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Waste Management Practices in Residential Educational Campus: A Case Study of Guru Nanak Dev University, Amritsar

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Abstract
Waste management has been a significant challenge for city governing bodies. The mismanagement of waste contributes to adverse environmental impacts. Therefore, local bodies must adequately manage waste from generation through treatment to disposal or reuse, in a safe and environmentally friendly manner. Educational institutions, especially universities and colleges, not only impart education but also act as role models for the community. To assess waste management practices at the university, the case of Guru Nanak Dev University is examined in the present paper. The University located in Amritsar city has grabbed the second position in Swachh Campus Ranking-2018 and 2019 amongst all government universities and is at the number one position, i.e. the most 'Swachh Campus' out of the multispecialty public universities having big campuses, thus making an ideal example to be assessed for waste management practices that are followed on the campus. The present paper focuses on evaluating the current waste management practices adopted on the GNDU campus. It also includes actions that institutions can take to support environmentally friendly waste disposal.
Keywords- solid waste management, educational institutions, university, campus waste management, waste collection, storage, transportation, processing, segregation and recycling

1. Introduction

Better economic opportunities and rapid urbanisation of towns and cities directly contributed to increased solid waste management issues in urban areas. Due to financial constraints, poor management capacity of urban local bodies, societal pressure, and costlier waste management, waste management is worsening (Vij, 2012). Therefore, waste management has become a challenge for the city and towns. Currently, most ULBs have a 50-60% waste collection efficiency, and a few even reach 90%. Only 10 per cent of the waste is treated and disposed of scientifically (NIUA, 2015; Mani, 2016). The remaining waste is managed unscientifically and is disposed of without treatment. Besides the mentioned constraints, there are several problems with waste management, including mixed waste streams, inadequate infrastructure, such as disposal sites and community bins, open dumping, limited financial resources, and population growth. These are a few of the waste-related challenges that need to be addressed.Various waste-associated issues, as identified above, are in almost every Indian city, including littering, mixed waste, lack of garbage bins, waste spillage and spread around the dustbins, lack of funds and workforce, insufficient number of vehicles and frequency of waste collection, and unscientific waste management practices. Since the waste problems found on campuses are the same as of cities, higher educational institutions have the responsibility and the institutional capacity to demonstrate sustainable and replicable waste management systems. The educational institutions can play a crucial role by adopting sustainable waste management practices. Higher Educational institutions act as exemplars of society, and their success can guide urban local bodies in improving citywide waste management. The larger educational campuses with residential and institutional areas generate substantial waste that requires management. Being prominent in the area and having on-campus residential areas generates solid and liquid waste that institutions must manage. The government has taken various measures to overcome waste management issues, from collection to disposal and reuse.

To address these issues, the union ministries, namely the Ministry of Environment, Forest and Climate Change (MoEFCC) and the Ministry of Housing and Urban Affairs (MoHUA), have taken various policies and project-level initiatives to manage waste (Mani, 2016). The Municipal Solid Waste Management Rules were first framed in 2000 as a regulatory framework for urban waste management. These rules primarily focused on the collection, storage, transportation, processing, and disposal of municipal waste by concerned authorities. The rules laid down standards for different treatment and disposal methods, including landfill site selection. The Government revised these rules through the Solid Waste Management Rules, 2016. The revised rules shifted the focus from the municipal disposal approach to an integrated waste management system. The focus of the rules is on source segregation, door-to-door collection, recycling, reuse, composting, waste-to-energy, decentralised processing, and reducing dependence on landfill. It also expanded responsibility beyond municipalities by imposing duties on waste generators, thereby making the producers accountable.

The erstwhile Ministry of Urban Development has also prepared a draft manual on MSWM to lend support to cities and towns (CPHEEO, 2016). However, besides the support, the cities and towns struggle to perform to the desired levels due to a lack of financial support, poor institutional capacities and clarity among different stakeholders and poor enforcement by the concerned authorities.

