Jurnal Serambi Engineering JSE
Volume XI, No.4, Oktober 2026 Hal 21581 - 21591
p-ISSN : 2528-3561
e-ISSN : 2541-1934

Design of an Underground Trashbin Based on the Morphological Characteristics of Organic Waste at Palangpang Beach, Ciletuh Geopark, Sukabumi Regency

Aisyah Bestari Siswohartono*, Yunita Majud

Environmental Engineering Department, Universitas Presiden, Bekasi, Indonesia
***Corresponding author**: aisyah.siswohartono@student.president.ac.id

Received: August 31, 2026 Approved: September 7, 2026

Abstract
Palangpang Beach, located within the Ciletuh Palabuhanratu UNESCO Global Geopark in Sukabumi Regency, West Java, experiences continuous accumulation of natural organic debris twigs, bamboo, driftwood, and beach litter—along its 1,848-meter shoreline, while large-scale cleanup is conducted only once a year. This study identifies the morphological characteristics of natural organic debris, evaluates existing waste management infrastructure, and designs underground trash bins suited to the material characteristics and site conditions of the Geopark. Data were collected through field observations and spatial analysis using QGIS to determine study area boundaries, coastline length, and slope profiles. Measurements showed twigs and bamboo averaging 25–30 cm in length and 1.5–2 cm in diameter, while driftwood reached 60–65 cm in length and 10–12 cm in diameter, ranging from dry to semi-wet condition. These morphological parameters were translated into technical design parameters through a morphology-based design approach. The resulting containers have an outer diameter of 800 mm, inner diameter of 780 mm, HDPE wall thickness of 10 mm, and buried height of 2,000 mm, with only 30 mm visible above ground. Each unit provides a geometric volume of 956 L and effective capacity of 765 L; based on an estimated annual accumulation of 9,240 L along the shoreline, 13 units spaced about 142 m apart are recommended, yielding a total system capacity of 9,945 L, meeting roughly 108% of annual need. Dark brown HDPE was selected through a seven-criteria evaluation matrix. The findings show how bin specifications can be derived directly from field-measured material morphology, offering a design logic applicable to conservation-based coastal tourism sites.
Keywords: *morphology-based design; natural organic waste; underground waste container; palangpang beach; unesco global geopark*

Abstrak
Pantai Palangpang, di kawasan Geopark Global UNESCO Ciletuh Palabuhanratu, Sukabumi, Jawa Barat, mengalami akumulasi sampah organik alami ranting, bambu, kayu apung, dan sampah pantai sepanjang 1.848 meter garis pantai, sementara pembersihan besar hanya setahun sekali. Penelitian ini mengidentifikasi morfologi sampah organik alami, mengevaluasi infrastruktur pengelolaan sampah, dan merancang tempat sampah bawah tanah sesuai material dan lokasi. Data dikumpulkan melalui observasi lapangan dan analisis spasial QGIS untuk batas area, panjang garis pantai, dan kemiringan lahan. Ranting dan bambu berpanjang rata-rata 25–30 cm dan berdiameter 1,5–2 cm, sedangkan kayu apung mencapai panjang 60–65 cm dan diameter 10–12 cm, kondisi kering hingga semi-basah. Parameter ini diterjemahkan menjadi desain teknis berbasis morfologi. Wadah berdiameter luar 800 mm, dalam 780 mm, dinding HDPE 10 mm, tinggi tertanam 2.000 mm, hanya 30 mm terlihat di permukaan. Setiap unit memiliki volume 956 L dan kapasitas 765 L; berdasarkan akumulasi tahunan 9.240 L, direkomendasikan 13 unit berjarak 142 m, total kapasitas sistem 9.945 L, memenuhi 108% kebutuhan tahunan. HDPE cokelat tua dipilih melalui matriks evaluasi tujuh kriteria. Temuan menunjukkan spesifikasi tempat sampah diturunkan dari morfologi material hasil pengukuran lapangan, menawarkan logika desain untuk lokasi wisata pesisir konservasi.
Kata Kunci: *desain berbasis morfologi; limbah organik alami; tempat sampah bawah tanah; pantai palangpang; geopark global unesco*

