ISSN 2278-2540 | DOI: 10.51583EMAS | Volume XV, Issue X, October2026

# Solid Waste Generation, Composition and Recycling Opportunities at Juaso Senior High Technical School, Ashanti Region, Ghana

**Kizito Attah Gesuli-Saliba[1]*, Felix Tetteh Kabutey[1], Stephen Twumasi Annan[2], Mohammed Tanko[1], Jonas Ametepey Kisseh[1], Gifty Nyarko Kwakye[1], Jamie Ob-Yang[1]**

**[1]Department of Environmental Science, University of Education, Winneba, Ghana.**

**[2]Department of Integrated Science Education, University of Education, Winneba, Ghana.**

**DOI: https://doi.org/10.51583/IJLTEMAS.2026.151000065**

**Received: 21 October 2026; Accepted: 26 October 2026; Published: 06 November 2026**

## ABSTRACT

Solid waste management remains a significant environmental challenge in educational institutions, particularly where increasing student populations, consumption activities and, inadequate waste management infrastructure place pressure on existing collection and disposal systems. This study assessed solid waste generation, composition, and recycling opportunities at Juaso Senior High Technical School in the Ashanti Region of Ghana. A quantitative waste characterization approach was employed to determine the quantity and composition of solid waste generated at six selected sampling points comprising one selected student residential house (House A), Dining Hall, Classroom Block, Laboratory Block, Open Space and, Administration Block. Waste was collected and weighed at the selected sampling points during the study period and subsequently sorted into organic, plastic, paper, metal, glass, textile, and e-waste. Descriptive statistics, including total waste mass, mean daily generation, percentage composition, and standard deviations, were used to summarise the results. A one-way analysis of variance (ANOVA) was conducted to test whether mean daily waste generation differed across the six sampling points. The study recorded a total of 6,846.80 kg of waste over the 14-day period, corresponding to an overall mean of 489.06 kg/day. The Student Residential House (House A) recorded the highest total (1,900.00 kg), followed by the Dining Hall (1,500.00 kg), whereas the Laboratory Block recorded the lowest (696.80 kg). Organic waste was the dominant component (46.87%), followed by plastics (25.72%) and paper (16.21%). Plastics, paper, metals, and glass together accounted for approximately 47.93% of the total waste stream, indicating potential for material recovery, while the high organic fraction suggests opportunities for composting. Smaller proportions of metals, glass, textiles, and e-waste were also recorded. However, the absence of effective source segregation may limit material recovery. The study provides an institution-specific baseline to support waste segregation, recycling, and composting at Juaso Senior High Technical School.

**Keywords**: Characterization, generation, composition, recycling, resource recovery

## INTRODUCTION

Solid waste management is an important component of environmental sustainability and public health because the generation, handling, storage, collection, and final disposal of waste can have significant environmental and social consequences (Malakahmad et al., 2010). Rapid population growth, increasing consumption, and changing lifestyles have contributed to the rising quantities of solid waste in many developing countries, whereas inadequate collection systems, limited source segregation, and weak recovery infrastructure continue to constrain effective waste management (Cadavid-Rodríguez & Agudelo-Morales, 2017; Karuku & Kathula, 2021).

Mason et al. (2004) argued that waste should not be regarded solely as material for disposal but also as a potential source of recoverable resources when appropriate separation, treatment, and recovery systems are available. Effective solid waste management therefore requires a clear understanding of the quantities and

ISSN 2278-2540 | DOI: 10.51583EMAS | Volume XV, Issue X, October2026

physical characteristics of the waste generated, because this information provides an important basis for planning appropriate collection, treatment, recycling, and disposal strategies (Khan et al., 2022; Ng & Yusoff, 2013).

Educational institutions are important waste-generating environments because they bring together large numbers of people and a wide range of activities within a relatively confined area (Moqbel, 2018; Subamathi et al., 2025). In addition to teaching and learning activities, schools may contain residential facilities, laboratories, dining facilities, administrative offices, and open spaces, each of which can generate waste of different quantities and compositions (Safo-Adu & Owusu-Adzorah, 2023).

The resulting waste stream may include organic materials, plastics, paper, metals, glass, textiles, and e-waste. The composition of waste generated in an institution is therefore influenced by the functions and activities undertaken at particular locations. The composition of waste generated in an institution is influenced by the functions and activities undertaken at particular locations. Bhusal et al. (2020) argued that waste characterisation is important for identifying dominant waste streams and determining appropriate options for reduction, reuse, recycling, composting, and other forms of resource recovery.

In Ghana, solid waste management remains a persistent environmental challenge, particularly where waste generation continues to increase while source segregation and recovery systems are limited (Mbuligwe, 2002; Mukhtar et al., 2016). Educational institutions form part of this challenge because daily food consumption, academic activities, residential accommodation, and administrative operations generate substantial quantities of waste (Ugwu et al., 2020).

Ampofo, (2020) stated that the characteristics of waste generated within schools may differ from those of household or commercial waste because school activities follow distinct patterns. Understanding these patterns is essential for developing waste-management interventions suited to the operational conditions of individual institutions rather than relying solely on generalised approaches (Syafrudin et al., 2023).

Previous studies have demonstrated the value of waste characterisation in educational institutional settings. Studies conducted in secondary schools have shown that school waste can contain substantial quantities of materials suitable for recycling and other recovery methods. For example, a study in secondary schools in Kumasi Metropolis identified significant recyclable components in the waste stream, demonstrating the importance of assessing waste composition before developing recovery programs (Safo-Adu & Owusu-Adzorah, 2023). Similarly, studies of institutional waste have emphasised that knowledge of waste generation rates and composition is necessary for designing efficient integrated waste management systems (Dery et al., 2018). The findings indicate that characterisation can provide an empirical basis for identifying which waste fractions should be prioritised for recovery and which require appropriate disposal.

Despite the growing attention to sustainable waste management in educational institutions, there remains a need for institution-specific evidence that links the quantity and composition of waste to practical recovery opportunities (Baldwin & Dripps, 2012). Existing studies provide useful evidence from selected schools and other institutions, but waste generation patterns are likely to vary according to student population, facility use, food consumption patterns, operational practices, and the availability of waste management infrastructure. Consequently, findings from one institution cannot automatically be assumed to represent another institution. For Juaso Senior High Technical School, there is a need for current empirical information on the amount and composition of waste generated across the major functional areas of the school and on the materials that may potentially be recovered through recycling, composting and related interventions.

This study therefore seeks to provide an empirical assessment of solid waste generation and composition at six major sampling points within Juaso Senior High Technical School, namely, one selected student residential house (House A), the dining hall, classroom block, laboratory block, open space, and administration block. Specifically, this study quantifies the solid waste generated at these sampling points, determines the percentage composition of the different waste streams, and assesses the recycling and

ISSN 2278-2540 | DOI: 10.51583EMAS | Volume XV, Issue X, October2026

resource recovery opportunities associated with the major waste categories identified. By examining different functional areas rather than treating the school as a single homogeneous waste generation unit, this study seeks to provide a more detailed understanding of how institutional activities influence waste generation patterns.

The significance of the study lies in its potential to provide a practical evidence base for improving solid waste management at JUASTECH. The findings can support the identification of areas generating relatively large quantities of waste, guide the placement and management of waste collection facilities, and inform source segregation initiatives that may reduce the amount of waste requiring disposal. In addition, the findings may assist school authorities and other relevant stakeholders in developing waste management measures that are appropriate to the specific activities undertaken within different sections of the school.

