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Evaluation of Waste Containment and Collection at Dramaga Campus, IPB University

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Abstract: Effective waste management at university campuses requires systematic evaluation of containment systems and collection operations. This study assessed waste generation, containment conditions, and collection practices at Dramaga Campus, IPB University, Indonesia. Waste sampling was conducted over eight days at 40 collection points across academic, dormitory, general facility, and canteen zones, following SNI 19-3964-1994. Waste at Taman Semangat Integrated Waste Management Facility (TPST) was sampled on two additional days. Total daily waste generation averaged 3.25 tonnes, yielding a per capita generation rate of 0.13 kg/person/day, which is below the global average for higher education institutions (0.19–0.21 kg/person/day). Organic waste dominated all source zones (39–66% by weight), followed by plastic (17–44%) and paper (10–25%). Waste containment relied on two container types—concrete and plastic—classified as communal containers. Evaluation against SNI 19-2454:2002 revealed multiple non-conformities: absence of waste segregation at source, inconsistent container placement, and underutilized containers at peripheral sites. Waste collection follows a Stationary Container System operated by two colour-coded trucks across two daily shifts. The existing fleet of two active trucks requires a total of five trips per day to remove all generated waste, but the current schedule is insufficient to fully serve all sites daily. Recommendations include spatial redistribution of containers, enforcement of source segregation, and expansion of collection capacity.

Keywords: IPB, waste, management, containment, collection

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1. Introduction

Rapid population growth and expanding human activities have intensified solid waste generation at a rate that frequently outpaces waste management infrastructure capacity [1]. In urban and peri-urban environments, waste management challenges typically involve shortfalls in equipment, land, and human resources [2]. University campuses constitute a distinctive category of urban environment: they accommodate large, dynamic populations engaged in academic, residential, and commercial activities, producing waste with heterogeneous physical and compositional characteristics [3].

Higher education institutions (HEIs) generate waste from academic operations, student residences, food service areas, and public facilities. Literature consistently shows that HEIs produce an average of 0.19–0.21 kg of waste per person per day [4]. The composition is dominated by organic material, paper, and plastic, reflecting patterns of food consumption and study-related activities [5].

Despite the significance of this waste stream, campus-specific management strategies often lag behind comprehensive waste planning [6].

Institut Pertanian Bogor (IPB) University, situated at its Dramaga Campus in Bogor Regency, Indonesia, operates a waste management system comprising communal containment, truck-based collection, and centralised processing at the Taman Semangat Integrated Waste Processing Facility (TPST). The current system employs a Stationary Container System (SCS) in which waste is collected from fixed containers by dedicated vehicles, without relocating the containers. Waste from all campus zones is ultimately transported to the TPST for sorting, composting, and residual disposal.

Indonesian national standards, specifically SNI 19-2454:2002 (Technical Guidelines for Urban Solid Waste Operational Management), provide the normative framework for evaluating containment and collection practices [7]. This standard specifies requirements for container design, placement, collection frequency, and route planning. Compliance assessment against this standard can identify structural gaps and guide operational improvement.

This study aimed to: (1) characterise waste generation at the containment level and at the TPST; (2) evaluate existing waste containment conditions against SNI 19-2454:2002; and (3) assess the waste collection system—route, scheduling, and capacity—in light of the same standard. The findings are intended to support evidence-based planning for sustainable campus waste management at IPB University.

2. Method

2.1. Study Area

The study was conducted at Dramaga Campus, IPB University, Bogor Regency, West Java, Indonesia. The campus encompasses academic buildings, six dormitory clusters, general public facilities (mosque, clinic, gymnasium, marketplace), and canteen areas. Waste generated on campus is managed by the university's Sustainable Campus Development Board (BPKB) and conveyed to the TPST Taman Semangat Cikabayan.

2.2. Waste Sampling at Source

Sampling was carried out from 21 to 28 February 2025 at 40 waste collection points distributed across four source types: academic zone (15 sites), dormitory zone (6 sites), general facility zone (16 sites), and canteen zone (3 sites), as shown in **Figure 1**. Methodology followed SNI 19-3964-1994 (Method for Sampling and Measurement of Urban Solid Waste Generation and Composition) [7]. An empty bucket was weighed, filled with waste, and compacted by dropping it three times from a height of approximately 20 cm. Volume and weight were recorded. Waste was then manually sorted into nine categories: organic (food waste and leaves), paper, wood, rubber/leather, textile/cloth, plastic, metal, glass/ceramics, and unclassified.