1. Introduction

Beach tourism areas bordering forests or coastal vegetation often experience the repeated accumulation of natural organic waste such as twigs, wood, and leaves, as these materials are constantly shed and dispersed by natural coastal processes, making it difficult to prevent them at the source. Wood and twigs accounted for 10.77% of Indonesia's national waste composition in 2025 [1], and similar studies

at Randusanga Beach in Central Java and the coast of Banyuwangi in East Java also identified wood and twigs as recurring components of coastal waste [2], [3]. If left unmanaged, this accumulation can degrade coastal environmental quality, aesthetics, and visitor comfort, indicating that naturally occurring organic waste must be explicitly accounted for in waste management planning for coastal tourist areas [4], [5].

Waste management in coastal tourist areas is becoming increasingly complex due to fluctuations in visitor numbers, diverse sources of waste, and a mismatch between the types and capacities of available containers and the actual physical characteristics of the waste generated [4]; a related issue to note is that inadequate waste management facilities directly affect visitor satisfaction, as a decline in environmental cleanliness has been shown to reduce tourists' satisfaction with beach destinations [5]. The need for appropriate infrastructure is becoming increasingly urgent in areas with conservation status, such as the Ciletuh Palabuhanratu UNESCO Global Geopark, which has been part of the UNESCO Global Geoparks Network since April 2018 and covers an area of approximately 126,000 ha of geologically significant territory in the southwestern part of Sukabumi Regency, West Java [6]. Infrastructure built within the UNESCO Global Geopark is expected to adhere to the principles of conservation, sustainability, and landscape harmony in addition to its primary function [7]; therefore, waste management facilities at Palangpang Beach must align their functional performance with the Geopark's aesthetic and conservation characteristics.

Palangpang Beach is the main tourist gateway to the Ciletuh Palabuhanratu UNESCO Global Geopark, located in Ciwaru Village, Ciemas Subdistrict, Sukabumi Regency. This area is surrounded by casuarina trees (Casuarina equisetifolia), mangroves, coconut palms, and acacia trees, which continuously shed litter, twigs, and branches onto the shoreline. Field observations reveal a significant gap between this ongoing accumulation of waste and the scope of available waste management infrastructure: trash bins are limited to parking areas and do not reach the zones where natural organic material accumulates most heavily, and there is no regular collection schedule large scale cleanups are generally conducted only once a year, on Fishermen's Day. During the 2025 National Waste Awareness Day (HPSN) beach cleanup in Palangpang, more than 800 participants were mobilized to clear the accumulated organic material [8], underscoring the scale of the problem that existing infrastructure is unable to handle.

Natural organic waste differs from conventional urban waste in that its shape and size vary greatly and it tends to be elongated rather than dense or compact. Field observations identified twigs and bamboo pieces with an average length of 25-30 cm and a diameter of 1.5-2 cm, while driftwood reached lengths of 60–65 cm with diameters of 10-12 cm dimensions that can exceed the opening size of conventional waste bins. Waste collection infrastructure designed for these materials must therefore be tailored to their physical characteristics specifically length, diameter, and shape [9] a principle consistent with SNI 3242:2008, which classifies wood, leaves, and twigs as waste components distinct from ordinary household waste [10]. Underground waste containers offer a sensible alternative because they can accommodate large-sized materials while minimizing the visual impact of the infrastructure on the coastal landscape.

Previous studies on coastal litter in Indonesia have largely focused on identifying the types and composition of litter for example, at Randusanga Beach and Banyuwangi [2], [3] while studies on waste management planning at other coastal tourist sites generally address the distribution of facilities and cleanup logistics, rather than container design [11], [12], [13]. Research on the Ciletuh Palabuhanratu Geopark itself has also focused more on geodiversity, geoheritage, and the outcomes of sustainable development, rather than on waste management infrastructure [6], [7].