The principal contribution of this study is its provision of an institution-specific baseline for solid waste generation and composition at JUASTECH and its linking of the measured waste streams to practical recovery opportunities. Rather than considering waste solely as a disposal problem, this study provides evidence for identifying materials that can potentially be diverted from disposal through recycling, composting, reuse, and other recovery options. This research offers practical evidence that can aid in implementing more organized source separation and resource recovery at the school level. It also lays the groundwork for future research on reducing waste, recovering materials, and planning sustainable solid waste management in educational institutions in Ghana.

## MATERIALS AND METHODS

This study was conducted at Juaso Senior High Technical School, located at Juaso in the Asante Akim South District of the Ashanti Region, Ghana. The school is situated along the Kumasi-Accra Highway and is a mixed day and boarding senior high technical school. Ghana Education Service records identify the school as Juaso Senior High Technical School and provide its location at approximately 6.585827°N latitude and 1.123545°W longitude (Sarquah et al., 2023).

The school accommodates students and provides a range of academic, residential, food-service, laboratory, and administrative activities that generate different types and quantities of solid waste. For the purpose of the study, waste generation was assessed at six major functional sampling points: one selected student residential house (House A), Dining Hall, Classroom Block, Laboratory Block, Open Space, and Administration Block. These locations were selected to represent the major activities undertaken within the school and to allow comparison of waste generation and composition patterns among different functional areas. The selected student residential house (House A) comprised residential facilities used by students, while the dining hall represented food preparation and consumption activities. The classroom block represented teaching and learning activities, and the laboratory block represented practical and laboratory-related activities. The open space represented waste generated from outdoor and general student activities, whereas the administration block represented administrative and office-related activities. This functional classification provided a basis for assessing variations in solid waste generation and composition across the school.

### Research Design

This study adopted a quantitative descriptive research design based on direct measurement and physical characterization of solid waste generated at selected functional areas of Juaso Senior High Technical School (Masjhoer et al., 2020; Syafrudin et al., 2023). The design involved systematic collection, weighing, sorting, and classification of solid waste to determine the quantity and composition of waste generated at the selected sampling points. The approach was designed to generate empirical data that could be used to assess waste generation patterns and identify opportunities for recycling, composting, and other forms of resource recovery (Amo-Asamoah et al., 2020; Gesuli-saliba et al., 2026).

ISSN 2278-2540 | DOI: 10.51583EMAS | Volume XV, Issue X, October2026

**Study Population**

The study population comprised the waste generation and collection points located within the six selected functional areas: one selected student residential house (House A), dining hall, classroom block, laboratory block, open space, and administration block of JUASTECH. These areas were identified as major locations where solid waste is generated, accumulated, and collected within the school (Zakarya et al., 2020). A preliminary field assessment was conducted to identify and document the waste collection bins serving each of the selected functional areas (Potiracha & Baars, 2026).

A total of twenty-four (24) waste collection bins constituted the sampling frame. The bins were distributed across the six functional areas and represented the principal points at which solid waste was collected within the school. The identified bins provided the basis for selecting the waste sampling units used for the characterization exercise.

**Sample Size Determination**

Solid waste was collected from the twelve (12) selected waste bins over a fourteen (14) day sampling period. The 14-day period was chosen to capture two full weeks of waste generation, thereby accounting for weekly variation in consumption patterns associated with the school's timetable, including differences between weekdays and weekends. This duration was considered sufficient to obtain a representative sample of routine waste generation while remaining logistically feasible for daily collection, transportation, and manual sorting. Seasonal or term-time variation was not explicitly examined in this study, and this is acknowledged as a limitation.

Two (2) bins were selected from each of the six sampling points, giving a total of twelve (12) bins. This allocation provided equal representation of the six functional areas in the waste characterization exercise. The decision to sample two bins per functional area was based on the need to capture variability in waste generation within each area while maintaining a manageable daily sorting workload. While a larger sample would have improved representativeness, the two-bin allocation per stratum was considered sufficient to provide indicative data on waste generation patterns and is acknowledged as a limitation.

**Sampling Procedure**

A stratified sampling procedure was used to ensure that the major functional areas of JUASTECH were represented. The school was divided into six strata: the selected student residential house (House A), Dining Hall, Classroom Block, Laboratory Block, Open Space, and Administration Block (Igibah et al., 2019; Karuku & Kathula, 2021). A preliminary field survey was conducted to identify the location, type, size, and use of waste collection bins within each stratum (Al-Shatnawi et al., 2020). Twenty-four waste collection bins were identified, with four bins in each functional area. Two bins were then selected from each stratum, giving a total sample of 12 bins. To select House A, all residential houses were assigned sequential numbers, and one house was selected using a random-number generator. Within each stratum, each bin was assigned a unique identifier, and two bins were selected using a random-number generator (Bartlett II et al., 2001; Cochran, 1997).

**Waste Collection and Sorting**

Solid waste was collected from the twelve (12) selected waste bins over a fourteen (14) day sampling period. The selected bins were distributed across the six functional areas of the school: one selected student residential house (House A), dining hall, classroom block, laboratory block, open space, and administration block.

At each sampling point, the empty weight of the waste collection bin was first determined using a calibrated electronic weighing scale (Model: Camry 50 kg capacity, precision ±0.01 kg). The scale was calibrated daily using standard weights before each weighing session.

ISSN 2278-2540 | DOI: 10.51583EMAS | Volume XV, Issue X, October2026

The net waste weight was calculated using:

$$W_n = W_l - W_e$$

Where:

$W_n$ = the net weight of waste (kg).

$W_l$ = the weight of the loaded bin (kg).

$W_e$ = the weight of the empty bin (kg).

The collected waste was transported to a designated sorting area where it was manually sorted into seven categories: organic waste, plastics, paper, metals, glass, textiles, and e-waste. Rakes, hand forks, and hand trowels were used to spread and separate the waste materials to facilitate identification and weighing (Ratnaningrum et al., 2024). Each separated waste category was weighed individually and recorded for subsequent determination of its percentage composition. To ensure consistency in sorting, two trained research assistants performed the sorting independently for the first three days, and their results were compared. The inter-sorter reliability was high (Cohen's kappa = 0.92), indicating strong agreement in waste categorization. Personal protective equipment, including heavy-duty rubber gloves, protective boots, masks, and aprons or other protective clothing, was used during waste collection, handling, and sorting to minimize exposure to potentially hazardous materials (WHO, 2024)

The waste sampling procedure was conducted consistently throughout the fourteen (14) day study period to obtain repeated measurements from the selected sampling points and capture variations in waste generation during the study.

**Data Analysis**

The data collected during the fourteen (14) day sampling period were organized according to the six functional sampling points and the seven identified waste categories. Descriptive statistics summarized the quantity and composition of solid waste generated at each sampling point (Millanzi et al., 2023). These included total waste generated, mean daily waste generation, standard deviation, and percentage composition of waste categories.

The average daily waste generation was calculated by dividing the total mass of the waste generated during the fourteen-day sampling period by fourteen:

$$G_d = \frac{W_t}{14}$$

Where:

$G_d$ = the mean daily waste generation (kg/day).

$W_t$ = the total waste generated during the fourteen-day sampling period (kg).

The percentage composition of each waste category was calculated as:

$$P_i = \frac{W_i}{W_t} \text{ x } 100$$

Where:

$P_i$ = percentage composition of a particular waste category (%).

ISSN 2278-2540 | DOI: 10.51583EMAS | Volume XV, Issue X, October2026

$W_i$ = weight of that particular waste category (kg).