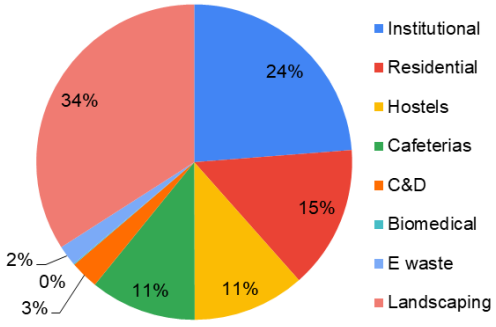
The present paper focuses on the solid waste management practices of Guru Nanak Dev University as a case example. The key objectives of the paper include an assessment of solid waste generation on campus, methods and processes for solid waste from generation to treatment and reuse that can be replicated at a larger city scale. It also identifies existing problems and potential solutions to be addressed.

2. **A Brief University Campus Overview:**Guru Nanak Dev University (GNDU), established in 1969, is a residential university Campus. The university is a multidisciplinary institution with a 500-acre campus and serves more than 20,000 students, of whom more than 40% live on campus. Of the total area, less than 10% is built-up, while the remainder is open, making it a lush green Campus. The university is located in Amritsar and is a planned green campus of the Punjab State. The University is one of the leading and top-performing state public universities in India. In terms of sustainability, the campus was ranked second in India in the Swachhta Campus Ranking in 2019 and was also recognised as the District Green Campus Champion (2021-22) (GNDU, 2025). The university has successfully implemented various solid waste management initiatives and campus cleanliness drives. The subsequent sections cover a detailed appraisal of waste management on the campus. A detailed study of campus waste generation has been conducted, including category-wise waste generation, classification of waste categories, and the waste management process, which includes waste segregation, recycling, collection, transportation, treatment, and disposal.

3. **Waste Management in the GNDU Campus:** The quantity of waste generated from different sources is divided into eight categories: institutional, residential, hostels, cafeterias, construction and demolition, biomedical, e-waste, and landscaping waste. Waste collection is door-to-door, with transportation provided by tractors and tricycles. Further, this section focuses on the treatment, disposal, and recycling of waste on campus.

3.1 Quantity of Waste: The total quantity of waste generated on the university campus is 1702.27 Kg per day. The waste generated can be further subdivided into institutional, residential, hostels, cafeteria, biomedical, e-waste, construction, management and landscaping, as shown in Figure 1. As the university is a green campus, the maximum waste generated is from landscaping, i.e., 580 Kg per day, followed by residential and hostel waste, i.e., 250.2 kg and 195.7 Kg per day. 404.6 Kg of waste per day is generated by institutional areas that are not taken into account, as it is only paper waste that is recycled. Cafeterias are another significant source of waste, producing 185 Kg per day.

Figure 1: Category-wise Waste Generation



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1. ***Institutional Waste***

Mixed waste is generated in the institutional area, totalling 404.6 kilograms per day. The significant contribution is paper waste, i.e. 51%, as depicted in the figure. Plastic and inert waste contribute 18% and 15%, respectively. Hazardous chemical waste is generated at 3% by labs on campus, as depicted in Figure 2. The majority of waste generated from the institutional area is readily biodegradable, so it does not harm the environment.

2. ***Residential Waste***

The total waste generated in the campus residential area is calculated across all residences for teaching and non-teaching staff. There are 417 houses on campus, divided into different types with varying occupancies. Considering a per capita waste generation of 150.5 grams per day, the total waste requirement for residential areas is 250 kilograms per day. The waste generated is divided into categories, i.e., organic, paper, plastic, sanitary glass, and inert waste, as depicted in Figure 3. The highest composition is organic waste (53%), while the lowest is inert waste (1%). Plastic waste accounts for 10% because plastic wrapping is used for most food and other household items. Paper waste is only 8% and is also reusable, so it doesn't contribute much to waste generation. The highest waste generation is from D- and E-type houses, where most people reside.

