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Solid Waste Estimation Per Capita in Equity Girls Hostel Blocks, Igbinedion University Okada, Nigeria

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A B S T R A C T

Characterization and quantification of solid waste in Equity girls hostel blocks, Igbinedion University Okada was carried out to provide data for waste management strategy in the University. The waste survey was done for 3 months by collecting generated wastes from various rooms on a daily basis excluding Sundays. The collected wastes were segregated and sorted into their various constituents and weighed using an automatic weighing scale. Waste per capita per head was also determined by estimating the total number of students/population in the study area. Identified wastes constituents were plastics, paper, glass, bottles, organic wastes, etc. The total amount of waste recorded was 1605.65kg for 3 months. Organic wastes recorded the highest amount of wastes generated with a total of 304.542kg (19%) followed by glass/bottles recorded as 250.993kg (16%). Waste per capita per day was estimated as 0.045kg. From the wastes stream, some wastes were identified as reusable and recyclable which can generate income for the university when properly handled and it will indirectly aid in decreasing the volume and amount of wastes to be disposed. Organic wastes have been identified to constitute the highest amount of waste in the waste stream. These organic wastes are degradable and can be utilized for crop production and agricultural purposes which invariably contribute to waste stream reduction. Adopting efficient waste mangement strategy will create wealth, reduce pollution and demand on raw materials, and provide a greener environment.

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INTRODUCTION

Solid wastes are materials in the solid form generated and produced due to human activities and are discarded as useless and unwanted to the environment. It was a serious environmental problem beforehand. Problems and risks associated with solid wastes and their indiscriminate disposal on society cannot be over-emphasized. Humans and their activities cannot be void of generating wastes, but the major challenges anchor on the control, management, and disposal of these wastes in an environmentally friendly manner without hazards or health implications. The invention of new technologies, products, and services has changed the quality and quantity of produced wastes over the years. Standard of living, economy, peoples' income, culture, etc., affects waste characteristics and volume of waste disposed within a region or community. Development influences society positively and negatively, of which waste generation and its environmental burden are one of them. Waste problems, impacts and risks must always be an integral part of human existence [1]. Solid wastes refer to wastes which are solid in nature. Liquid wastes may be categorized or considered as wastewater while gaseous waste may be termed air pollution. However, these wastes are coined especially with regard to their nature, efforts must be made to ameliorate their pollution effect on the environment and society. The responsibility of solid waste and its management does not bother on government and its tiers alone, individuals must also get involved. Management of wastes individually is the originating point of control which coincidentally handles the waste at the generating point. Some wastes which may have been discarded at the generation point may still be useful at

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another end termed as reuse. But many of these waste substances can be reused and can be a resource for an industry [2].

Solid waste sources and types are categorized based on the nature of activities from which the wastes evolved. Domestic or residential waste are wastes generated from homes or residential apartment [3]. Institutional wastes originate from schools; primary, secondary, and higher institutions or places of learning, churches, hospitals, offices and government establishments like courts etc. Commercial wastes originate from places where commercial activities occur such as markets, parking lots, plazas, recreational centers, cinemas, stores, hotels, restaurants. Industrial waste: industrial waste constitute hazardous and non-hazardous chemicals, processes, production and manufacturing activities that release solid waste into the environment. The amount of waste depends on the quantity and type of product manufactured. Agricultural wastes mainly comprise agricultural bye products. They are basically of organic origins such as garbage and rubbish. Vegetables, fruits, cassava peels, rice husk are examples of agricultural wastes. Construction and demolition waste are generated from the construction, renovation, and demolition sites e.g., include concrete, wood, brick pieces, steel, metals, etc. Some materials can be recovered from wastes. Managing solid waste is the most tedious and unpredictable essential services due to its spontaneous change and heterogeneous nature that may happen over time e.g., rapid urbanization. Rapid urbanization creates changes in the waste characteristics, composition and volume, due to population increase, the establishment of industries and businesses, etc. Environment and human health can be affected by poor and inadequate solid waste management. Indiscriminate disposal of wastes and improper or lack of solid waste management deteriorates society and impair human health [3]. The risks associated involved the following though not limited; environmental sanitation degradation; blockage of drains leading to flooding and accidents; loss of lives and properties, breeding places and sites for mosquitoes and other rodents that transmit diseases; contamination of water bodies with chemicals and leachate from dumpsites, etc. Toxic materials and chemicals may percolate into the soil and contaminate the groundwater [4]. The objective of a solid waste management scheme is to decrease the volume and amount of waste disposed of and its impacts on the environment in a very controlled manner without creating another environmental problem. Managing solid wastes begins with characterization and quantification of generated solid waste which is the main focus of this project. In Igbinedion University Okada, the management and handling of solid waste has not been fully effectuated and implemented. For effective and efficient suitable solid waste management, necessary information on waste characteristics, composition, and volume of waste expected within the area are needed. Hence the necessity of this research. According to Abila and Kantola [5], inefficient and improper management of solid waste by consumers can be attributed to inadequate and lack of information on waste quantity, handling, management, and implementation. Also, the identification of reuseable materials will help to reduce the quantum of waste discarded from the hostel. One of the societal challenges is to minimize waste generation and convert it to a useful resource [6]. This research aim is to quantify and characterize solid waste generated in the hostel with the objectives to; identify and recover useable materials for reuse or energy recovery; characterize the waste into their various constituents for proper management and control; estimate the total generated wastes in the study hostel. The purpose of this work is to evaluate per waste generation of students in the hostel per capita.

