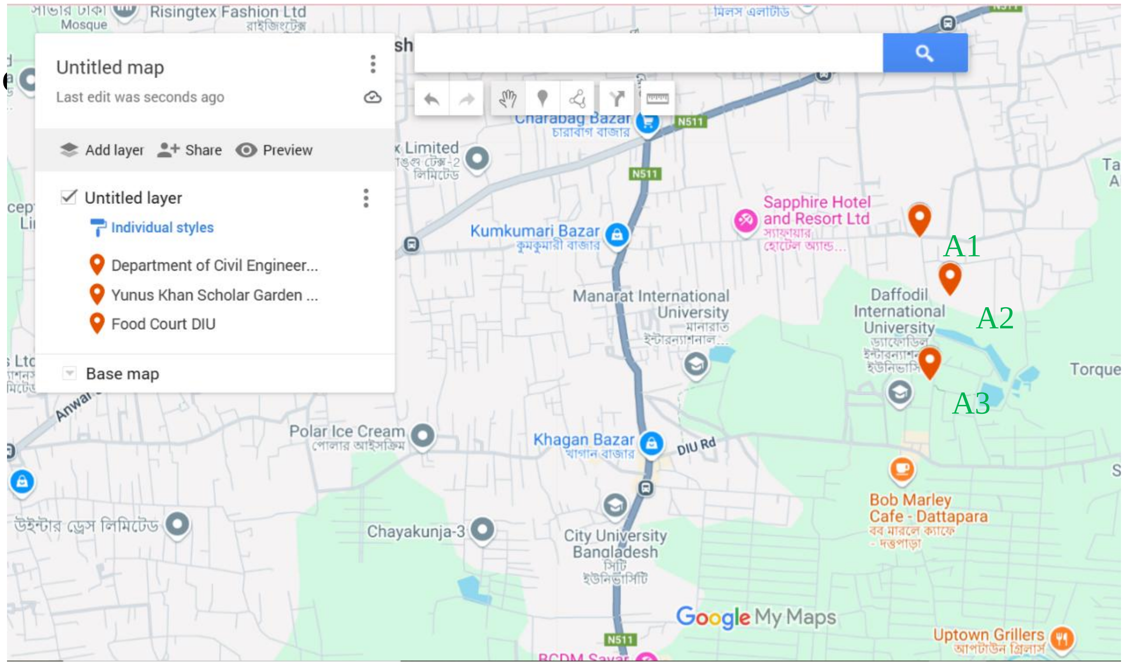

Figure 3.2: Study Area.

3.4 Waste Sampling and Collection

Solid waste samples were collected every day from March 2 to March 11, 2025. Samples were collected manually with safety gloves and containers. The gathered garbage was classified by collection site and recorded with the date and location.

The collected samples were immediately taken to the laboratory for measurement to minimize moisture loss. The wet and dry mass of each sample was documented for the examination of moisture content. A total of 9 samples were gathered for moisture content measurement, whilst bulk density was assessed using three samples from each site.

Figure 3.3: Waste Collection with separated by the category.

3.5 Determination of Moisture Content

The oven-drying technique compliant with ASTM D2974 was used to assess moisture content. The process followed these guidelines:

- Weighing the waste sample's wet mass (Ww).
- Drying the sample for 24 hours in an oven set at 105°C.
- After cooling, the dry mass (Wd) is weighed.
- The formula was used to determine the moisture content:

$$Moisture\ Content\ (\%) = \frac{W_{wet} - W_{dry}}{W_{wet}} \times 100$$

This approach offers a consistent projection of the water content in solid waste, which is essential for assessing treatment alternatives like thermal treatments or composting.

Figure 3.4: Oven dry procedure of waste.

3.6 Measurement of Bulk Density

Estimating the mass-to-volume ratio of rubbish in conventional dustbins allowed one to calculate bulk density. The dustbin measured had a known total volume of 0.1299 m^3.

- The garbage was packed to a given proportion of the bin's capacity (e.g., 65%, 50%, etc.).
- A digital scale was used to weigh the filled bulk.
- The volume was calculated as:
- Bulk Density (kg/m^3) was determined by means of:

$$Density\ (kg/m^3) = \frac{Mass\ of\ sample\ (kg)}{Volume\ of\ container\ (m^3)}$$

This method aligns with **ASTM D698**, which is a standard for assessing compaction characteristics.