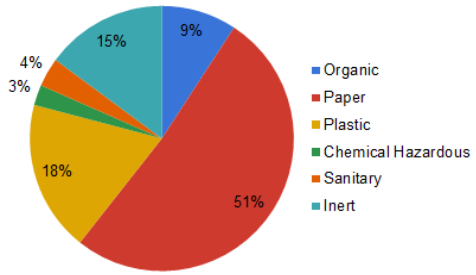

Figure 2: Institutional Waste

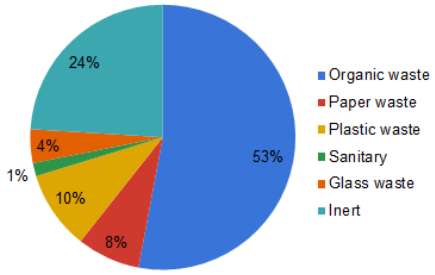

Figure 3: Residential Waste

*3. **Cafeterias Waste:** The campus cafeterias also generate the majority of biodegradable waste, which is easily recyclable, rather than the 17% plastic waste from items and food packaging, as depicted in Figure 4. Organic waste consists of 56% leftover food items, followed by 16% paper waste, which can also be easily reused. Hazardous and sanitary waste are not found in the waste generated by the cafeterias.*

*4. **Hostels Waste:** The campus hostels also contribute to a mix of waste, as 4112 students reside in them. The highest waste generation is organic and plastic waste, i.e. 28% and 38%, respectively, as depicted in Figure 5. The organic waste is generated from the food items in the mess and canteen, while the plastic waste is from the daily-use items used by the students. No chemical or hazardous waste is generated from the hostels, while sanitary and inert waste contribute 8% and 10%, respectively.*

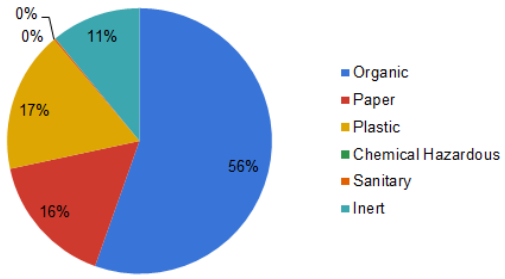

Figure 4: Cafeteria Waste

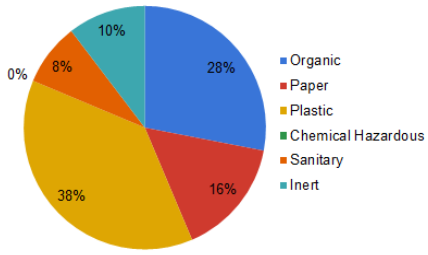

Figure 5: Hostel Waste

*5. **Landscaping Waste:** The total landscaping waste generated by the campus is 580 kilograms per day. The waste collected is divided into different zones, i.e., parks, hostels, roads, open spaces, tree pruning, and botanical gardens, as depicted in Figure 6. The highest waste generation is from tree pruning (38%) to maintain the campus's landscaping. Botanical gardens and residential parks contribute 13% and 14% of the waste, respectively. The waste collected from landscaping is fully biodegradable and can be easily recycled.*

*6. **Chemical and Hazardous Waste:** The chemical and hazardous waste composition is 1.37 kilograms per day, produced by the lab across different departments, as depicted in Figure 7. The highest waste generation is from the Chemistry and Environmental Sciences blocks, which contribute 29% of the waste. Food Science and Zoology blocks contribute the lowest percentages of waste, i.e., 2% each. Biology, Human Genetics and Physics are the other blocks contributing 19%. 9% and 10% of the waste, respectively.*

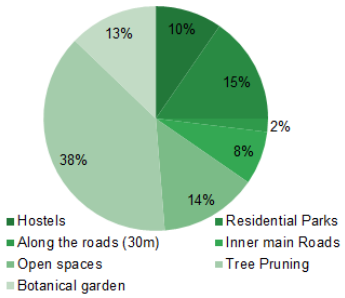

Figure 6: Landscaping Waste

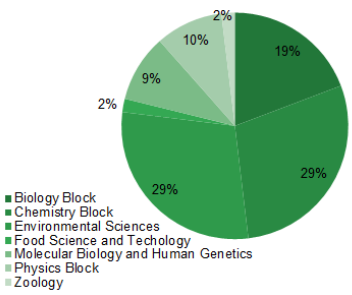

Figure 7: Chemical and Hazardous Waste

3.2 Categorisation of Waste: To assess waste management on campus, a category-wise breakdown and analysis have been carried out. Based on the same, different categories of waste analysed include organic waste, paper waste, e-waste, biomedical waste, landscaping waste, construction and demolition waste and other waste.