MATERIAL AND METHODS

Study area

Equity hostels are girls' hostels located in the residential crown estate, Igbinedion University Okada, Edo State Nigeria. The hostels are mainly for students from 200L to 500L of all disciplines in the University. Some commercial stores such as restaurants, hair salons, barbers shops, etc, are located within the hostels' premises. They perform commercial activities including the selling of essential commodities, goods, and services needed for the well-being of students which invariably contribute to the volume of wastes generated in the study area**.** Figure 1 is the front view of Equity girls' hostels in Igbinedion University Okada**.** Equity girls' hostels have three structural buildings which are named block A, block B, and block C as shown in Figure 1. Each of the hostel (block) has a total of 42 rooms. Therefore, the total number of rooms for all the blocks summed up to 126 rooms. The total number of rooms occupied by students is 123 rooms while the remaining 3 rooms serve as porters/administration offices. No of residents in each room is a maximum of 3 students and a minimum of 2

Figure 1. Front view of Equity girls' hostels in Crown Estate Campus, Igbinedion University Okada

students.The total number of residents in Equity girls' hostels is 369 students. The hostels also have other residents in the compound who contribute to the waste generation chain for example the guards, cleaners, food shop owners, tailors, porters etc, which are estimated to be 25 people in total. Figure 2 is the dumping site of wastes in Equity girls' hostels. All the collected wastes from various rooms and blocks are dumped at the dumping site.

Materials and equipment

Materials utilized in carrying out this research are textbooks, journals, online resources, etc., while equipment includes hand gloves, polyethylene bags, weighing scale, nose mask, boots, cell tape, book and pen for recording data, etc. Figure 3 is an automatic weighing scale (WeiHeng Model) used in this project.

Methodology

The research methodology is outlined for the purpose of achieving the stated aim and objectives.

Estimation of number of rooms

Rooms in each block of equity girls hostels were identified and the total number of rooms in each block being occupied by students is 41. Therefore, for the three blocks, the total number of rooms is 123.

Figure 2. Dumping site of generated waste

Figure 3. Automatic weighing balance

Estimation of the number of students and residents in the hostel for the 2020/2021 academic session

Three students are allocated in each room, thus a total number of 369 students are in Equity hostel blocks. Also, 25 other residents which include guards, porters, cleaners, etc. were also counted. Therefore, the population count for this project is estimated at 394 persons.

Collection of generated waste

The generated wastes from students' rooms and other sources were collected on a daily basis morning and evening excluding Sundays. Collected wastes on Monday were regarded as 2 days count.

Handling of collected wastes

Wastes were collected from storage bins located in front of the students' rooms. Segregation and sorting of wastes into various constituents/ components were done manually. Weighing of the individual waste components for each day was done using an automatic weighing scale. Total wastes collected within the period were recorded and per waste capita was evaluated. Figure 4 is segregated wastes in the components packed in polyethylene bags for weighing.

Disposal of collected wastes

Wastes are disposed of at a scheduled time mostly in the morning and evening in a secluded area at a reasonable distance from the hostel blocks. The wastes generated in the hostel are taken care of by the hostel workers and cleaners. They accumulate the wastes at the dumping site before burning them. The measured wastes were also sent finally to the dumping site after recording.