Figure 3.5: Taking weight of the wastes.

3.7 Estimation of Energy Content (Calorific Value)

Apart from moisture and density studies, an elemental composition model depending on the empirical formula was used to assess the energy content (lower heating value, LHV) of the trash.

Waste formula: $C_{60}H_{100}O_{40}N_1$

The estimate included:

- Using molecular weights and mole fractions to calculate the mass contributions of each elements—C, H, O, N, S.
- Using empirical energy coefficients (in kJ/kg) for every component.
- Including the ash content (6%) as an inert component without energy contribution.

3.8 Waste Composition Analysis

Component-wise separation was done to grasp the qualitative character of the trash. Every sample gathered was classified into the following groups:

- Food Waste
- Paper (Paper, Tissue)
- Cardboard
- Plastics (Pen, Duster, Water Bottle, Polythene)
- Garden trimmings
- Wood
- Tin cans

A precise scale was used to individually weigh each component. The component weights were then compared across the three sites to identify probable treatment or recycling choices and prevalent trash kinds.

3.9 Data Recording and Analysis

Structured tables and spreadsheets documented all data. Averages of moisture content and bulk density measurements were taken each site. Patterns over areas were seen using graphs and comparison charts.

Analytical emphasis was placed on:

- Relationship between waste type and moisture content.
- Relationship between garbage density and site activity (academic, residential, food service).
- Physical characteristics determining waste's appropriateness for several disposal choices.

3.10 Limitations of Methodology

- Seasonal changes in waste properties were not included in the research.
- Waste chemical and biological characteristics were not assessed.

- Disposal recommendations were based only on physical characteristics moisture and density.

Notwithstanding these constraints, the approach offers a consistent tool for evaluating physical waste characteristics in institutional environments, hence supporting educated waste disposal choices.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

Analytical findings obtained from the experimental methods detailed in Chapter 3 are presented in this chapter. It emphasizes the physical and thermal characterization of the solid waste gathered from the university site. Key factors under study include moisture content, density, and energy content. Particularly in regard to its calorific value and handling needs, these results provide insightful analysis of waste's possibilities for treatment and disposal.

4.2 Moisture Content Analysis

Table 4.1: Moisture content

No.	Date	Location	Wet Mass	Dry Mass	Moisture Content
1	02/03/2025	A1	695 gm	603 gm	13%
2	03/03/2025	A1	736 gm	626 gm	15%
3	04/03/2025	A2	1772 gm	929 gm	48%
4	05/03/2025	A3	2108 gm	1498 gm	28%
5	06/03/2025	A3	1372 gm	808 gm	41%
6	08/03/2025	A2	2232 gm	1093 gm	51%
7	09/03/2025	A3	766 gm	586 gm	23%
8	10/03/2025	A1	910 gm	818 gm	10%
9	11/03/2025	A2	1588 gm	893 gm	44%

A1 = Civil Engineering Building

A2 = Yunus Khan Scholar Garden 2

A3 = Food Court 2

- **Observation**: A2 (residential garden) exhibits the highest moisture, likely due to food waste presence.