2.3. Waste Sampling at TPST

Additional sampling at the TPST Taman Semangat was performed on 23 and 25 April 2025, using the same SNI 19-3964-1994 methodology. The TPST receives consolidated waste from all campus source areas; measurements at this location therefore reflect the overall campus waste stream.

2.4. Containment Evaluation

All waste containers at the 40 sampling points were inventoried and photographed. Their material type, dimensions, placement, segregation provision, and maintenance condition were recorded. These characteristics were evaluated against the criteria specified in SNI 19-2454:2002, Section 5.1, which

defines requirements for container material, waterproofing, ease of emptying, segregation by waste type, and siting [7].

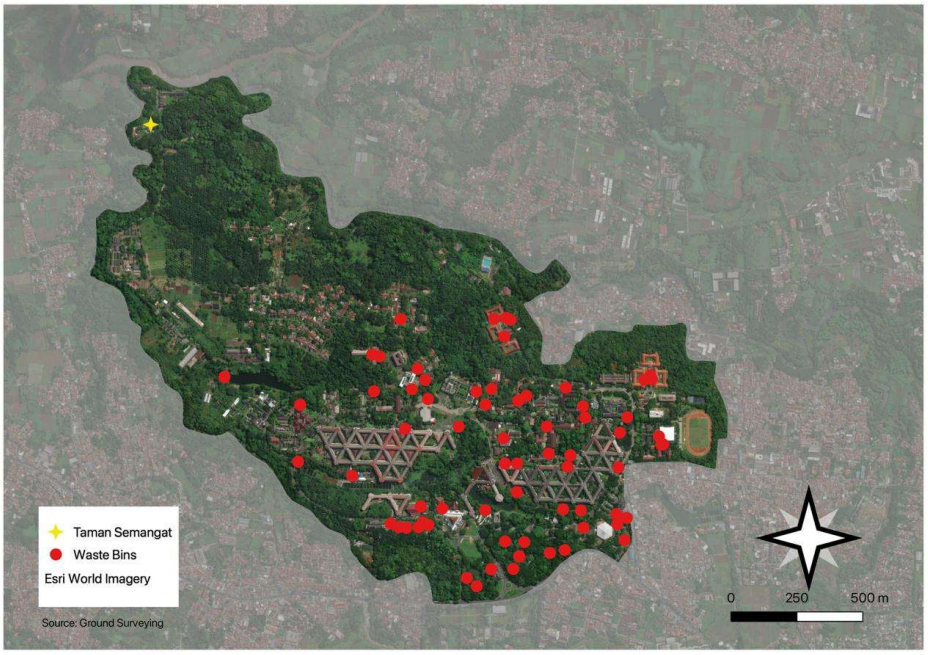

Figure 1. Sampling points at waste bins across IPB Dramaga Campus

2.5. Collection Route and Capacity Assessment

Field observation of waste collection operations was conducted on 20 May 2025. The route, stop sequence, service time per container, travel time between stops, and total trip duration were recorded for two trucks (red truck and yellow truck), each operating two shifts (morning and afternoon). Container coordinates were recorded using OpenStreetMap. Vehicle capacity (m^3) and average load density (kg/m^3) were used to calculate the number of trips required to remove all campus waste per day, and the result was compared with the existing schedule.

2.6. Data Analysis

Waste generation data were summarised as mean daily weight (kg/day) and volume (L/day) per source zone and waste category. Density (kg/L) was calculated for each waste category. Per capita generation was estimated by dividing total TPST daily waste by the campus population (24,190 persons) [8]. Containment and collection practices were evaluated against SNI 19-2454:2002 criteria using descriptive conformity assessment.

3. Results and Discussion

3.1. Waste Generation

3.1.1 Waste Characteristics at the Containment Level

Across all 40 collection points, total daily waste generation from source areas ranged from approximately 2 to 3 tonnes per day. The academic zone and general facility zone each contributed 38% of total waste by weight (approximately 755.8 kg and 754.7 kg per day, respectively), followed by the dormitory zone at 17% and the canteen zone at 10% (**Figure 2**). By volume, the academic zone dominated at 44% of total volume (12.7 m^3 out of 28.7 m^3 total), highlighting the intensive academic activities generating bulky waste.