1. ***Organic Waste :***

Of the total waste generated on campus, organic waste is segregated, and all waste is reused. In residential areas, the households are doing source segregation. The kitchen waste is segregated and collected for conversion into manure. The campus has two vermicomposting systems (one in the agricultural area and the other in the botanical garden) and a composting pit that treats all residential organic waste into manure. The manure produced is used in-house for landscaping purposes. The campus sanitary department segregates organic waste generated by the canteens, mess, and various cafeterias. The waste is further segregated into wet and dry waste and is collected by the local dairy farms.

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2. ***E-waste :*** *E-waste is generated by different departments, including computers, laptops, printers, CD/DVDs, keyboards, mice, switches, photocopiers, refrigerators, air conditioners, etc. The e-waste generated has been managed in accordance with CPCB's guidelines since 2018. Waste from different departments and regional campuses is collected and delivered only to authorised e-waste recyclers. The campus has a separate e-waste write-off committee that oversees the e-waste management procedure. Total e-waste generated in 2020-2021 amounts to 13085 kg, including recycled e-waste from regional campuses.*

3. ***Biomedical Waste :*** *Biomedical waste generated on campus includes waste from the health centre and from various departments, including Biotechnology, Human Genetics, Zoology, Pharmaceutical Sciences, and Microbiology. The waste generated includes needles, scalpel blades, body fluids, gloves, bandages, human or animal tissue and organs, etc. The biomedical waste generated is segregated into yellow, red, white, and blue bins according to waste category. According to the campus biomedical waste management report, the average annual biomedical waste generated is 500 Kg/year. Of the total waste, 47 per cent is yellow bag waste, 37 per cent is red bag waste, 15.1 per cent is blue bag waste, and 0.6 percent is white bag waste. The segregated waste is collected and transported by an outsourced contractor M/s. Amritsar Enviro Care (P) Ltd. (AECS), with whom a three-year contract has been made from April 1, 2020. The AECS has set up a facility to treat and dispose of the BMW generated by the health care establishments at Ibban Kalan, Chhabal Road, Amritsar.*

4. ***Paper Waste:*** *The entire paper waste on campus is recycled. The paper waste is generated by various departments, including answer sheets from previous sessions, old records, newspapers, and paper bags. The paper waste is collected from the departments at a centralised location and is sold to recyclers. A total of 16,617 kg/year of institutional paper waste is recycled. The paper waste from residential areas is segregated at the centralised facility under the sanitary department. The waste is segregated into hard and soft cartons and paper, then recycled. The campus keeps a detailed record of segregated waste. On average, 46 kg of paper waste from residential waste is segregated and recycled daily.*

5. ***Landscaping Waste :*** *Landscaping waste consists of dead leaves, prunings, dead wood logs, etc. All landscaping waste is managed on campus. In unplanned green areas, dead tree leaves settle in adjacent areas, forming mulched beds that retain soil moisture, increase soil fertility, and improve soil health, thus reducing the water demand of trees and plants. It also enhances the landscape's aesthetics. In planned green spaces and lawns on the campus itself. Landscaping waste from institutional areas, hostels and residential areas is also collected separately by the department at periodic intervals.*

6. ***Construction and Demolition (C&D) Waste :*** *The C&D waste is collected and segregated by the campus's construction and maintenance department and reused on campus. It is reused for different construction purposes, such as levelling and filling under the new building on campus.*

3.3 Waste Segregation and Recycling: Waste segregation is done in two ways: at-source and post-collection. At the source, segregation consists of residential waste, while after collection, it consists of cooked and uncooked food, trash, paper waste, bottles, and recyclable waste.

1. At Source Segregation: *At the source, 132 kg of residential organic waste is segregated for on-site composting.*

2. ***After Collection Segregation :*** *It is done at a centralised campus facility within the university. The total waste in this category is 262 Kg per day, with cooked waste at 107 Kg per day and trash at 70 Kg per day. Other categories of waste are uncooked waste, i.e. 31 Kg per day, recyclable waste, i.e. 54 Kg per day, thin and thick cartons consisting of 15 Kg per day each, white paper is 16 Kg per day, and 9 Kg per day is bottle waste.*

Table 1: Segregation After Collection of Waste

Segregation After Collection	Average kg/day
Cooked Waste (Kg)	107
Uncooked Waste (Kg)	31
Trash Waste (Kg)	70
Thin carton	15
Thick Carton	15
White Paper	16
Bottle	9
Recyclable Waste (Kg)	54
Total waste (kg)	262

Source: Sanitary Office, GNDU

3.4 Waste Recycling and Usage: Of the total 1703 Kg of waste generated, the largest share is construction and demolition waste, followed by landscape waste, i.e., 630 Kg. Both are used on campus for various tasks. The waste sent to the landfill is 625 Kg, and 37.22 kg is handed over to authorised vendors. Sanitary waste is also treated on-site, consisting of 15.8 Kg.