Estimation of per capita of waste generation

Waste generation rate for each student/resident of Equity girls hostel blocks was calculated using the total amount of waste collected for 3 months estimated as 90 days and the population count estimated in the blocks/premises as described in Equation (1):

Figure 4. Segregated wastes packed in polyethylene bags

$$Grcd = \frac{Twc(kg)}{Pc \times number\ of\ days} \quad (1)$$

where *Grcd* means the generation rate per capita per a day, *Pc* means the count of population within the study area, and *Twc* is the total collected waste.

RESULTS AND DISCUSSION

The solid waste survey was carried out within the study area for 3 months from February 22nd to June 5th, 2021 excluding Sundays. The sorted wastes constituents include organic wastes, paper, plastic glass bottles, tin and cans, rubber, food pack, leather and textile materials, sanitary pads. The composition/constituents of wastes collected are recorded in days of the week as summarized in Table 1. From Table 1, organic waste recorded the highest amount of wastes collected of about 28.307kg followed by glass/bottles (perfumes, wine bottles, etc.) weighing 20.568 kg. Table 2 is the summary table of collected wastes from Equity girls hostel blocks in 12 weeks for 3 months stated. Organic wastes recorded the highest amount of wastes collected which directly depicts its nature of origin and source. This shows that human beings consume more organic products.

Figure 5 revealed the highest order of waste components collected. From Figure 5, organic wastes recorded the highest amount of waste collected at about

Table 1. Composition of waste generated from 22nd – 27th of February 2021 (Week 1)

S/N	Constituents	Mass (kg)						
		Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Total in week 1
1	Organic waste	4.625	3.583	4.930	4.891	6.240	4.038	28.307
2	Paper	0.100	0.203	0.950	0.065	0.330	0.628	2.276
3	Plastic	2.310	2.350	3.612	2.338	2.308	2.734	15.652
4	Polyethylene bags	0.418	0.335	0.370	0.080	0.308	0.310	1.821
5	Glass/Bottle	4.305	3.635	3.953	2.440	2.730	3.505	20.568
6	Tin cans	3.560	2.750	2.800	3.273	2.333	1.935	16.651
7	Rubber	2.186	2.850	3.050	2.365	2.815	3.273	16.539
8	Textile and leather	2.000	1.345	1.625	1.375	1.894	1.500	9.739
9	Sanitary pad	0.955	0.700	0.320	1.308	1.100	1.068	5.451
10	Food packs	2.186	2.350	2.150	2.730	1.686	1.306	12.408

Table 2. Cumulative of all collected wastes in various weeks

S/N	Constituents	Weeks (kg)												
		1	2	3	4	5	6	7	8	9	10	11	12	Total
1	Organic waste	28.31	25.73	26.92	28.84	27.62	28.29	20.31	23.02	21.16	23.82	23.30	27.23	304.54
2	Paper	2.28	5.40	1.79	5.24	3.28	1.72	2.94	2.04	3.30	2.61	4.15	2.75	37.48
3	Plastic	15.63	15.88	17.28	20.09	16.00	17.10	18.57	16.21	19.39	14.95	15.37	17.11	203.57
4	Polyethylene bags	1.82	4.41	3.48	3.13	1.95	2.56	2.88	2.32	2.60	1.88	3.11	2.33	32.47
5	Glass/Bottle	20.57	24.96	21.43	22.52	21.06	15.91	21.18	18.56	22.58	19.26	20.88	22.09	250.99
6	Tin cans	16.65	19.91	15.96	15.14	14.18	15.37	18.45	16.14	19.46	15.77	17.26	16.41	200.71
7	Rubber	16.54	17.27	17.13	18.48	15.91	15.26	17.00	15.45	17.36	13.60	16.06	15.69	195.74
8	Textile and leather	9.74	8.66	8.81	8.44	9.10	4.52	6.55	4.26	7.20	5.15	6.58	7.23	86.21
9	Sanitary pad	5.45	7.82	10.76	6.70	12.12	12.93	7.47	7.70	8.70	7.96	7.84	8.81	104.26
10	Food pack	12.41	14.95	17.62	14.49	20.26	15.39	14.36	15.71	17.46	15.61	15.46	15.95	189.66
	Total	129.39	144.98	141.17	143.07	141.46	129.04	129.73	121.38	139.20	120.62	130.02	135.59	1605.65

304.542kg which invariably showed higher consumption and generation rate of organic products. Diaz et al. [7] reported that organic wastes form the greatest category of waste in every municipal solid waste stream and consequently, take the largest disposal cost or have the capacity to emit the highest greenhouse gases. Organic wastes can be used for compost formation and production applied to soil for enrichment. Compost obtained aerobically is biologically reliable and stable with sufficient chemical balance to be utilized to enrich the soil for agricultural purposes [8]. The university can use these organic wastes for agricultural purpose, According to Bayu et al. [9], biodegradable solid wastes can be converted into charcoal briquette for energy production such as cooking, etc, to reduce the environmental pollution of solid wastes.