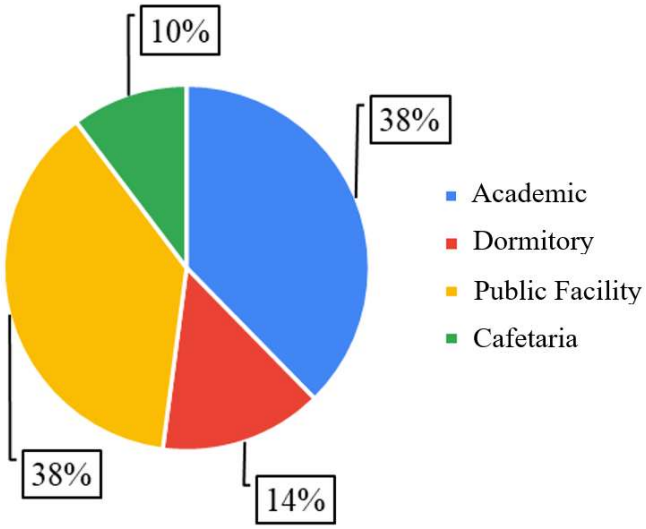

Figure 2. Waste generation from each source at IPB Dramaga Campus

Overall, organic waste (food waste and leaves) was the most abundant category, constituting 42% of total weight (approximately 851 kg/day) and 37% by volume. Plastic ranked second (29% by weight, 584.4 kg/day; 30% by volume), and paper third (22% by weight, 440.4 kg/day; 25% by volume). The remaining categories—wood, rubber, textile, glass, metal, and unclassified—collectively accounted for approximately 7% by weight. Density analysis showed that organic waste was the densest material at 0.079 kg/L, followed by plastic at 0.068 kg/L and paper at 0.063 kg/L, explaining the disproportionate volumetric contribution of plastic relative to its weight.

Waste composition varied meaningfully across source zones. In the academic and general facility zones, the dominant sequence was organic > plastic > paper, whereas in the dormitory zone, plastic was the leading category (44% by weight) ahead of organic (18%) and paper (21%), suggesting high consumption of packaged products among residential students. The canteen zone exhibited the strongest organic dominance (66% by weight), consistent with the concentrated food preparation and consumption activities there, and also showed the highest material densities (organic: 0.134 kg/L; plastic: 0.114 kg/L), likely reflecting greater compaction in high-traffic disposal points.

3.1.2 Waste Characteristics at the Temporary Waste Disposal (TPST Taman Semangat)

Daily waste arrivals at the TPST were recorded at 2.70 tonnes (23 April 2025) and 3.80 tonnes (25 April 2025), yielding a mean of 3.25 tonnes per day. The compositional pattern at the TPST closely mirrored the source-level findings, confirming that the distribution of waste types is preserved through the collection chain. Organic waste accounted for 45% of total weight and 32% of volume, plastic for 30% of weight and 34% of volume, and paper for 19% of weight and 29% of volume. The comparatively high volumetric fraction of plastic relative to its weight again reflects its lower bulk density. Minor categories—wood, textile, glass, metal, and unclassified—each contributed approximately 1% of total weight or volume. Rubber/leather waste was not detected during TPST sampling.

Using a campus population of 24,190 persons [8], the per capita generation rate was estimated at 0.13 kg/person/day. is notably lower than the reported global average for higher education institutions of 0.19–0.21 kg/person/day [4]. This per capita output is also lower than that of other campuses, such as Middle East Technical University in Turkey at 0.40 kg/person/day [9], President University at 0.238 kg/person/day [10], and Itenas Bandung at 0.156 kg/person/day [11]. In terms of total daily volume, IPB generates an average of 3.25 tonnes, which is slightly higher than the 2.895 tonnes per day reported at

Universitas Gadjah Mada [12]. The waste composition at IPB is characterized by a high plastic fraction of 30%, which significantly exceeds the plastic levels found at UGM (7%) [12] and Itenas (14.09%) [11]. While organic waste is the dominant category at IPB (45%), it is less prevalent compared to UGM (67%) [12] and Itenas (50.78%) [11], where food scraps and leaves constitute the majority of the waste stream. These differences highlight IPB's unique challenge with non-organic recyclables, particularly in dormitory zones, where plastic can reach up to 44% of the waste weight.