4.3 Component-wise Waste Distribution

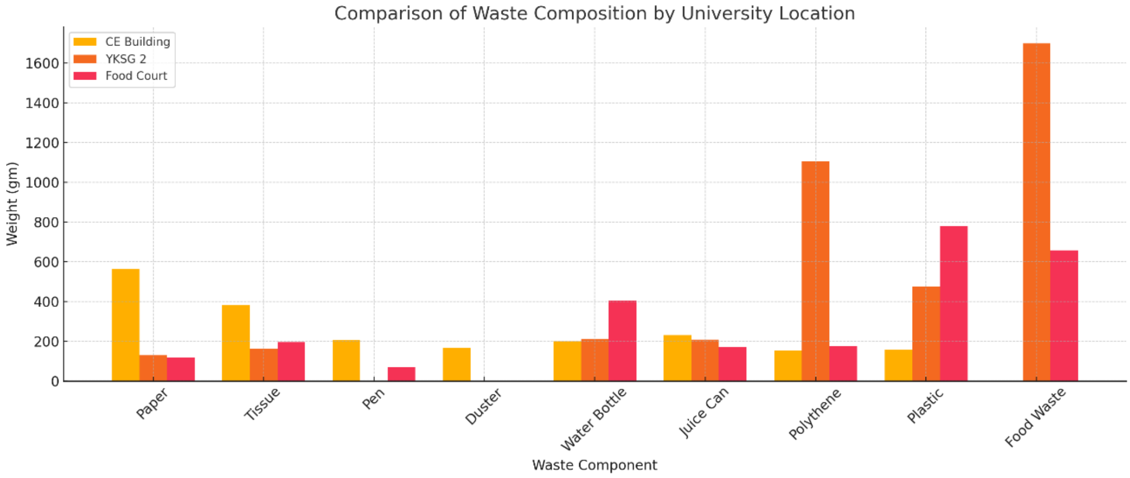

Chart 4.2: Component-wise Waste Distribution

The composition of solid waste produced in three separate sites of the university—the CE Building, YKSG 2, and the Food Court—was evaluated using a comparative study. The data was classified into several categories including food trash, plastic, polythene, juice can, water bottle, duster, pen, tissue, paper, and others.

From the observation:

- Paper waste was highest in the CE Building, followed by YKSG 2 and the Food Court, perhaps because of regular academic activity and documentation.
- All three sites showed notable tissue waste, with the CE Building producing the most, suggesting major sanitary or personal hygiene use.
- Exclusive to the CE Building and Food Court, pen and duster waste reflected higher academic or utility-related activity there.
- Everywhere had water bottles and juice cans; the Food Court had the most, indicating significant drink usage.

- YKSG 2 and the Food Court showed a notable amount of polythene and plastic trash, maybe from packaging materials used in daily use or food delivery.

These results show different use trends and waste production habits depending on the purpose and occupancy of every location. These findings allow for customization of suggestions for enhanced waste management techniques including segregation and recycling.

4.4 Waste Composition

Table 4.3: Waste Compositions

Sample =	**8.01**	**kg**							
Component	**Wet Mass (kg)**	**Typical Moisture Content**	**Dry Mass (kg)**	**Composition, kg**					
				C	**H**	**O**	**N**	**S**	**Ash**
Food wastes	2.358	70	0.7074	0.34	0.05	0.27	0.02	0.00	0.04
Paper	1.549	6	1.45606	0.63	0.09	0.64	0.00	0.00	0.09
Cardboard	0	5	0	0.00	0.00	0.00	0.00	0.00	0.00
Plastics	4.102	2	4.01996	2.41	0.29	0.92			0.40
Garden trimmings	0	60	0	0.00	0.00	0.00	0.00	0.00	0.00
Wood	0	20	0	0.00	0.00	0.00	0.00	0.00	0.00
Total	8.01		6.18	3.38	0.42	1.82	0.02	0.01	0.52
				From Water =	0.20	1.62			

4.5 Waste Composition

A typical formula's elemental composition—$C_{1572}H_{3483}O_{1200}N_9S_1$—was used to determine the energy content of the garbage. The study also took into account the ash content.

The next table shows the elemental breakdown, mass contributions, and energy coefficients applied to calculate the overall calorific value:

Table 4.4: Estimate the energy content of the waste having a formula of $C_{50}H_{100}O_{40}N_1$. The waste has an ash content of 6%.

	Moles	**kg/mol**	**Mass, kg**	**Percent mass**	**Co-efficient**	**Energy**
Carbon	1572	12	18864	42.52	337	14,328.59
Hydrogen	3483	1	3483	7.85	1428	11,210.41
Oxygen	1200	16	19200	43.28	-178.5	-7,724.66
Nitrogen	9	14	126	0.28	0	0.00
Sulphur	1	32	32	0.07	95	6.85
Ash				6		
			41705	100.00	kJ/kg =	17,821.19

With moisture levels lowered, the mixed waste's estimated calorific value of 17,821.19 kJ/kg indicates modest energy potential and possible suitability for controlled incineration or RDF (Refuse-Derived Fuel) generation.