Glass, bottles, plastics, and tins used for packaging water, soft drinks, beverages, perfumes, etc, also contribute immensely to the waste stream. Some of these materials can be reused if properly handled at the generation point to avoid contamination. There is a need for a recycling program to be properly adopted by the university management. Some of the plastics and other useable containers are normally picked up by individuals from the dumping site to earn a living; however, the university can initiate a better program to address waste storage and handling for proper segregation which indirectly will form part of the university's internal generated fund. Figure 6 is plastic containers sorted out from the dumping site by an individual for sale or reuse.

Reasonable quantities of rubber, polyethylene bags, food packs, and leather wastes were also recorded from students' hostels. They form part of the materials needed for daily activities. Most students prefer food in food/plastic packs and as such would contribute to the waste stream of students' residential arena. A low quantity of paper could be a result of the digitalized system, where many students have laptops and perform their academic activities online with less paper. Figure 7 showed the pie chart percentage composition of the waste constituents within the study area. Sanitary pads form part of the waste stream because of the gender in the hostel blocks.

Plastic and polyethylene bags contribute to 15% of waste generated in the waste stream. This confirms the assertion by Adedugbe [10] that over 15% of municipal solid waste is generated from nylon and plastics.

Estimation of waste per capita per day

Evaluation of waste per capita per day of the hostel residents was done using Equation (1). Generation rate per person within the study area helps in knowing the expected quantity of waste within a particular time or period which helps and provides information on the volume and amount of waste to be handled.

$$Grcd = \frac{1605.65\ kg}{394\ persons\ or\ students * 90\ days}$$

$$Grcd = 0.045\ kg\ per\ person\ per\ day$$

Figure 6. Plastic containers segregated in Equity girls' hostel blocks

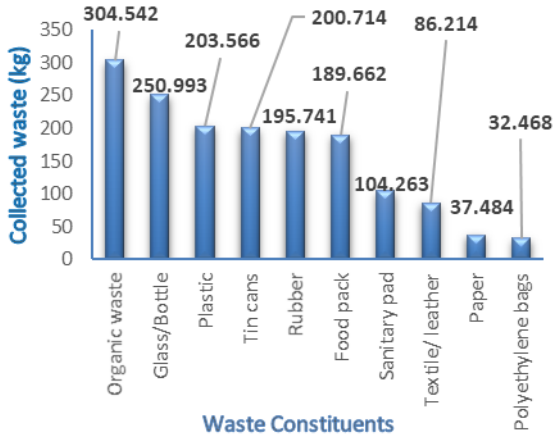

Figure 5. Bar chart of different wastes constituents in Equity girls hostel block

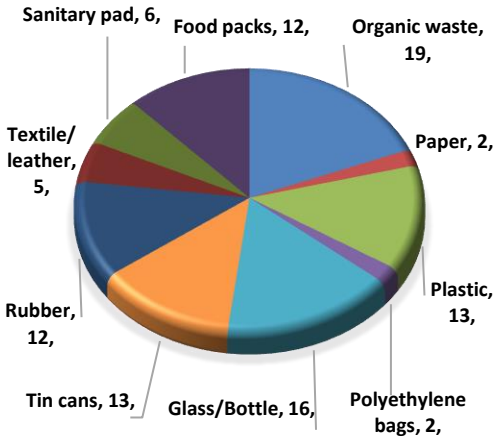

Figure 7. Percentage (%) composition of collected waste

From the above calculation, the generation rate per individual or student, or person per day within the study area is estimated at 0.045kg.

Strategies that enhance efficient use of natural resources through economic stimulus and incentives facilitate waste reduction at the generating sources and invariably reduce environmental hazards and human health risk exposures [11].