A small but consistent discrepancy exists between total measured source waste (~2–3 tonnes/day) and TPST receipts (3.25 tonnes/day). This difference likely arises from unsampled waste-generating activities—campus events, open corridors, and parking areas—and possible day-to-day accumulation of waste from sites served on alternate days.

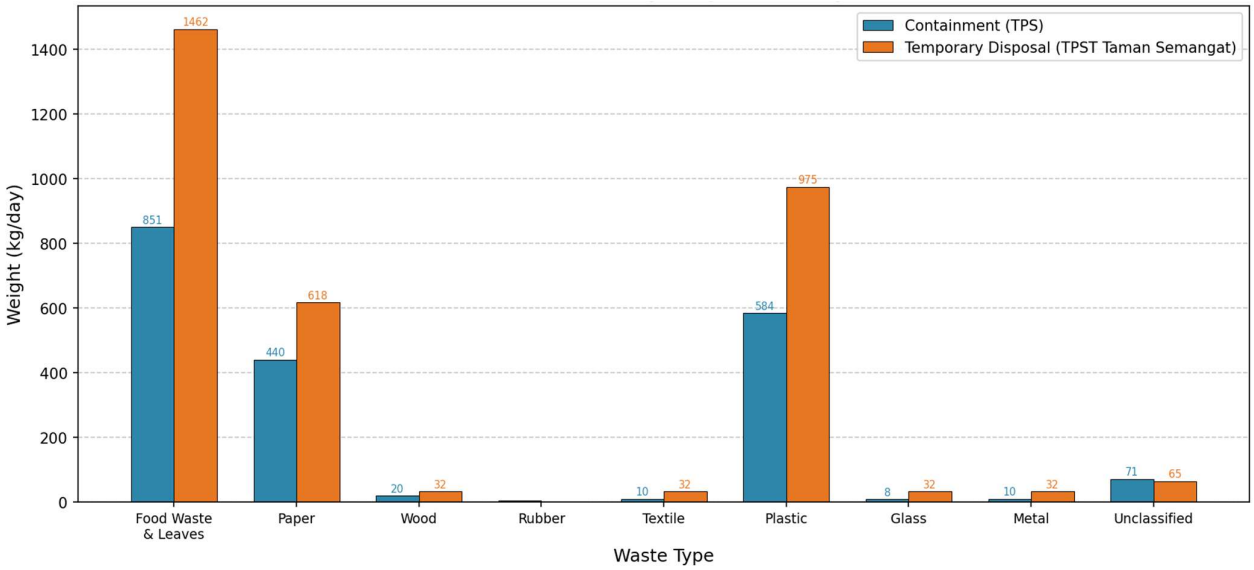

Figure 3. Comparison of daily waste generation by type at the containment level (TPS) and at the temporary waste disposal facility (TPST Taman Semangat)

Figure 3 compares the daily mass of each waste category between the containment level and the TPST. The organic waste fraction shows the largest absolute increase from containment (~851 kg) to TPST (~1,462 kg), reflecting additional organic inputs from zones not covered in the 40-point sampling frame. Plastic waste also increased from ~584 kg to ~975 kg. These patterns confirm that sampling at fixed collection points alone underestimates total campus waste, and TPST-level measurement is necessary for system-wide capacity planning.

3.2. Waste Containment

IPB Dramaga Campus uses two categories of waste containers: (1) permanent concrete bins of cylindrical form (diameter 80 cm) or rectangular form (up to 300 × 210 × 140 cm), and (2) mobile plastic containers of varying dimensions (approximately 100–141 × 58–80 × 80–126 cm, accommodating capacities of approximately 0.5–1.5 m^3). Both container types function as communal containers, meaning that waste from multiple users or activities is deposited together. No containers are designated for individual source households or offices.