$W_t$ = total weight of all waste categories (kg).

The quantities of potentially recyclable and recoverable materials were determined from the measured weights of relevant waste categories. The results were presented using tables to facilitate comparison of waste generation and composition patterns among the six functional sampling points.

To test whether daily waste generation differed among the six functional areas, a one-way analysis of variance (ANOVA) was conducted using daily waste weight as the dependent variable and functional area as the independent variable. Statistical significance was set at $\alpha = .05$. Tukey's honestly significant difference (HSD) test was used for post hoc comparisons.

### Ethical Considerations

Institutional permission to conduct the study was obtained from the Headmistress of Juaso Senior High Technical School. The study did not involve human participants directly, and all waste materials were handled in accordance with standard safety protocols. The research was conducted in compliance with the ethical guidelines of the University of Education, Winneba.

## RESULTS AND DISCUSSION

### Solid Waste Generation at Selected Sampling Points

Solid waste generation varied across the six selected functional sampling points during the fourteen (14) day sampling period. The total quantity of waste generated across the six sampling points was 6,846.80 kg during the study period, corresponding to an overall average generation of 489.06 kg/day.

The Student Residential House recorded the highest cumulative waste generation with 1,900.00 kg over the 14-day period, equivalent to a mean daily generation of 135.71 kg/day (SD=18.50 kg/day). The Dining Hall recorded the second highest total of 1,500.00 kg, corresponding to 107.14 kg/day (SD=15.00 kg/day). The Classroom Block generated 1,000.00 kg with a mean daily generation of 71.43 kg/day (SD=8.50 kg/day), while the Open Space generated 950.00 kg, averaging 67.86 kg/day (SD=10.00 kg/day). The Administration and Laboratory Blocks recorded lower quantities of 800.00 kg and 696.80 kg, respectively, corresponding to mean daily generation rates of 57.14 kg/day (SD=6.00 kg/day) and 49.77 kg/day (SD=7.00 kg/day) in **Table 1**.

A one-way ANOVA revealed a statistically significant difference in mean daily waste generation among the six functional areas, $F(5, 78) = 111.74$, $p < .001$ (**Table 2**). **Figure 1** presents the mean daily generation at each sampling point. The Student Residential House and Dining Hall generated significantly more waste than the Classroom Block, Open Space, Administration Block, and Laboratory Block ($p < .05$). Differences among the Classroom Block, Open Space, Administration Block, and Laboratory Block were not statistically significant.

The relatively high waste generation recorded at the Student Residential House may be associated with students' continuous presence and the range of daily residential activities (Malakahmad et al., 2010). In a study of Ghanaian secondary schools, (Safo-Adu & Owusu-Adzorah, 2023) found that kitchen waste had the highest average quantity among the functional locations assessed. Residential areas can generate waste from food consumption, personal activities, and packaging materials, making them important waste generation points in boarding schools (Tariq et al., 2024). The high generation at the Dining Hall is also understandable because food preparation, serving, and consumption are concentrated there. These findings highlight the importance of prioritising high-waste-generation locations when allocating bins and determining collection frequency (Boskovic & Jovicic, 2015; Ojuri et al., 2024).

ISSN 2278-2540 | DOI: 10.51583EMAS | Volume XV, Issue X, October2026

The comparatively large quantity generated at the Classroom Block is also noteworthy. Although academic spaces may generate less waste per user than residential or food-service facilities, their cumulative contribution can be substantial because classrooms are used repeatedly throughout the school day. Dery et al., (2018); Saleem et al., (2018) similarly identified classroom blocks as important sources of paper waste in Ghanaian secondary schools. This suggests that the function of an area is an important determinant of the quantity and types of waste generated.

The Open Space also contributed substantially to total waste generation in the results. This may be associated with student movement, social interaction, and the consumption of packaged products outside enclosed facilities. Plastics are particularly likely to become visible in open areas because lightweight packaging can be readily discarded or transported by wind. However, this explanation should be interpreted as a functional interpretation rather than direct evidence of student behaviour because behavioural variables were not measured in the present study (Balcom, 2025; Starovoytova & Namango, 2018).

The Administration Block and Laboratory Block recorded the lowest quantities. The lower quantity in the Administration Block may be associated with a waste stream dominated by paper and office-related packaging rather than food waste. The Laboratory Block may generate less waste by mass because its activities are specialised and may occur intermittently compared with residential and food-service activities. Nevertheless, a low waste mass does not necessarily imply low management importance, particularly when specialised or electronic materials are present (Rodríguez-Guerreiro et al., 2024).

The observed differences demonstrate that institutional waste generation should be interpreted in relation to activity type and occupancy, rather than only physical location. Asare et al., (2022) suggested in a large-scale Ghanaian waste characterization study, waste generation rates vary substantially across geographical and settlement contexts and that waste composition is strongly influenced by the activities and circumstances of the waste generators. The present study extends that principle to functional areas within a senior high school environment. The findings also have practical implications for waste-collection planning. High-generation locations such as the Student Residential House and Dining Hall would require sufficient bin capacity and frequent collection, whereas locations dominated by dry recyclable materials could benefit from source-segregation systems (Yukalang et al., 2017). Such differentiated management would be more appropriate than applying identical bin capacity and collection frequency to every facility.

**Table 1**: Total and mean daily solid waste generation at the selected sampling points

| **Sampling point** | **Total waste (kg)** | **Mean daily generation (kg/day)** | **SD (kg/day)** |
|---|---|---|---|
| Student R. House | 1,900.00 | 135.71 | 18.50 |
| Dining Hall | 1,500.00 | 107.14 | 15.00 |
| Classroom Block | 1,000.00 | 71.43 | 8.50 |
| Open Space | 950.00 | 67.86 | 10.00 |
| Administration Block | 800.00 | 57.14 | 6.00 |
| Laboratory Block | 696.80 | 49.77 | 7.00 |
| **Total** | **6,846.80** | **489.05** | **28.71** |

Source: Field survey (2026).

ISSN 2278-2540 | DOI: 10.51583EMAS | Volume XV, Issue X, October2026

**Table 2**: One-way ANOVA results for daily solid waste generation across functional areas

| **Source of Variation** | **Sum of Squares** | **df** | **Mean Square** | **F** | **P-value** |
|---|---|---|---|---|---|
| Between Groups | 76,772.08 | 5 | 15,354.42 | 111.74 | < 0.001 |
| Within Groups | 10,718.50 | 78 | 137.42 | | |
| **Total** | **87,490.58** | **83** | | | |

Source: Field survey (2026).