2. Material and Methods

Study Area

This study was conducted at Palangpang Beach, Ciwaru Village, Ciemas Subdistrict, Sukabumi Regency, West Java Province, which is located within the Ciletuh–Palabuhanratu UNESCO Global Geopark (approximately 7°10'52.42"S, 106°27'49.87"E). The field survey was conducted over four days, from June 15 to 19, 2026. The study area is surrounded by casuarina, mangrove, coconut, and acacia vegetation, which are the primary sources of natural organic material that accumulates along the shoreline.

Jurnal Serambi Engineering JSE
Volume XI, No.4, Oktober 2026 Hal 21581 - 21591
p-ISSN : 2528-3561
e-ISSN : 2541-1934

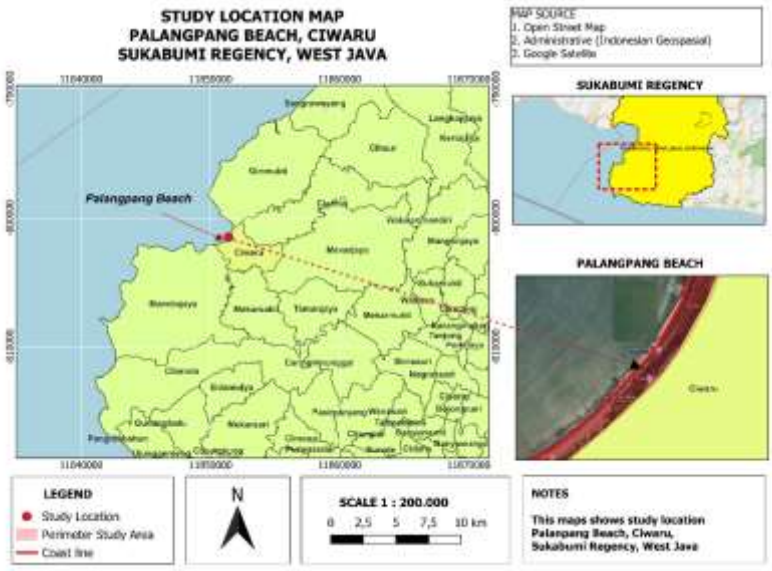


Fig. 1: Study Location Map of Palangpang Beach, Ciwaru, Sukabumi Regency, West Java
Source: Author's analysis based on OpenStreetMap, Indonesian Geospatial Information Agency, and Google Satellite (2026).



Fig. 2: Proposed Distribution Layout of Underground Waste Containers along the Palangpang Beach Coastline

Data Collection

Primary data were collected through (1) field observations of existing waste management infrastructure and documentation of the dominant types of natural organic waste, (2) direct morphological measurements of waste materials (length, diameter, cross-sectional shape, and physical condition), and (3) spatial analysis using QGIS, utilizing OpenStreetMap base data, Indonesian administrative boundaries, and Google satellite imagery, to define the study area boundaries, measure coastline length, and characterize land slope using a digital elevation model and zonal statistical analysis.

Data Analysis

Two complementary approaches were used in this study. Descriptive analysis was used to characterize the existing conditions of the site infrastructure, vegetation, and topography as a basis for the engineering design. Furthermore, a morphology-based technical analysis systematically translates each measurable morphological parameter of natural organic waste material type, average length, average diameter, cross-sectional shape, and physical condition into corresponding technical design parameters, following the principle that the physical characteristics of the objects to be contained should be the primary

determinants of container specifications [9]. Since the bulk density of the material is not measured directly, an engineering assumption of 60 kg/m³ is used, representing dry organic material with a loosely packed density.

Design Criteria

Design decisions are evaluated simultaneously based on four interrelated dimensions: (1) functional criteria, derived from the measurable morphology of the material (opening dimensions, capacity for a single seasonal accumulation cycle, emptying by a single person, internal drainage); (2) technical-structural criteria for coastal conditions (resistance to salinity, UV radiation, and humidity; structural stability; installation depth adjusted to the slope of the land); (3) contextual-aesthetic criteria (low visual profile, as well as colors and shapes that blend with the coastal forest landscape); and (4) material sustainability criteria (local availability of materials, a minimum service life of 5 years, and recyclability) [9], [14].