Field observation found that waste segregation at source is not practised. All waste types—organic, plastic, paper, and residual—are commingled in a single container at each point. This is confirmed by the sorting data, which required separation after collection rather than before. Some high-traffic sites (e.g., near GWW Junction, CCR area) consistently filled their containers to capacity, requiring additional

collection runs within a single day. Conversely, remote sites such as behind Botani Bakery (TPS-28, average 5.29 kg/day) and the international dormitory area (TPS-21-B, average 6.01 kg/day) showed persistently low fill rates, indicating a mismatch between container placement and actual waste generation patterns.

SNI 19-2454:2002 Section 5.1 specifies that waste containers must: (a) be durable and waterproof; (b) be easy to empty; (c) be economical and accessible; (d) support waste segregation at source; (e) be sited to avoid obstruction of pedestrian or vehicular traffic; and (f) for communal containers, be positioned away from main road edges and as close as possible to the waste source [6].

Table 1. Conformity of waste containment at IPB Dramaga Campus with SNI 19-2454:2002

SNI 19-2454:2002 Criterion	Conformity Status	Observation
Container durability and waterproofing	Partially Conforming	Concrete bins are durable; plastic containers show variable wear. No lids recorded on most containers.
Ease of emptying	Conforming	Both container types can be emptied using the SCS method without relocating the container.
Source segregation support	Non-Conforming	Only single unsegregated containers exist at most points. No organic/inorganic split as required.
Container placement away from traffic obstruction	Partially Conforming	Most containers are roadside. Some placements are near building entrances; a few are in locations that may impede pedestrians.
Container proximity to waste source	Partially Conforming	Some remote sites (e.g., behind Seafast, Asrama Sylvestari) have containers with very low fill rates, suggesting poor spatial alignment with waste-generating activities.
Container capacity matching waste volume	Non-Conforming	High-traffic sites overflow and require double collection; peripheral sites consistently underutilised. Capacity–demand mismatch across the network.

The most critical non-conformity is the absence of source segregation. SNI 19-2454:2002 stipulates that waste should be sorted at the point of generation into at minimum two streams (organic and non-organic), ideally into multiple categories corresponding to downstream treatment options [7]. Without source segregation, the TPST must process mixed waste, reducing the efficiency and quality of composting and material recovery. This finding aligns with evaluations of other Indonesian institutions where mixed-waste containment was identified as the primary impediment to effective solid waste management [13].

Container mismatch across sites is the second major non-conformity. The coexistence of chronically overloaded and chronically underutilised sites reflects a static placement strategy that has not been updated to reflect changes in campus land use and population distribution. Relocating or consolidating underutilised containers to high-generation zones would improve efficiency and reduce litter spillage from overflows.

3.3 Collection

Waste collection at IPB Dramaga Campus employs a Stationary Container System (SCS), in which waste is removed from fixed containers by trucks making sequential stops along a defined route. Three trucks are nominally designated—a red truck, a yellow truck, and a green truck—originally differentiated

by waste type (paper, plastic, and organic/green waste, respectively). In current practice, however, the red and yellow trucks collect commingled waste from all non-organic source categories, while the green truck focuses on garden and vegetative waste (grass, leaves, branches), some of which is composted at the TPST and some of which is deposited at a roadside depression near the TPST. The route for red and yellow trucks is presented in **Figure 4**.

Both the red truck and the yellow truck operate two shifts daily: a morning shift (approximately 07:00–11:00) and an afternoon shift (approximately 13:00–15:00), each completing one collection trip (rit). The red truck's morning route covers 25 stops, with a total trip duration of approximately 2 hours 39 minutes, while its afternoon route covers 6 stops in approximately 1 hour 10 minutes. The yellow truck's morning route spans 8 stops in approximately 1 hour 45 minutes, and its afternoon route covers 11 stops in approximately 1 hour 25 minutes.

The morning red-truck route begins at the TPST, traverses the western academic zone (FEM, CCR, FEMA areas), continues east to the marketplace corridor (Yellow Corner, GWW Junction), extends to the Faculty of Agriculture zone, and returns to the TPST via the LSI–Al-Hurriyah axis. The yellow truck's morning route serves the dormitory cluster (Sylvalestari, Satari, Asrama Putra) before proceeding to the FPIK canteen area and returning. Afternoon routes cover supplementary stops that could not be completed in the morning, particularly sites serviced on an every-other-day basis.