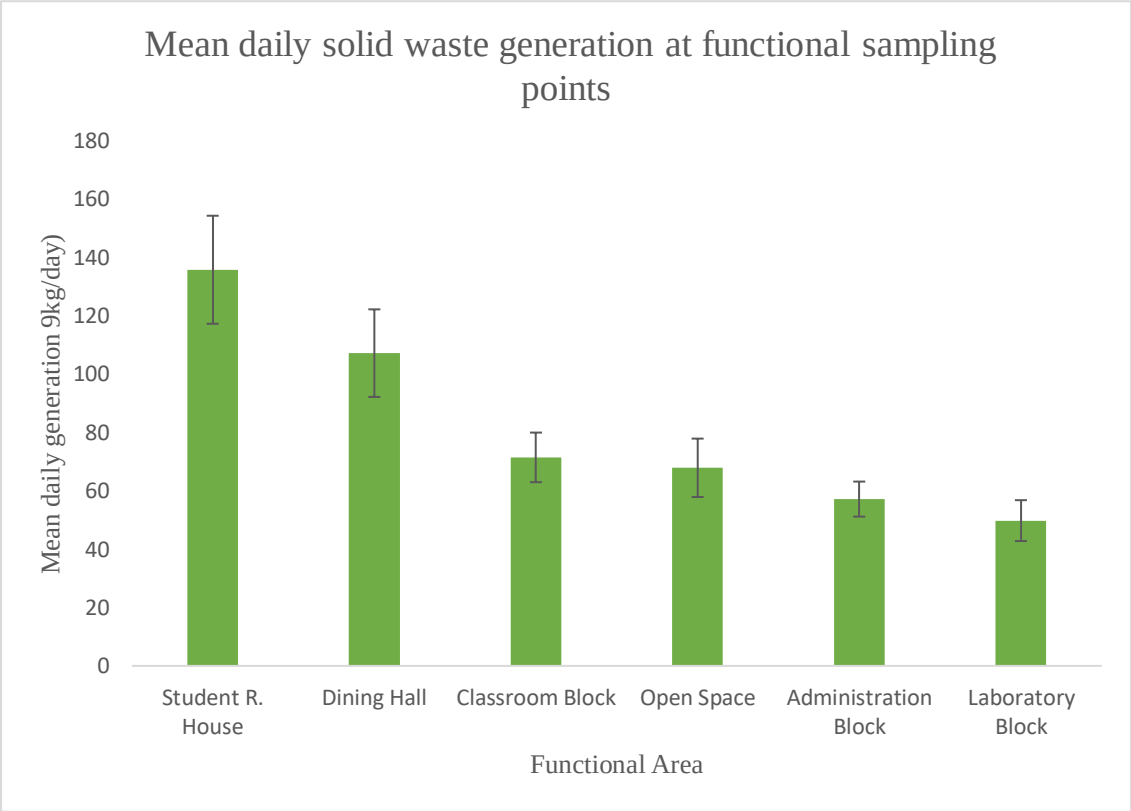



**Figure 1:** Mean daily solid waste generation (kg/day) at the six functional sampling points

**Percentage Composition of Solid Waste**

The physical composition of the waste was determined by sorting the collected materials into seven categories: organic waste, plastics, paper, metals, glass, textiles, and e-waste. Composition differed considerably across the six functional sampling points, indicating that the activities undertaken at each location influenced the types of waste generated (**Table 3**).

Organic waste was the dominant fraction in the Student Residential House and Dining Hall, accounting for 60.00% and 70.00%, respectively. Its dominance at the Dining Hall is consistent with the function of the facility because food preparation, serving, and consumption generate considerable quantities of biodegradable material. Adeniran et al., (2017) similarly observed that the kitchen had the highest organic-waste component among the sources assessed in their institutional study. The high organic fraction is also broadly consistent with Ghana's household-waste profile. Miezah et al., (2015) reported that organic

ISSN 2278-2540 | DOI: 10.51583EMAS | Volume XV, Issue X, October2026

material represented approximately 61.00% of household waste nationally. Although household and school waste are not directly equivalent, this similarity indicates that food and other biodegradable materials are important components of waste streams in Ghanaian settings.

The organic fractions at the Classroom Block (35.00%) and Laboratory Block (30.00%) were lower than those recorded at the residential and dining locations. This difference may reflect the principal activities at these facilities, which involve teaching, learning, and practical work rather than food preparation. (Polin et al., 2023). The result illustrates the importance of considering facility function when designing waste-segregation systems.

Plastics constituted an important component throughout the school, ranging from 20.00% at the Dining Hall to 38.00% at the Open Space. The highest plastic fraction occurred at the Open Space, where plastics represented 38.00% of the waste stream. This can be associated with packaged food, drinking water bottles, and other disposable materials consumed during outdoor activities. Likewise (Gesuli-saliba et al., 2026; Pinto et al., 2023) identified plastics as one of the principal waste fractions in Ghana, accounting for approximately 14% nationally, although the proportion varied considerably across locations.

The relatively high plastic fraction observed in the school compared with the national household average is plausible because school environments provide a concentrated setting for consumption of packaged products. However, the difference also demonstrates why waste composition should be measured at the institutional level instead of simply importing municipal or household averages into school waste management planning (Mbuligwe, 2002).

Paper displayed a distinctly different pattern. The Administration Block had the highest paper proportion at 50.00%, followed by Classroom Block at 32.00% and the Laboratory Block at 25.00%. This distribution is consistent with the paper-intensive functions of administration and academic facilities and is attributed to the examination period of the school during the study. This distribution is consistent with findings by (Miezah et al., 2015; Smyth et al., 2010), who reported relatively high paper waste levels. However, confirm that both cited studies specifically concern educational institutions before retaining that claim. The high paper fraction in the Administration Block is important for resource recovery because paper is easier to separate before it becomes contaminated by food and other wet waste. Source segregation at office collection points could therefore improve the quality of material available for recycling.

The high paper fraction in the Administration Block is particularly important from the resource recovery perspective because paper is relatively easy to isolate before contamination by food and other wet waste occurs. Source generation at the office points could therefore substantially improve the quality of material available for recycling.

Metals, glass, textiles and e-waste occurred in smaller proportions than organic waste, plastics and paper. Their lower mass does not imply that they can be ignored. Metals and glass are potentially recoverable materials, while textiles can be reused or recycled depending on their condition (Nyakuma & Ivase, 2021). E-waste requires a more controlled management route because environmental significance is not necessarily proportional to quantity. The composition pattern demonstrates that the school waste stream is heterogeneous and source-dependent

**Table 3**: Percentage composition of solid waste at the selected sampling points

| **Waste category** | **Student R. House (%)** | **Dining Hall (%)** | **Classroom Block (%)** | **Laboratory Block (%)** | **Open Space (%)** | **Administration Block (%)** |
|---|---|---|---|---|---|---|
| Organic | 60.00 | 70.00 | 35.00 | 30.00 | 40.00 | 10.00 |
| Plastic | 25.00 | 20.00 | 23.00 | 28.00 | 38.00 | 25.00 |

ISSN 2278-2540 | DOI: 10.51583EMAS | Volume XV, Issue X, October2026

| | | | | | | |
|---|---|---|---|---|---|---|
| Paper | 05.00 | 03.00 | 32.00 | 25.00 | 08.00 | 50.00 |
| Metal | 03.00 | 02.00 | 03.00 | 07.00 | 05.00 | 05.00 |
| Glass | 02.00 | 03.00 | 01.00 | 04.00 | 03.00 | 01.00 |
| Textile | 04.00 | 01.00 | 04.00 | 03.00 | 05.00 | 07.00 |
| E-waste | 01.00 | 01.00 | 02.00 | 03.00 | 01.00 | 02.00 |
| **Total** | **100.00** | **100.00** | **100.00** | **100.00** | **100.00** | **100.00** |

Source: Field survey (2026).

**Overall Waste Composition**

When the six sampling points are considered together, organic waste accounted for 46.87% of the total waste stream, followed by plastics (25.72%) and paper (16.21%). Metals, glass, textiles, and e-waste accounted for 3.70%, 2.30%, 3.73%, and 1.47%, respectively (**Table 4**). As shown in **Figure 2**, organic waste, plastics, and paper together accounted for approximately 88.80% of the total waste stream.