Capacity and Dimension Calculation

The annual accumulation volume of natural organic material is estimated based on the accumulation rate per unit of coastline length and the measured coastline length:

$$V_{accumulation} = Accumulation\ rate \times Coastline\ length$$

where the accumulation rate (0.005 m³/m/year) is used as a conservative engineering estimate based on the literature. The minimum inner diameter of the container is determined from the maximum length of the dominant material:

$$D_{inner,min} = L_{material,max}$$

The geometric volume of the container (cylindrical in shape) is calculated using:

$$V = (\pi/4) \times D^2_{(inner)} \times H$$

where D_(inner) is the inner diameter of the container and H is the total height of the buried container. The number of units required is then obtained from:

$$n = V_{accumulation} / V_{effective,per\ unit}$$

with rounding up, since rounding down would result in a total capacity lower than the estimated annual accumulation. No additional formulas other than those mentioned above are used in this design.

Material Selection

Candidate construction materials (thick HDPE, reinforced concrete, and fiberglass) were evaluated using a multi-criteria matrix with seven criteria: resistance to salinity, resistance to UV radiation, weight and ease of installation, ease of fabrication, cost, service life in a coastal environment, and flexibility in color customization. The material with the highest cumulative score was selected as the primary construction material.

3. Results and Discussion

Study Area and Existing Waste Management Conditions

Spatial analysis using QGIS measured the perimeter of the study area at 3,876 m and the coastline length at 1,848 m. Land slope analysis, using a digital elevation model summarized through zonal statistical analysis, showed values ranging from 1.60% to 2.78%, with an average of 2.12%—classified as “flat”. This relatively flat topography facilitates excavation work, reduces the volume of earthwork required for installation, and limits the risk of erosion and surface runoff that could potentially affect the stability of the buried container.

The existing waste management infrastructure shows a significant gap compared to the scale of waste accumulation. Trash bins are available only in limited numbers in parking areas and do not reach the coastal zones where organic material accumulates the most; there is no routine collection mechanism, and large-scale cleanups take place only about once a year, on Fishermen’s Day. The HPSN 2025 cleanup, which involved more than 800 participants as well as heavy equipment such as excavators to clear the organic material that had accumulated in Palangpang [8], reinforces the evidence that the volume and physical

characteristics of the accumulated waste have exceeded the capacity of the current conventional infrastructure.



Fig. 3: Observed Natural Organic Waste and Coastal Conditions at Palangpang Beach
Source: Field Observation (2026).

Morphological Characteristics of Natural Organic Waste

Field observations identified four dominant categories of natural organic debris on Palangpang Beach: twigs, bamboo pieces, driftwood, and beach litter, which is consistent with reports that wood and twigs are recurring components of coastal debris at other locations in Indonesia [2], [3]. **Table 1** summarizes the morphological characteristics measured for these four categories.

Table 1. Morphological characteristics of organic waste at Palangpang Beach

Material type	Avg. length	Avg. diameter	Cross-section	Physical condition
Twig	25–30 cm	1.5–2 cm	Irregular cylindrical	Dry–semi-wet
Bamboo segment	25–30 cm	1.5–2 cm	Hollow cylindrical	Dry
Driftwood	60–65 cm	10–12 cm	Irregular	Wet–semi-wet
Beach litter	5 cm	3 cm	Irregular, fine	Dry

Driftwood is the largest and most structurally demanding fraction, with a length-to-diameter ratio and an elongated shape characteristic of dry coastal organic litter [9]. These dimensions—particularly the maximum length of driftwood, which is 60–65 cm—are the primary factors determining the size of the opening and the internal diameter of the container, given that the openings of conventional trash cans (typically ranging from 20–30 cm) would be unable to accommodate this material without prior cutting.

Translation of Waste Morphology into Design Requirements

Each morphological parameter is mapped to a corresponding engineering requirement and design parameter, following the sequence: material characteristics → engineering requirements → design parameters. **Table 2** summarizes the mappings that have the greatest impact on the design.