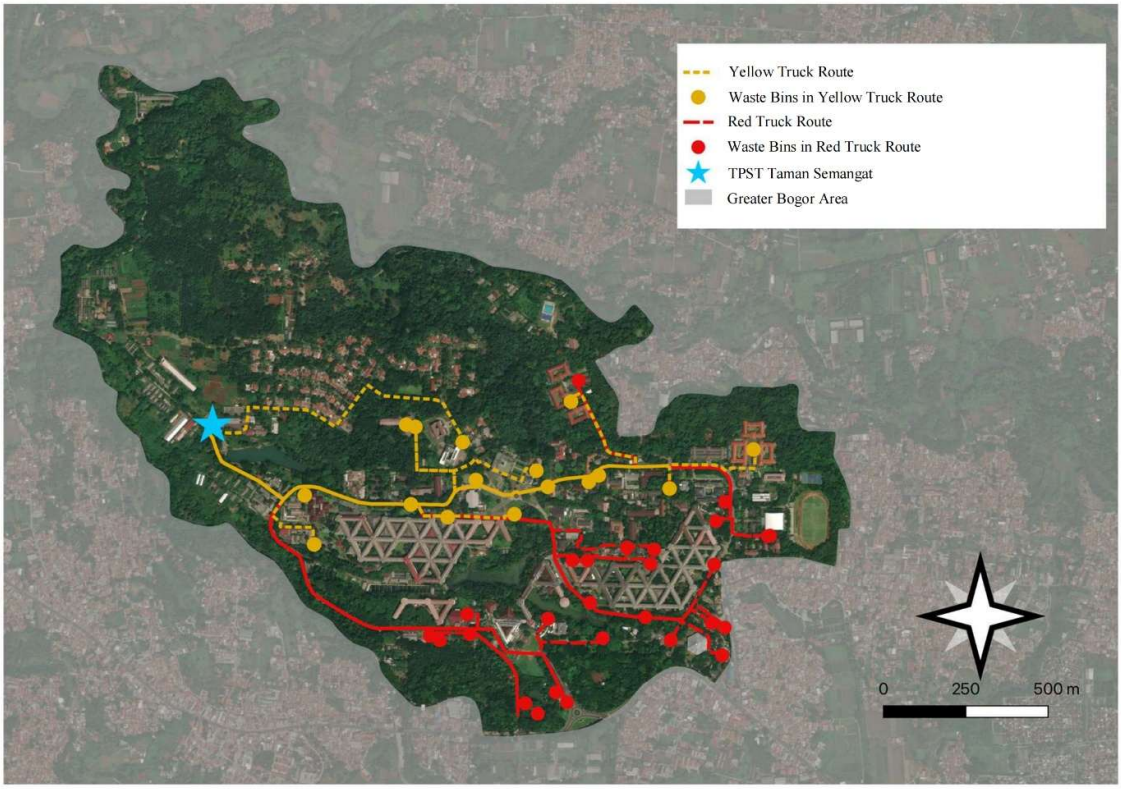

Figure 4. IPB Dramaga Red and Yellow Truck Transportation Routes

SNI 19-2454:2002 Section 5.2 specifies that waste collection should: (a) follow a regular schedule; (b) ensure all waste-generating areas are served; (c) minimise travel distance and dead-heading; (d) be carried out by adequately equipped vehicles; and (e) avoid overloading containers between collection events (7). **Table 2** summarises the conformity assessment for the collection system.

Table 2. Conformity of waste collection at IPB Dramaga Campus with SNI 19-2454:2002

SNI 19-2454:2002 Criterion	Conformity Status	Observation
Regular collection schedule	Partially Conforming	Daily morning and afternoon shifts are scheduled, but some sites are served only every two days due to capacity constraints.
Universal coverage of waste-generating areas	Non-Conforming	Not all 40 sites are visited daily. Campus community complaints confirm waste accumulation at skipped sites.
Vehicle capacity adequate for waste volume	Non-Conforming	Each truck carries ~0.7 tonnes/trip; 5 trips/day needed for 3.25 tonnes total. Only 4 trips are currently scheduled (2 trucks × 2 shifts).
Segregated collection matching waste types	Non-Conforming	Red and yellow trucks, originally designated for paper and plastic respectively, now collect mixed waste. Segregated collection has ceased.
Route optimisation to minimise travel distance	Partially Conforming	Routes follow geographically logical sequences, but the absence of route optimisation analysis means dead-heading and idle time are not minimised.