This concentration suggests that targeted interventions addressing these three fractions could divert a substantial share of the waste generated at the school (Diggle & Walker, 2022; Millanzi et al., 2023). Similar patterns have been reported in Ghanaian household and educational institution waste studies. Tahiru et al., (2024) found that organic materials dominated Ghana's household waste stream, while (Owojori et al., 2020; Subamathi et al., 2025) identified organic waste, paper, and plastics as major components of waste generated in educational institutions.

The result also reinforces the argument that waste characterization should precede waste management planning. Without quantitative knowledge of the composition, management interventions may focus disproportionately on final disposal while underutilizing potentially recoverable materials.

**Table 4**: Overall composition and estimated mass of solid waste

| **Waste category** | **Total mass (kg)** | **Overall composition (%)** |
|---|---|---|
| Organic | 3,209.04 | 46.87 |
| Plastic | 1,761.10 | 25.72 |
| Paper | 1,110.20 | 16.21 |
| Metal | 253.28 | 03.70 |
| Glass | 157.37 | 02.30 |
| Textile | 255.40 | 03.73 |
| E-waste | 100.40 | 01.47 |
| **Total** | **6,846.80** | **100.00** |

Source: Field survey (2026).

ISSN 2278-2540 | DOI: 10.51583EMAS | Volume XV, Issue X, October2026

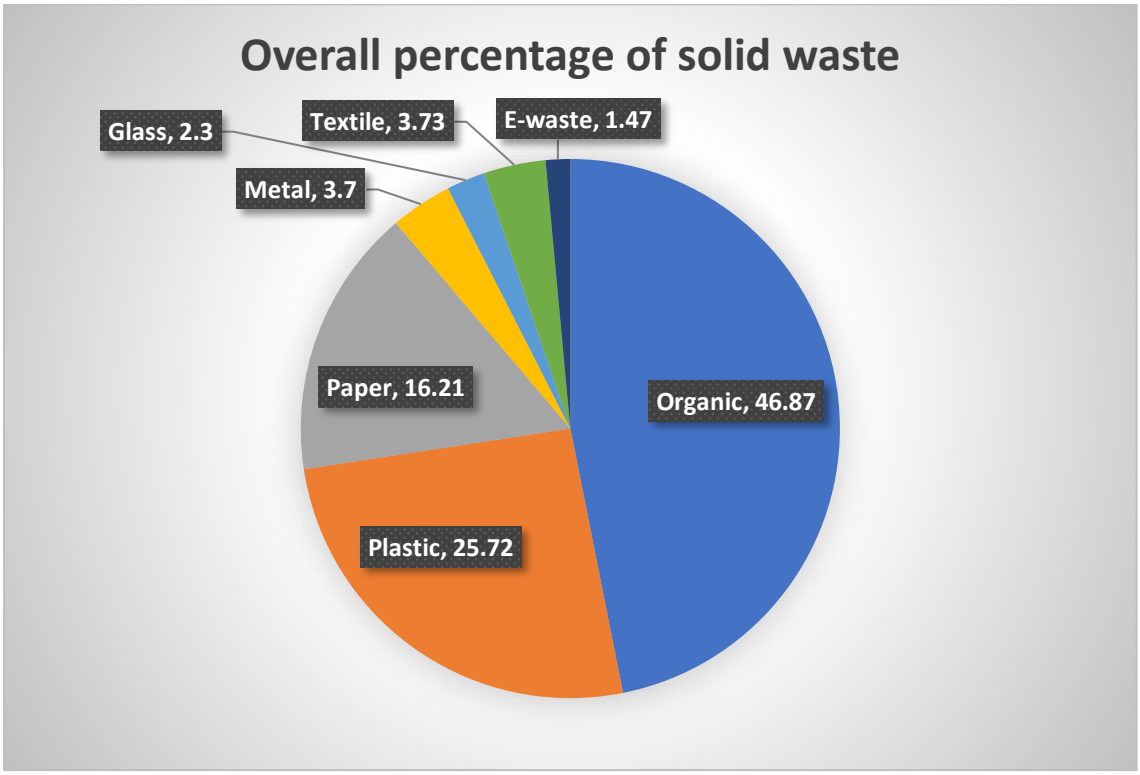



**Figure 2:** Overall percentage composition of solid waste generated at JUASTECH.

**Recycling and Resource Recovery Opportunities**

The total mass of conventionally recyclable materials (plastics, paper, metals, and glass) was 3,281.95 kg, equivalent to approximately 47.93% of the total waste stream. Plastics accounted for the largest share (1,761.10 kg), followed by paper (1,110.20 kg); metals and glass contributed smaller amounts (**Table 5**).

The high quantity of plastics is significant because plastics can persist in the environment and are particularly problematic when mixed with organic waste (Al-Shatnawi et al., 2020). However, effective recycling depends strongly on source separation and contamination control. Spierling et al., (2026); Zakarya et al., (2020) highlighted the importance of separation efficiency in waste management and the value of separating biodegradable waste from other fractions.

Administration Block had the highest recyclable fraction at 81.00%, driven primarily by its 50.00% paper content. This suggests that a dedicated paper-recovery programme could be particularly effective in administrative areas. The Classroom Block also demonstrated considerable recovery potential, largely because paper and plastics represented substantial proportions of its waste stream.

The Dining Hall had the lowest conventional recyclable fraction at 28.00%, which is not surprising considering its high organic content. This is important as it shows that recycling alone cannot be the only waste-diversion method employed by the school. At food-service facilities, source separation of organic waste and composting may be more important than maximizing conventional recycling.

The high recovery potential observed across several areas is consistent with findings by Elijah et al., (2023); Scarlat et al., (2015), who reported that 97% of the waste in their study fell within their recyclable category and recommended recycling and composting as sustainable treatment options.

However, the 97% figure should not be applied directly to the present study because the studies may use different classification systems. In the cited studies, organic waste was classified as recyclable or compostable material; comparisons should therefore be made only after confirming that the categories are defined consistently.

ISSN 2278-2540 | DOI: 10.51583EMAS | Volume XV, Issue X, October2026

**Table 5**: Potentially recyclable material generated at the selected sampling points

| Sampling point | Plastic (kg) | Paper (kg) | Metal (kg) | Glass (kg) | Total recyclable material (kg) | Recyclable fraction (%) |
|---|---|---|---|---|---|---|
| Student R. House | 475.00 | 95.00 | 57.00 | 38.00 | 665.00 | 35.00 |
| Dining Hall | 300.00 | 45.00 | 30.00 | 45.00 | 420.00 | 28.00 |
| Classroom Block | 230.00 | 320.00 | 30.00 | 10.00 | 590.00 | 59.00 |
| Laboratory Block | 195.00 | 174.20 | 48.78 | 27.87 | 445.95 | 64.00 |
| Open Space | 361.00 | 76.00 | 47.50 | 28.50 | 513.00 | 54.00 |
| Administration Block | 200.00 | 400.00 | 40.00 | 8.00 | 648.00 | 81.00 |
| **Total** | **1,761.10** | **1,110.20** | **253.28** | **157.37** | **3,281.95** | **47.93** |

Source: Field survey (2026).

**Organic Waste and Composting Potential**

The organic fraction totalled 3,209.04 kg over the 14-day period, making it the largest waste category. The Dining Hall had the highest organic fraction (70.00%), followed by the Student Residential House (60.00%). This large organic fraction suggests that composting could be a key component of the school's waste diversion strategy. Safo-Adu & Owusu-Adzorah, (2023) also recommended composting for the biodegradable fraction of secondary-school waste and reported that more than half of the waste stream was biodegradable under their classification. Composting could reduce the amount of biodegradable waste sent for disposal and convert part of the waste stream into a useful product for landscaping or other purposes. Its success would, however, depend on keeping plastics, glass, and other contaminants out of the organic fraction.