Economic benefits and management of identified wastes from the hostel

Organic wastes: wastes categorized as organic wastes include leftover food waste, fruits, vegetables, agricultural products, peels from banana, yam, orange, etc. These wastes are biodegradable and can be managed by natural composting which utilizes, presence of micro-organisms in the organic matter and soil to decompose organic material to a useful end product for soil enrichment. According to Anupama [12], organic waste equally contains 80–85% moisture content and can be recycled or converted into useful organic manure or fertilizer, while the agricultural and food waste can be used for feeding some animals like cattle.

Paper

Collected waste paper include newspapers, A4 paper (printing paper), exercise books, magazines, cardboards, textbooks, novels, cartons used for packaging, etc. The volume of discarded waste paper can be reduced drastically by practicing paper waste prevention. Digital learning is an improved technological method of learning that economizes resources with zero contribution to waste paper generation. Prevention of volume of waste paper and recycling minimizes the environmental impact associated with manufacturing of paper from raw materials [13]. Waste paper can also be managed and converted into bioethanol, bioplastics (poly-3-hydoxybutyrate) and secondary fuel, which are environmentally friendly [14-16].

Plastic and food packs

Plastic waste collected includes water bottles, cans, containers, soft drinks, plastic chairs, buckets, food packs, etc. Plastic wastes are environmental hazards that occupy the earth's surface, thereby requiring efficient strategies and techniques for management [17]. According to Kehinde et al. [18], one of the most effective and efficient strategy of managing plastic wastes is by recycling, which has potential economic benefits especially in industries, such as construction, clothing, arts and design and architecture. In addition, selling of plastic wastes can also be a source of income. Reuse of plastic waste also reduces the cost of buying raw materials for construction and promotes green construction [19].

Polythene/Nylon

Collected wastes in this category include pure water sachet, used polythene bags, wrappers and nylon bags. They are used every day, especially in packaging products. According to Young [20], nylon recycling in Nigeria has great and good potential for making money with little effort. 1 kg of pure water nylon costs (Nigerian naira) ₦35–200 and a ton cost ₦20000–30,000 in Nigeria. Also, 1 kg of plastic wastes goes for ₦70 only. Jassin [21], reported that plastic cement can be produced from generated polythene waste and this was carried out by replacing sand with fine polyethylene waste at different percentage proportions. The end product with good workability was discovered at about 25-30% waste polyethylene

Glass/Bottle

Glass bottles are non-biodegradable waste that creates environmental problems when improperly managed. According to GPI [22], glass can be recycled 100% without purity and quality loss. More so, 95% of raw materials can be substituted with recycled glass, thereby reducing the higher demand and consumption of raw materials. As part of sustainable waste management, research conducted by Nyantakyi et al. [23], recommended the use of 30% glass bottle waste powder to replace cement in concrete.

Tin cans

Tin cans include aluminum cans of different types of drinks, and beverages which are non- biodegradable. Tin cans are readily recyclable waste materials which makes it easier to manage, thereby creating wealth and ensuring a green environment. Benson [24], reporting a woman who stated that aluminum and metals are most expensive recyclable waste in Nigeria with about one ton of aluminum costing more than ₦100000 only.

Rubber

Collected rubber wastes include foot wears, shower mats, floor mats, carpets, car mats and rubber plates. Others rubber waste materials outside the hostel premises include tires, tubes. Although waste rubber is difficult to recycle but it can be reuse in the following ways: creating artificial reef, in irrigation system as water channels, construction of erosion barriers, etc., [25].

Textiles and leather

These are discarded clothes and bags discarded as unwanted. Textile recycling is a method of recovering old clothing and fabric for the purpose of reprocessing the material into useful end products. Some discarded clothes can be donated to non-governmental and charitable organizations, such as orphanage homes, elderly homes and even individuals displaced from their homes due to natural disasters. Recovering waste has both environmental and economic benefits. According to Kumar [26], textile recycling reduces intensive pollution and energy processes utilized in making fresh materials

from textiles. Recyclable worn out clothes may be utilized again in textiles or other products. Leather is a multi-purpose material used to create and produce beautiful clothes; purses, bags, belts and even shoes. As part of a sustainable and management option for leather waste, cobblers or shoe repairers can fix and repair leather products for use, thereby extending the material life span and reducing the amount of waste generated. According to CEF [27], leather products can be upcycled to create and produce new leather products, such as making slouchy pillows, leather purses, pen pots, etc.

Sanitary pads

This is an absorbent woolen pad worn by women during their monthly menstrual flow. Recommended disposal methods include burning in an incinerator, throwing a wrapped sanitary pad in the pit toilet, land filling and using reusable cloth pads [28, 29].