4.6 Bulk Density Data

Dustbin Volume: 0.1299 m³

Table 4.5: CE Building

Sample	**Fill %**	**Mass (kg)**	**Volume (m³)**	**Bulk Density (kg/m³)**
1	65%	7.8	0.08443	92.4
2	50%	6.3	0.06495	97.0
3	90%	11.2	0.11691	95.8

Table 4.6: YKSG 2

Sample	**Fill %**	**Mass (kg)**	**Volume (m³)**	**Bulk Density (kg/m³)**
1	60%	15.0	0.07794	192.5
2	50%	13.0	0.06495	200.2
3	35%	8.7	0.04546	191.4

Table 4.7: Food Court

Sample	**Fill %**	**Mass (kg)**	**Volume (m³)**	**Bulk Density (kg/m³)**
1	75%	7.9	0.09742	81.1

2	55%	6.2	0.07144	86.8
3	85%	10.1	0.11041	91.5

The graph offers a comparison of the kinds and amounts of solid trash gathered from three main university sites: the CE Building, YKSG 2, and the Food Court. These sites' composition of garbage differs greatly depending on their use and activities.

- Reflecting the academic character of the neighborhood, paper waste is most common in the CE Building (564 gm), followed by YKSG 2 (130 mg) and the Food Court (117 gm).
- All three sites produce tissue trash; the CE Building produces the most (380 gramme), suggesting notable personal or cleaning use.
- While YKSG 2 had none, the CE Building (206 mg) and Food Court (70 gm) have pen waste, perhaps from student activities.
- Consistent with its academic goal, duster waste is noted just in the CE Building (166 gramme).
- Highlighting beverage usage, water bottles are thrown out everywhere; the most in the Food Court (404 gm), then YKSG 2 (212 gm) and the CE Building (200 gm).
- Juice cans likewise follow a similar pattern, with significant quantities in all three locations—20230 grammes in CE Building, 207 gm in YKSG 2, and 170 gm in the Food Court.
- With far less in the CE Building (154 gm) and Food Court (174 gm), polythene trash is somewhat considerable in YKSG 2 (1106 gm), indicating packing or storage usage.
- Reflecting different degrees of packaged products or disposables, plastic trash is most common in the Food Court (780 gm), followed by YKSG 2 (474 gm) and the CE Building (156 mg).
- The CE Building has no food waste; YKSG 2 has the most (1700 gm), followed by the Food Court (658 gm), which reflects food consumption trends in these sites.

This detailed composition helps in identifying dominant waste types in different zones of the university, which is essential for designing effective, location-specific waste management strategies.

4.7 Waste Disposal Strategies

Table 4.8: Waste disposal strategies

Property	Disposal Recommendation
Low Moisture & Low Density	**Recycling** (paper, plastic, metal)
High Moisture & High Density	**Composting** (organic waste), **Anaerobic digestion**
Medium Moisture	**Segregation**, **Thermal treatment** (plastics), **Composting**

- **Transport Implications**: High-density waste is economical to transport. Moist waste needs leak-proof containers.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This study was done to evaluate the solid waste composition produced by various Daffodil International University facilities and to investigate the possibility of energy recovery by means of efficient disposal techniques. The study looked at several physical qualities of the trash, including moisture content and density, and offered information on the kinds and amounts of garbage generated in academic, residential, and food service settings.

5.2 Conclusions

- The trash produced is heterogeneous, consisting of biodegradable elements (such as food waste and tissue), recyclable materials (plastic, polythene, paper), and flammable components (such as paper, plastic, and organic matter).
- Much of the trash is made up of high-energy-content materials including hydrogen-based compounds and carbon-rich substances.

The theoretical energy content of the garbage was determined to be about 17,821.19 kJ/kg using the projected chemical composition ($C_{1572}H_{3483}O_{1200}N_9S_1$). This high calorific content indicates that the trash offers significant possibility for energy recovery.

5.3 Recommendations

This paper strongly advocates incineration as the most appropriate waste disposal technique for the institution based on energy content assessment and the physical makeup of the trash. In this situation, the benefits of incineration are:

- Incineration can turn waste materials into useable thermal energy, which might then be utilized to heat university facilities or perhaps create power.
- This approach greatly lowers the amount of trash, hence lessening the load on nearby landfills.