**Priority Recovery Stream of Plastics**

Plastics accounted for 25.72% of the total waste stream and were particularly prominent in the Open Space, where they represented 38.00% of the waste. The Student Residential House and Administration Block also generated substantial quantities of plastic waste. Plastic waste can persist in the environment for years and may be dispersed when collection systems are ineffective (Hira et al., 2022). Miezah et al., (2015) estimated that plastics accounted for 14% of household waste in Ghana, although the proportion varied geographically and by waste source. For JUASTECH, plastic recovery should be concentrated at high-consumption locations. Collection bins for plastic packaging could be placed around the Open Space, Dining Hall, and residential areas to reduce contamination and increase the volume of material available to recycling operators.

**Paper Recovery from Academic and Administrative Sources**

Paper accounted for 16.21% of the overall waste stream and was especially prominent in the Administration Block (50.00%) and Classroom Block (32.00%). Paper recovery is technically easier when paper is separated from wet organic waste. Safo-Adu & Owusu-Adzorah, (2023) also identified the Classroom Block as the main source of paper waste in their assessment of secondary schools in Kumasi. The Administration

ISSN 2278-2540 | DOI: 10.51583EMAS | Volume XV, Issue X, October2026

and Classroom Blocks could introduce a dedicated paper-recovery system before paper is mixed with food or other wet materials. Source segregation would improve the quality of recovered paper and potentially reduce the quantity of waste requiring disposal (Syguła et al., 2021).

### E-Waste and Specialized Materials

E-waste accounted for a relatively small proportion of the total mass (1.47%). Nevertheless, it should be managed according to its material characteristics rather than mass alone. The e-waste proportions recorded in the Laboratory Block (3.00%) and Administration Block (2.00%) indicate that electronic equipment and related activities require careful handling. Metals, glass, and textiles were present in smaller proportions but may still have recovery value. Depending on their condition, textiles may be reused or recycled. Co-collection with general waste makes these materials harder to recover because mixing increases contamination and complicates sorting (Asefi et al., 2019; Vega et al., 2010).

### Implications for Sustainable Waste Management

The results suggest that the main waste-management opportunity at JUASTECH is not simply to increase the frequency of final disposal, but to establish a source-segregated recovery system. Prioritise organic waste collection in the Student Residential House and Dining Hall. Paper recovery should be prioritised in the Classroom and Administration Blocks, while plastic-collection facilities should also be placed in the Open Space. Specialised and electronic materials should be handled separately, particularly in the Laboratory Block. This functional-area approach is consistent with integrated waste management, in which waste prevention, segregation, reuse, recycling, biological treatment, and final disposal are treated as complementary components rather than independent activities (Rada et al., 2021). Research from Ghanaian educational institutions has also highlighted recycling and composting as options for reducing the amount of waste requiring disposal (Asare et al., 2022; Dery et al., 2018). An effective school system should therefore focus on three priorities: segregation at source, recovery of valuable materials, and controlled management of residual waste. These measures would reduce cross-contamination, improve the quality of recoverable materials, and support more systematic waste management.

## CONCLUSION

### Synthesis of Key Findings

This study provides empirical evidence that solid waste generation and composition vary significantly across the functional areas of Juaso Senior High Technical School. The total waste generated over the 14-day period was 6,846.80 kg, corresponding to an average daily generation of 489.06 kg/day. The Student Residential House recorded the highest waste generation (1,900.00 kg), followed by the Dining Hall (1,500.00 kg), while the Laboratory Block recorded the lowest (696.80 kg). Organic waste was the dominant component (46.87%), followed by plastics (25.72%) and paper (16.21%).

### Limitations

Several limitations should be acknowledged. First, the study was conducted at a single institution, which limits the generalizability of the findings. Second, the 14-day sampling period may not fully represent seasonal or term-time variations. Third, the study did not measure behavioural variables such as student attitudes regarding waste segregation. Finally, manual sorting is subject to human error, though inter-sorter reliability was checked.

### Implications for JUASTECH

The study recorded an average of approximately 229.22 kg of organic waste per day over the 14-day period. The school could introduce composting in phases, beginning with a facility designed to process 200 kg/day,

ISSN 2278-2540 | DOI: 10.51583EMAS | Volume XV, Issue X, October2026

provided that the remaining organic waste is managed separately and capacity is reviewed as the programme develops.

### Future Research Directions

Future research should conduct multi-institution studies, extend the sampling period to capture seasonal variations, incorporate behavioural surveys, and evaluate the effectiveness of implemented segregation and composting programmes over time.

## RECOMMENDATIONS

- Source-segregated waste bins should be installed at all major generation points, prioritizing the Student Residential House and Dining Hall for organic waste segregation.
- Composting programme: Given the generation of approximately 229 kg/day of organic waste, the school should establish a composting facility with an initial capacity of 200 kg/day.
- Paper recovery programme: A dedicated paper collection system should be established in the Administration Block and Classroom Block, where paper constitutes 50.00% and 32.00% of waste respectively.
- Plastic recovery: Plastic collection points should be strategically located in the Open Space (38.00% plastic) and Student Residential House (25.00%).
- E-waste management: A separate collection system should be established, particularly in the Laboratory Block (3.00% e-waste), with arrangements for safe disposal.
- Education and awareness: A sustained education campaign should be implemented to train students and staff on waste segregation practices.
- Partnerships: The school should collaborate with local recycling companies and NGOs to ensure that separated materials are effectively utilized.

### Acknowledgements

The authors thank the Environmental Science Department of the University of Education, Winneba, Ghana.

### Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

## REFERENCES

1. Adeniran, A. E., Nubi, A. T., & Adelopo, A. O. (2017). Solid waste generation and characterization in the University of Lagos for a sustainable waste management. Waste Management, 67, 3–10. https://doi.org/10.1016/j.wasman.2017.05.002
2. Al-Shatnawi, Z., Alnusairat, S., & Kakani, A. (2020). Towards Zero Solid Waste in Jordanian Universities: The Case of Al-Ahliyya Amman University. https://doi.org/10.5755/j01.erem.76.4.27369
3. Amo-Asamoah, E., Owusu-Manu, D. G., Asumadu, G., Ghansah, F. A., & Edwards, D. J. (2020). Potential for waste to energy generation of municipal solid waste (MSW) in the Kumasi metropolis of Ghana. International Journal of Energy Sector Management, 14(6), 1315–1331. https://doi.org/10.1108/IJESM-12-2019-0005
4. Ampofo, J. A. (2020). Implications of Poor Waste Disposal Management Practices on Senior High Schools Within the Wa Municipality of Ghana. International Journal of Applied Research in Social Sciences, 2(3), 53–70. https://doi.org/10.51594/ijarss.v2i3.156
5. Asare, W., Telunaya, R., Boaka, R., & Gameli, H. (2022). Plastic Waste Generation and Source Separation by Tertiary Students: A Case Study on a University Campus in Ghana. J Waste Manag Disposal, 5(1), 102. www.scholarena.com
6. Asefi, H., Lim, S., Maghrebi, M., & Shahparvari, S. (2019). Mathematical modelling and heuristic approaches to the location-routing problem of a cost-effective integrated solid waste management.