3.5 Collection and Transportation: The collection and transportation mechanism for the waste generated on the campus is as follows:

1. ***Collection:*** *Waste is collected by trolleys and tricycles. The waste from institutional areas is collected weekly, whereas the residential, hostel and roadside waste is collected daily on the campus.*

There are 180 bins on campus, further divided into three categories based on their colour: red, blue, and green. Red bins are 76, blue are 54, and green are 50. Each bin has a capacity of 50 litres and is located across the campus in different zones.

The campus's organic waste is collected daily, including waste from residential areas, hostels, cafeterias, and canteens. For landscape waste, separate collection is handled by the landscape department. The e-waste and biomedical waste are collected and managed by authorised recyclers.

2. ***Transportation:*** *Waste is transported by trolleys and tricycles, as depicted in Table 2. The waste from institutional areas is collected weekly, whereas the residential, hostel and roadside waste is collected daily.*

Table 2: Collection of Waste

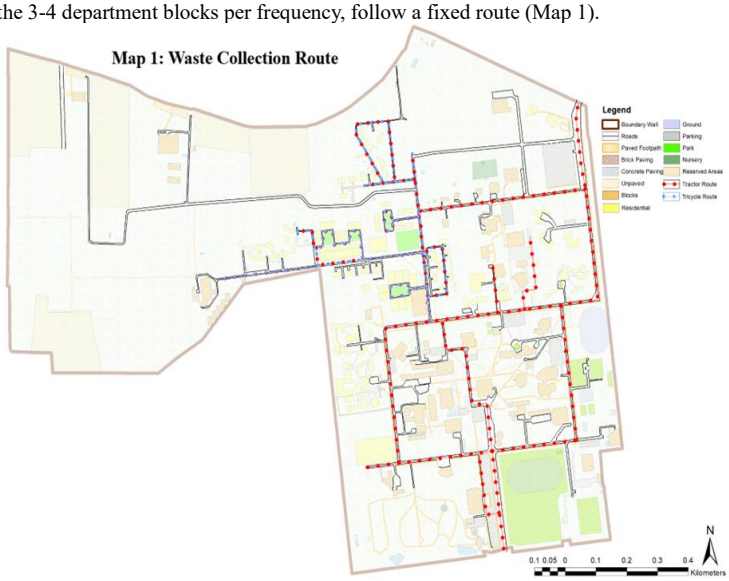
Particulars	Number of Vehicles	Capacity (kg)	Sanitary Office*	Landscape Office**	Maintenance Office***
Tractor-trailer	3	500	1	1	1
Tricycle	5	50	3	2	0

Source: *Sanitary Office, GNDU; ** Landscape Office, GNDU and ***Maintainance Office, GNDU

3. *Routing*

The route followed by the trolley is not fixed. Still, the collection usually starts at the Administrative block, then goes to Verka and the library, and finally covers the Dashmesh Auditorium. Then again, after half an hour, the collection process begins with the residential zone and then covers the hostels. Finally, while covering the 3-4 department blocks per frequency, follow a fixed route (Map 1).

Map 1: Waste Collection Route



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3.6 Treatment and Disposal

The treatment and disposal methods precede the waste management system. These include composting, vermicomposting, and landfill disposal. 37% of the waste generated is sent to the landfill, whereas 63% is utilised; refer to Figure 8. Two Vermicompost units are located on campus: one at the Botanical Garden and the other in the agricultural area.