The most pressing collection deficiency is insufficient fleet capacity. With each truck capable of transporting approximately 0.7 tonnes per trip (8.2 m^3 × 85 kg/m^3 average density), and total daily waste of 3.25 tonnes, a minimum of five vehicle-trips per day is required. The current schedule provides only four effective trips per day (red truck: 2 trips; yellow truck: 2 trips), leaving a daily transport deficit of approximately 0.5 tonnes. This structural gap is directly responsible for reported waste accumulation at unserved sites.

To close the capacity deficit, the analysis indicates two feasible operational configurations: (a) retain two trucks, operating three trips (morning, midday, afternoon) with the red truck and two trips with the yellow truck; or (b) commission a third truck, each completing two trips per day. The former option requires longer operational windows or additional overtime; the latter offers greater operational flexibility and resilience against vehicle breakdown.

The discontinuation of segregated collection further compounds the problem. The colour-coded truck system was designed to facilitate separated delivery of recyclable fractions to the TPST, supporting downstream material recovery. Its collapse—attributed to the absence of source-level segregation upstream—reflects a systemic failure where containment non-compliance propagates into collection inefficiency. Reinstating segregated collection requires parallel investment in source-segregation infrastructure (separate containers for organic and non-organic waste), community behaviour change programmes, and monitoring mechanisms. These findings parallel those from similar waste management evaluations conducted at Indonesian institutions, where containerisation and collection deficiencies have been identified as co-limiting factors in achieving recycling and recovery targets [13,14].

The waste management challenges at IPB University, characterized by a daily transport deficit of approximately 0.5 tonnes and the absence of source segregation, mirror systemic deficiencies across Indonesian institutional waste systems, where containment and collection gaps serve as co-limiting barriers to recovery. These findings are consistent with the evaluation of Pasar Remu in Sorong, where non-conformity with SNI 19-2454-2002 was driven by the mixing of organic and inorganic waste during the "pewadahan" (containment) stage and the failure to implement standardized collection and transport equipment [13]. This parallel is further supported by the context of TPST and TPS 3R roles in Kota Batu,

where a lack of decentralized sorting and adequate facilities results in waste accumulation that negates the potential for significant volume reduction at the source [14,15]. At IPB, this manifests in a "capacity-demand mismatch" where high-traffic sites overflow while peripheral containers are underutilized, a structural inefficiency that echoes observations in Batu and Sorong where manual transfer and unoptimized logistics prevent the successful transition to a 3R-based circular economy [13,14,16]. Ultimately, these comparisons suggest that institutional recycling targets will remain unattainable without a synchronized upgrade to both standardized containment and fleet capacity, as the failure of one component inevitably propagates through the entire management chain [13,14].

4 Conclusion

This study evaluated waste generation, containment, and collection at Dramaga Campus, IPB University. Key findings are as follows. Daily waste generation averaged 3.25 tonnes (0.13 kg/person/day), dominated by organic waste (45%), plastic (30%), and paper (19%), with consistent patterns across source zones and at the TPST. The canteen zone produced the densest and most organic-dominated waste, while dormitories showed the highest plastic fraction.

Evaluation against SNI 19-2454:2002 identified critical non-conformities in the containment system, particularly the absence of source segregation and the spatial mismatch between container placement and actual waste generation. The collection system's most urgent deficiency is insufficient fleet capacity: the existing schedule provides only four vehicle-trips per day, whereas five are required to fully remove daily campus waste. Segregated collection, though originally designed into the truck colour-coding system, has ceased due to upstream failure in source segregation.

Recommended interventions include: (1) spatial redistribution and consolidation of waste containers to align capacity with generation patterns; (2) introduction of at minimum dual-bin source segregation (organic and non-organic) across all campus zones; (3) addition of one collection trip per day or commissioning of a third collection vehicle; and (4) reinstatement of segregated collection routes linked to source-segregated containers. Implementation of these measures would improve compliance with SNI 19-2454:2002 and advance the campus sustainability targets of IPB University.

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