ISSN 2278-2540 | DOI: 10.51583EMAS | Volume XV, Issue X, October2026

Annals of Operations Research, 273(1–2), 75–110. https://doi.org/10.1007/s10479-018-2912-1
7. Balcom, P. (2025). Advancing Campus Sustainability through Waste Sorting and Value Addition at Gulu University. 2025 IEEE Global Humanitarian Technology Conference, GHTC 2025, 1–2. https://doi.org/10.1109/GHTC66843.2025.11266540
8. Baldwin, E., & Dripps, W. (2012). Spatial characterization and analysis of the campus residential waste stream at a small private Liberal Arts Institution. Resources Conservation and Recycling, 65, 107–115. https://doi.org/10.1016/J.RESCONREC.2012.06.002
9. Bartlett II, J. E., Kotrlik, J. W., & Higgins, C. C. (2001). Determing appropriate sample size in survey research. Information Technology, Learning, and Performance Journal, 19(1), 43–50. https://www.opalco.com/wp-content/uploads/2014/10/Reading-Sample-Size1.pdf
10. Bhusal, P., Bashyal, K., Pandit, R., & Adhikari, B. (2020). Qualitative and Quantitative Analysis of Municipal Solid Waste (MSW) in Butwal Sub-metropolitan City, Nepal. Acta Scientific Agriculture, 4(9), 03–08. https://doi.org/10.31080/asag.2020.04.0883
11. Boskovic, G., & Jovicic, N. (2015). Fast methodology to design the optimal collection point locations and number of waste bins: A case study. Waste Management and Research, 33(12), 1094–1102. https://doi.org/10.1177/0734242X15607426
12. Cadavid-Rodríguez, L. S., & Agudelo-Morales, C. E. (2017). SOLID WASTE MANAGEMENT IN A COLOMBIAN UNIVERSITY. https://www.semanticscholar.org/paper/f2a102bfc5725f79e40c391031b0586d24879dd7
13. Cochran, W. G. (1997). Cochran_1977_Sampling_Techniques_Third_E.pdf (pp. 76–78). https://www.academia.edu/29684662/Cochran_1977_Sampling_Techniques_Third_Edition
14. Dery, F., Kuusaana, E., & Owusu-Sekyere, E. (2018). 2018 Solid Waste Characterization and Recycling Potential for University Campuses in Ghana: Case Study of Two Ghanaian Universities. Journal of Waste Recycling, Vol.3(No.1:3), 1–9. https://www.imedpub.com/articles/solid-waste-characterization-and-recycling-potential-for-university-campuses-in-ghana-case-study-of-two-ghanaian-universities.pdf%0Ahttp://www.imedpub.com/resources-recycling-and-waste-management/
15. Diggle, A., & Walker, T. R. (2022). Environmental and Economic Impacts of Mismanaged Plastics and Measures for Mitigation. Environments - MDPI, 9(2). https://doi.org/10.3390/environments9020015
16. Elijah, E. U., Ojo, D. O., Yakubu, E. A., Ezeuzo, E. B., & Cyril, C. (2023). Life Cycle Assessment ( LCA ) of Solid Waste Management Systems in African Countries : A Systematic Review. Kurdistan University of Medical Sciences, 11(4), 194–204. https://doi.org/10.34172/jaehr.1306
17. Gesuli-saliba, K. A., Kabutey, F. T., Annan, S. T., Nyieku, F. E., Agbosu, W. K., & Lumorh, P. D. (2026). Solid Waste Generation and Management Practices at the University of Education , Winneba. 16(3), 905–926. https://doi.org/10.4236/ojapps.2026.163054
18. Hira, A., Pacini, H., Attafuah-Wadee, K., Vivas-Eugui, D., Saltzberg, M., & Yeoh, T. N. (2022). Plastic Waste Mitigation Strategies: A Review of Lessons from Developing Countries. Journal of Developing Societies, 38(3), 336–359. https://doi.org/10.1177/0169796X221104855
19. Igibah, E. C., Agashua, L., & Sadiq, A. A. (2019). Influence of wastes management and viable improvement in Nigeria: case study of Kubwa, Abuja in Northern Nigeria. IOP Conference Series: Earth and Environmental Science, 331, null. https://doi.org/10.1088/1755-1315/331/1/012011
20. Karuku, L. C., & Kathula, D. N. (2021). Rapid Urbanization, a Solid Waste Management Challenge in Micro, Small and Medium Enterprises in Kenya: A Case Study of Kawangware Ward in Nairobi. Journal of Entrepreneurship & Project Management, 5(2), 84–96. https://stratfordjournals.org/journals/index.php/journal-of-entrepreneurship-proj/article/view/828
21. Khan, A. H., López-Maldonado, E. A., Alam, S. S., Khan, N. A., López, J. R. L., Herrera, P. F. M., Abutaleb, A., Ahmed, S., & Singh, L. (2022). Municipal solid waste generation and the current state of waste-to-energy potential: State of art review. Energy Conversion and Management, 267(March). https://doi.org/10.1016/j.enconman.2022.115905
22. Malakahmad, A., Nasir, M., Kutty, S., & Isa, M. (2010). Solid Waste Characterization and Recycling Potential for University Technology PETRONAS Academic Buildings. American Journal of Environmental Sciences, 6, 422–427. https://doi.org/10.3844/AJESSP.2010.422.427
23. Masjhoer, J. M., Retawimbi, A. Y., & Sari, Y. S. (2020). PARTICIPATION OF LOCAL RESTAURANTS IN SOLID WASTE MANAGEMENT IN SOUTH COAST OF GUNUNGKIDUL

ISSN 2278-2540 | DOI: 10.51583EMAS | Volume XV, Issue X, October2026

REGENCY, INDONESIA. Volume 4 No. 1 Maret 2020, null, null. https://doi.org/10.23969/jcbeem.v4i1.1978