CONCLUSION

The importance and significant of a clean and sustainable environment cannot be overemphasized. It directly influences and impact on the socio-economic and health welfare of humans. Many factors, conditions and characteristics contribute to a cleaner, healthier and greener environment. An effective, efficient and practical solid waste management system/program will absolutely and definitely contribute to a clean environment. The university is one of the active sectors that can create an outstanding strategic framework for emulation. However, a proper solid waste management scheme cannot be established without information or data. Hence, this research was centered on providing generation rate and quantity, type of wastes for proper management strategy.

Mostly generated wastes are organic wastes, glass, bottles, plastics, tin, cans, rubber, polyethylene bags, food packs, textile, leather, sanitary pad, paper, etc. 1605.65kg of wastes were recorded during the 3 months of study, with organic waste being the highest quantity of waste collected with 19% of the total. Glass and bottles recorded 250.99kg of about 16% of the total waste stream. Plastic, tins, cans, rubbers, polyethylene, and food packs form wastes generated within 12 – 13% of the total waste collected. Sanitary pad constituent part of the waste stream because of the study area which comprises more of the female gender. Such waste needs a proper disposal method.

From the waste stream, some wastes were identified for reuse and recycling which can generate income for the university. Some of those wastes are plastics, paper, nylon, rubber, textiles, bottles, etc. And for such reuse or recycling, proper management of waste storage, handling, and collection needs to be adopted to avoid more contamination. The estimated generation waste rate per capita per person per day within the study area is 0.045kg.

From the findings derived from this study, the following recommendations are made to enhance healthy living, a good environment, a proper waste management strategy etc. For the university.

- Enlightenment and awareness programs should be continuous to ensure proper waste storage and handling by students in their hostels.
- Different waste bins should be provided and identified for each waste constituent. This will enhance easy handling and management. It is also a part of segregation actioned by the student from the generation point. This will also reduce the cost and manpower needed for separation after collection.
- Organic wastes realized from the waste stream can be properly channelled towards agricultural purposes thereby reducing the volume of waste for final disposal. It also helps to prevent methane generation (greenhouse gas) that is responsible for global warming.

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Persian Abstract

چکیده

خصوصیات و کمی‌سازی پسماند جامد در بلوک‌های خوابگاه دخترانه Equity واقع در دانشگاه ایگبیندیون Okada برای ارائه داده‌هایی در استراتژی مدیریت پسماند در دانشگاه انجام شد. بررسی پسماند به مدت ۳ ماه با جمع‌آوری روزانه زباله‌های تولیدشده از اتاق‌های مختلف به استثنای روزهای یکشنبه انجام شد. پسماندهای جمع‌آوری شده به اجزای مختلف خود تفکیک و با استفاده از ترازوی اتوماتیک توزین شدند. سرانه ضایعات نیز با تخمین تعداد کل دانشجویان/جمعیت منطقه مورد مطالعه تعیین شد. ضایعات شناسایی شده شامل پلاستیک، کاغذ، شیشه، بطری، ضایعات آلی و غیره بوده است. ضایعات آلی بیشترین میزان ضایعات تولید شده را با ۳۰۴/۵۴۲ کیلوگرم (۱۹ درصد) و پس از آن شیشه/بطری‌ها با ۲۵۰/۹۹۳ کیلوگرم (۱۶ درصد) ثبت کردند. سرانه زباله در روز ۰/۰۴۵ کیلوگرم برآورد شد. از جریان پسماندها، برخی زباله‌ها به‌عنوان قابل استفاده مجدد و قابل بازیافت شناسایی شدند که در صورت مدیریت صحیح می‌توانند درآمدزایی برای دانشگاه داشته باشند و به طور غیرمستقیم به کاهش حجم و میزان زباله‌های دفع‌شده کمک کنند. پسماندهای آلی شناسایی شده بیشترین میزان زباله را در جریان تولید زباله تشکیل می‌دهند. این ضایعات آلی تجزیه‌پذیر بوده و می‌توانند برای تولید محصولات زراعی و اهداف کشاورزی مورد استفاده قرار گیرند که همیشه به کاهش روند تولید زباله کمک می‌کند. اتخاذ استراتژی مدیریت پسماند کارآمد باعث ایجاد ثروت، کاهش آلودگی و تقاضا برای مواد خام و ایجاد محیطی سبزتر خواهد شد.