- Incineration may handle a wide spectrum of waste kinds, including non-recyclable and hazardous materials.
- Modern incineration systems generate less methane—a strong greenhouse gas—than landfilling, thereby reducing greenhouse gases.

To implement this recommendation effectively, the following actions are suggested:

- Feasibility Study: Perform a thorough technical study and cost-benefit analysis for building a small-scale waste-to-energy incineration plant on or close to the campus.
- Encourage workers and students to separate garbage to increase incineration efficiency and cut emissions.
- Establish institutional procedures and infrastructure for methodical garbage collection, transportation, and incineration activities.
- Conduct awareness activities to inform university stakeholders about the environmental and energy advantages of incineration.

To sum up, incineration offers a sustainable and energy-efficient way to control the increasing amount of garbage at the institution. Adopted and properly controlled, it may change trash from an environmental burden to a useful energy source.

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APPENDIX

Table 4.3: Component-wise Waste Distribution

Component	CE Building	YKSG 2	Food Court
Paper	564 gm	130 gm	117 gm
Tissue	380 gm	162 gm	196 gm
Pen	206 gm	–	70 gm
Duster	166 gm	–	–
Water Bottle	200 gm	212 gm	404 gm
Juice Can	230 gm	207 gm	170 gm
Polythene	154 gm	1106 gm	174 gm
Plastic	156 gm	474 gm	780 gm
Food Waste	–	1700 gm	658 gm

Some Pictures from data collections and experimental procedures.

Figure 1: Field Data Collection and Sample Handling during Waste Characterization Study