24. Mason, I. G., Oberender, A., & Brooking, A. K. (2004). Source separation and potential re-use of resource residuals at a university campus. Resources Conservation and Recycling, 40, 155–172. https://doi.org/10.1016/S0921-3449(03)00068-5
25. Mbuligwe, S. E. (2002). Institutional solid waste management practices in developing countries : a case study of three academic institutions in Tanzania. 35, 131–146.
26. Miezah, K., Obiri-Danso, K., Kádár, Z., Fei-Baffoe, B., & Mensah, M. Y. (2015). Municipal solid waste characterization and quantification as a measure towards effective waste management in Ghana. Waste Management, 46, 15–27. https://doi.org/10.1016/j.wasman.2015.09.009
27. Millanzi, W. C., Herman, P. Z., & Mtangi, S. A. (2023). Knowledge, attitude, and perceived practice of sanitary workers on healthcare waste management: A descriptive cross-sectional study in Dodoma region,Tanzania. SAGE Open Medicine, 11. https://doi.org/10.1177/20503121231174735
28. Moqbel, S. (2018). Solid waste management in educational institutions: The case of the University of Jordan. Environmental Research, Engineering and Management, 74(2), 23–33. https://doi.org/10.5755/j01.erem.74.2.21037
29. Mukhtar, E. M., Williams, I. D., Shaw, P. J., & Ongondo, F. O. (2016). A tale of two cities: The emergence of urban waste systems in a developed and a developing city. Recycling, 1(2), 254–270. https://doi.org/10.3390/recycling1020254
30. Ng, C. G., & Yusoff, S. (2013). Municipal solid waste characterization for a university campus : University of Malaya. https://www.semanticscholar.org/paper/fdbb48aa26e36c3895728b8bf62a3e3ced52741b
31. Nyakuma, B. B., & Ivase, T. J. P. (2021). Emerging trends in sustainable treatment and valorisation technologies for plastic wastes in Nigeria: A concise review. Environmental Progress and Sustainable Energy, 40(5). https://doi.org/10.1002/ep.13660
32. Ojuri, O. O., Olowoselu, A. S., Akinrele, J., Ayodele, F. O., & Jayejeje, O. O. (2024). Sustainable integrated solid waste management for a university campus − A case study of the Federal University of Technology Akure (FUTA), Nigeria. Waste Management Bulletin, 2(2), 161–170. https://doi.org/10.1016/j.wmb.2024.04.004
33. Owojori, O., Edokpayi, J. N., Mulaudzi, R., & Odiyo, J. O. (2020). Characterisation, recovery and recycling potential of solid waste in a university of a developing economy. Sustainability (Switzerland), 12(12), 1–17. https://doi.org/10.3390/su12125111
34. Pinto, R. B., Barendse, T., van Emmerik, T., van der Ploeg, M., Annor, F. O., Duah, K., Udo, J., & Uijlenhoet, R. (2023). Exploring plastic transport dynamics in the Odaw river, Ghana. Frontiers in Environmental Science, 11(February), 1–11. https://doi.org/10.3389/fenvs.2023.1125541
35. Polin, K., Yigitcanlar, T., Limb, M., & Washington, T. (2023). The Making of Smart Campus: A Review and Conceptual Framework. Buildings, 13(4). https://doi.org/10.3390/buildings13040891
36. Potiracha, Y., & Baars, R. C. (2026). A review of remote sensing technology for plastic waste monitoring. Environmental Science and Pollution Research, 33(3), 766–782. https://doi.org/10.1007/s11356-025-37347-7
37. Rada, E. C., Tolkou, A., Katsoyiannis, I., Magaril, E., Kiselev, A., Conti, F., Schiavon, M., & Torretta, V. (2021). EVALUATING GLOBAL MUNICIPAL SOLID WASTE MANAGEMENT EFFICIENCY from A CIRCULAR ECONOMY POINT of VIEW. WIT Transactions on Ecology and the Environment, 253, 207–218. https://doi.org/10.2495/SC210181
38. Ratnaningrum, A. Y., Maharani, O., & Yudiarto, D. A. (2024). Legal Protection for Health Workers against Occupational Safety and Health Standards in Hospital. Green Medical Journal, null, null. https://doi.org/10.33096/gmj.v6i2.186
39. Rodríguez-Guerreiro, M. J., Torrijos, V., & Soto, M. (2024). A Review of Waste Management in Higher Education Institutions: The Road to Zero Waste and Sustainability. Environments - MDPI, 11(12), 1–24. https://doi.org/10.3390/environments11120293
40. Safo-Adu, G., & Owusu-Adzorah, N. (2023). Solid waste characterisation and recycling potential: A study in secondary schools in Kumasi Metropolis, Ghana. Cleaner Waste Systems, 4(September 2022). https://doi.org/10.1016/j.clwas.2022.100065

ISSN 2278-2540 | DOI: 10.51583EMAS | Volume XV, Issue X, October2026


41. Saleem, M., Blaisi, N. I., Alshamrani, O., & Al-Barjis, A. (2018). Fundamental investigation of solid waste generation and disposal behaviour in higher education institute in the Kingdom of Saudi Arabia. Indoor and Built Environment, 28, 927–937. https://doi.org/10.1177/1420326X18804853
42. Sarquah, K., Narra, S., Beck, G., Bassey, U., Antwi, E., Hartmann, M., Derkyi, N. S. A., Awafo, E. A., & Nelles, M. (2023). Characterization of Municipal Solid Waste and Assessment of Its Potential for Refuse-Derived Fuel (RDF) Valorization. Energies, 16(1). https://doi.org/10.3390/en16010200
43. Scarlat, N., Motola, V., Dallemand, J. F., Monforti-Ferrario, F., & Mofor, L. (2015). Evaluation of energy potential of Municipal Solid Waste from African urban areas. Renewable and Sustainable Energy Reviews, 50, 1269–1286. https://doi.org/10.1016/j.rser.2015.05.067
44. Smyth, D., Fredeen, A., & Booth, A. (2010). Reducing solid waste in higher education: The first step towards 'greening' a university campus. Resources Conservation and Recycling, 54, 1007–1016. https://doi.org/10.1016/J.RESCONREC.2010.02.008
45. Spierling, S., Barner, L., & Endres, H. (2026). Plastics and Sustainable Development – Identifying and Quantifying Ecodesign Strategies for Plastics. https://doi.org/10.1002/gch2.202500033
46. Starovoytova, D., & Namango, S. (2018). Solid Waste Management at University Campus (Part 4/10): Perceptions, Attitudes, and Practices of students and vendors. Journal of Environment and Earth Science, 8, 108–142. https://www.semanticscholar.org/paper/9612c87b6816d88a48f6bb424e0c0a97d19246c0
47. Subamathi, P., Poornima, K., D, M. M., & Kumaragurubaran, N. (2025). A Case Study on Campus Plastic Waste : An Audit. October.
48. Syafrudin, S., Masjhoer, J. M., & Maryono, M. (2023). Characterization and quantification of solid waste in rural regions. Global Journal of Environmental Science and Management, 9(2), 337–352. https://doi.org/10.22034/gjesm.2023.02.12
49. Syguła, E., Świechowski, K., Stępień, P., Koziel, J. A., & Białowiec, A. (2021). The prediction of calorific value of carbonized solid fuel produced from refuse-derived fuel in the low-temperature pyrolysis in co2. Materials, 14(1), 1–17. https://doi.org/10.3390/ma14010049
50. Tahiru, A. W., Cobbina, S. J., & Asare, W. (2024). Evaluation of energy potential of MSW in the Tamale metropolis, Ghana: An assessment of solid waste characteristics and energy content. Journal of the Air and Waste Management Association, 74(9), 639–663. https://doi.org/10.1080/10962247.2024.2380802
51. Tariq, N., Khan, S. B., Sajjad, N., Zaheer, N., & Urooj, R. (2024). Socio-Environmental Impacts of Solid Waste Management. Kurdish Studies, 12(4), 78–91. https://doi.org/10.53555/ks.v12i4.2940
52. Ugwu, C. O., Ozoegwu, C. G., & Ozor, P. A. (2020). Solid waste quantification and characterization in university of Nigeria, Nsukka campus, and recommendations for sustainable management. Heliyon, 6(6), e04255. https://doi.org/10.1016/j.heliyon.2020.e04255
53. Vega, C. A., Ojeda-Benítez, S., Aguilar-Virgen, Q., & Taboada-González, P. (2010). Solid Waste Management in a Mexican University Using a Community-Based Social Marketing Approach. The Open Waste Management Journal, 3, 146–154. https://doi.org/10.2174/1875934301003010146
54. WHO. (2024). Compendium of WHO and other UN guidance on health and environment. World Health Organization (WHO), 14. https://iris.who.int/handle/10665/378095
55. Yukalang, N., Clarke, B., & Ross, K. (2017). Barriers to Effective Municipal Solid Waste Management in a Rapidly Urbanizing Area in Thailand. International Journal of Environmental Research and Public Health, 14, null. https://doi.org/10.3390/ijerph14091013
56. Zakarya, I. A., Fazhil, N. S. A., Izhar, T. N. T., Zaaba, S. K., & Jamaluddin, M. N. F. (2020). Municipal solid waste characterization and quantification as a measure towards effective solid waste management in UniMAP. IOP Conference Series: Earth and Environmental Science, 616(1). https://doi.org/10.1088/1755-1315/616/1/012047