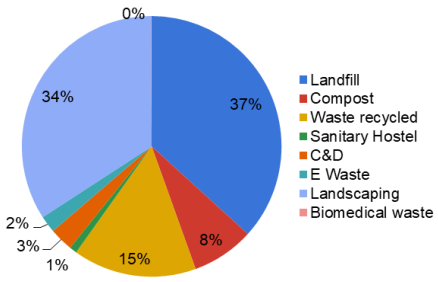

Figure 8 Treatment and Disposal of Waste

Household kitchen waste is converted into manure, while authorised vendors recycle paper and e-waste. Biomedical waste is contracted out to authorised dealers, while the remaining waste is sent to Naraingarh Landfill, Amritsar.

3.7 Material Recycling

In addition to the waste collected and managed as per the process identified in the above sections, an additional 1081 kilograms of waste are recycled separately annually. It consists of wood, an iron drum, and glassware totalling 296 Kg, 210 Kg, and 300 Kg, respectively, as depicted in Table 3.

Table 3: Waste Material Recycling

Waste Type	Quantity (KG) (Annual)
Wood	296
Plyboard	50
Iron drum	210
Brass nickel through taps	30
Glassware	300
Plastic waste in the form of store tanks	55
Steel door handles	40
Total	1081

Source: Aggarwal, Himani. (2016). Planning a zero-waste campus, GNDU, Amritsar

4. **Policy and Strategy Level Recommendations:**Various policies have been identified that the university can adopt to expand sustainable measures. Appropriate strategies can be developed to implement each policy effectively and achieve inclusiveness and sustainability. The various policy and strategy-level recommendations are as follows:

1. **Comprehensive Waste Management Policy:** A comprehensive waste management policy can be framed as an interdisciplinary approach for the campus, covering guidelines for sectors such as solid waste, biomedical waste, C&D waste, e-waste, and hazardous waste.

a. **Catering Policy:** A catering policy can be formulated on the campus to encourage the use of non-disposables and compostables for major events, seminars and functions. This would lead to biodegradable materials that would not harm the university's environment.

b. **Waste Segregation Policy:** A policy can be rolled out on campus to segregate cafeteria, canteen, and mess waste at the source, reducing the amount of waste going to the landfill and enabling efficient waste re-utilisation within the campus, creating a circular economy.

c. **3R Policy:** The reuse and recycling of waste can be increased by recycling the majority of waste generated on campus and reducing the amount sent to the landfill. The campus can adopt a 3R policy by reducing, reusing, and recycling waste produced on campus.

d. **Reuse of C&D Waste Policy:** The university's construction waste can also be reused on campus to make floor tiles, paver blocks, and kerbstones, which can be easily reused to create structures and footpaths.

e. **Eliminating Single-use Plastic Policy:** Takeaway food containers, such as single-use plastic glasses, polythene bags, and water bottles, need to be eliminated by switching to non-disposable, biodegradable alternatives urgently.

2. **C&D for Research:** Construction waste could also be used for educational and research purposes in the civil engineering and lifelong learning department, fostering the spirit of innovation and creativity among students and staff.

3. **Comprehensive Waste Audit:** An interdisciplinary campus waste audit can be conducted to manage various waste streams, including institutional, domestic, C&D, landscaping, biomedical, and hazardous waste.

4. **Reducing Paper Consumption:** Paper consumption can be reduced by replacing single-sided printers with double-sided ones or by switching to digital platforms entirely.

5. **Enlarging the Composting Site:** With the future expansion of the university campus, the composting site will also need to be enlarged to enhance its capacity.

6. **Landscape Waste:** As the campus is also lush green, it generates a considerable amount of landscaping waste, which is currently mulched on-site and could be auctioned to the nearby cogeneration plant, generating revenue for the university.

7. **Waste Collection Machines:** Install segregated waste collection machines linked to smart ID cards (IoT-Enabled Smart Waste Bins) where students can earn points that can be redeemed for various on-campus uses.

5. Conclusions

The University's waste management assessment highlights that the campus demonstrates self-sustaining waste management practices. One of the campus's major strengths is that the substantial waste generated on campus is managed through various processes. The biodegradable waste is recycled. The landscaping waste is used for mulching and for generating in-house manure. Waste is managed through authorised recyclers in accordance with the pollution control board guidelines. Biomedical waste is segregated and sent out to a certified treatment facility. Of the total waste, 1/3 is sent to the landfill site, thereby indicating that the campus follows at-source segregation practices and material recovery. To move toward a zero-waste campus, various strategies have been proposed, including source reduction and technology-enabled monitoring, among others.

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