Figure 2: Laboratory Setup for Moisture Content Determination

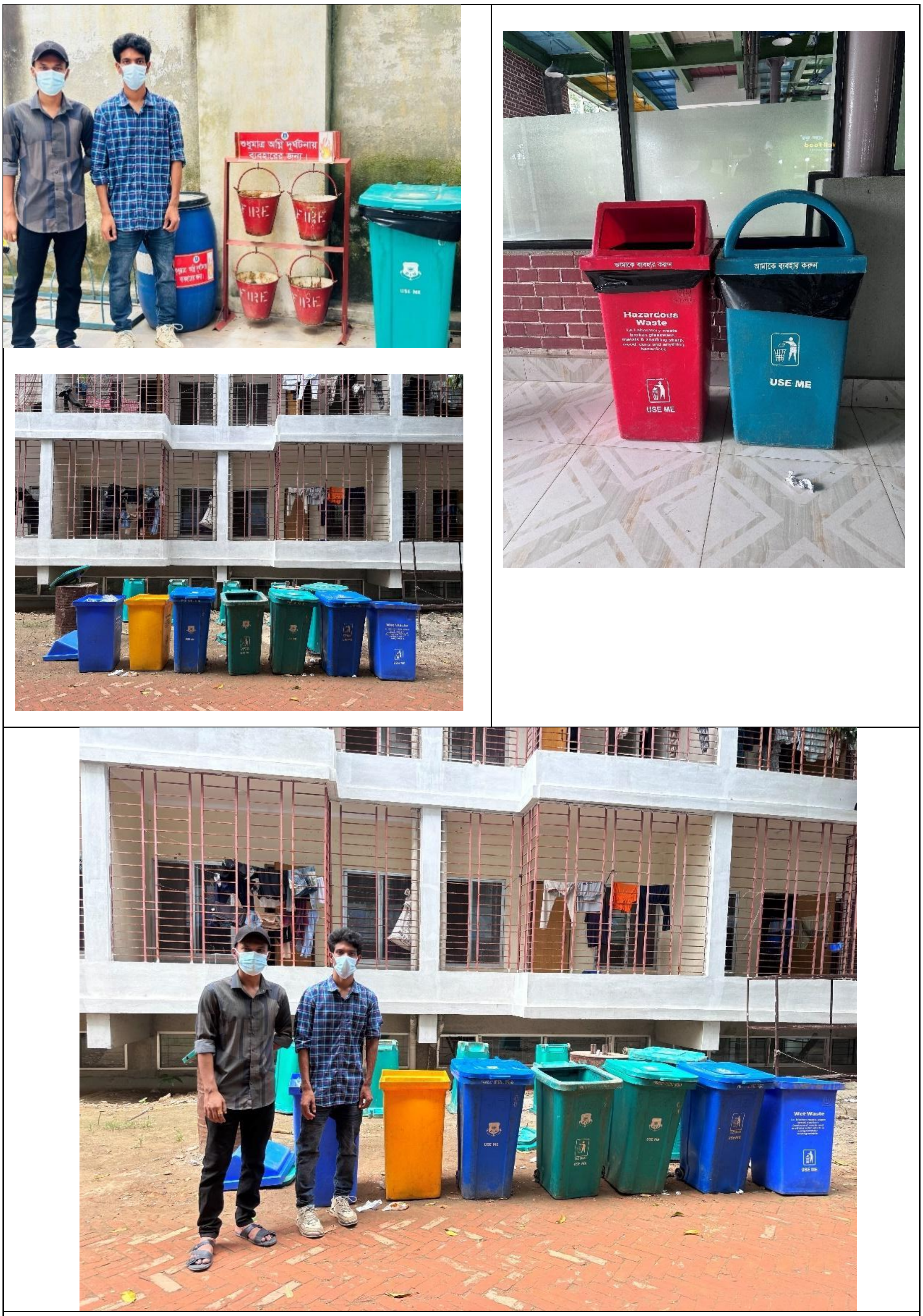

Figure 3: Site investigation.

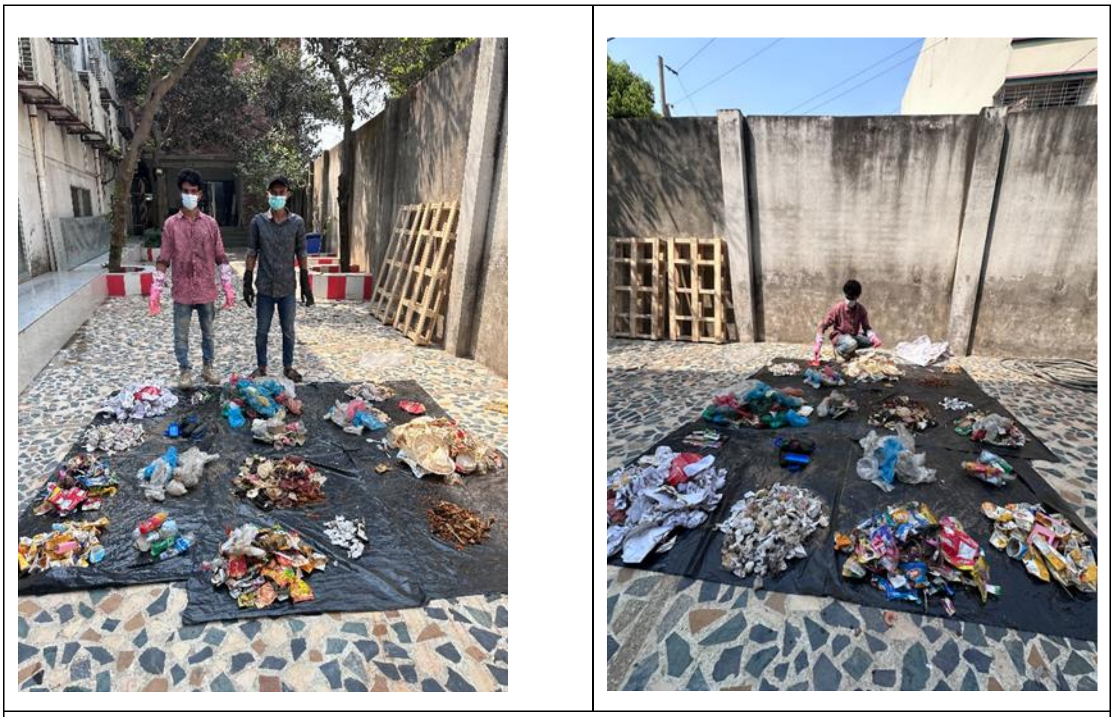

Figure 4: Waste Component Segregation and Composition Sorting