Table 2. Translation of morphological parameters into design requirements

Waste characteristic	Engineering requirement	Design parameter
Driftwood max. length (60–65 cm)	Opening must admit the longest routinely occurring material without pre-cutting	Minimum opening/inner diameter ≥ 70 cm; adopted inner diameter 780 mm
Driftwood max. diameter (10–12 cm)	Adequate clearance around inserted material	Minimum opening clearance ≥ 12 cm
Irregular / cylindrical cross-section	Opening geometry compatible with irregular shapes	Circular opening
Dry–to–semi-wet material condition	Prevent moisture build-up and odor	Ventilated lid + perforated base drainage
High salinity, UV, and humidity exposure	Long-term material durability	UV- and corrosion-resistant HDPE body
Geopark landscape and aesthetic requirements	Minimal visual impact on the coastal landscape	Low above-ground profile (30 mm); dark-brown color

Capacity and Number of Units

Using a total coastline length of 1,848 m and an accumulation rate of 0.005 m³/m/year, the estimated annual accumulation is 9.24 m³ (9,240 L) per year. With an internal diameter of 780 mm and a buried depth of 2,000 mm, the geometric volume of each container is 956 L; by applying an operational allowance factor

of 80% (to prevent overloading and facilitate the loading process), an effective capacity of 765 L per unit is obtained. Dividing the estimated annual accumulation by this effective capacity yields 12.08 units, which is rounded up to 13 units, since rounding down would result in insufficient system capacity. Distributing the 13 units evenly along the 1,848 m coastline results in a distance of approximately 142 m between units, with a total system capacity of 9,945 L about 108% of the estimated annual accumulation, representing a moderate surplus that accommodates the uncertainty inherent in conservative, literature-based accumulation rate estimates. A comparison of alternative unit counts (Table 3) confirms that 13 units is the minimum number required to meet the estimated demand without significantly excessive allocation.

Table 3. Comparison of scenarios by number of units

Scenario	Units	Total capacity	Fulfillment of 9,240 L	Remark
A	10	7,650 L	83%	Inadequate
B	11	8,415 L	91%	Inadequate
C	12	9,180 L	99%	Slightly inadequate
D	13	9,945 L	108%	Recommended
E	14	10,710 L	116%	Additional reserve
F	15	11,475 L	124%	Large reserve

Material Selection

Table 4 summarizes the results of the evaluation of the three candidate materials based on seven criteria. Thick HDPE received the highest score (7/7), outperforming reinforced concrete (2/7) and fiberglass (4/7), primarily because it does not corrode or require a protective coating in saline conditions, is much lighter for installation on coastal sand, and can be pigmented with dark colors as needed to blend with the landscape, whereas concrete is heavy and susceptible to chloride penetration, and fiberglass is relatively more expensive and prone to degradation due to long-term UV exposure [15].

Table 4. Seven-criteria evaluation of candidate construction materials

Criterion	Thick HDPE	Reinforced concrete	Fiberglass
Salinity resistance	✓	✗	✓
UV resistance	✓	✓	✗
Weight / ease of installation	✓	✗	✓
Ease of fabrication	✓	✗	✗
Cost	✓	✗	✗
Coastal service life	✓	✓	✓
Color customization	✓	✗	✓

Thick, dark brown HDPE, with added UV-resistant and anti-corrosion additives, was selected as the primary material for the container body and lid; meanwhile, the hinges and other metal components were specified to be made of 304 stainless steel, which was chosen for its proven resistance to corrosion in chloride-containing environments [15].

Final Underground Trash Bin Design

The proposed container is a vertical cylinder buried to a depth of 2,000 mm, with only a 30-mm-high lid visible above the surface. **Table 5** summarizes the complete technical specifications.

Table 5. Final technical specifications of the underground trash bin

Parameter	Specification	Basis
Outer diameter	800 mm	Inner diameter + 2 × wall thickness
Inner diameter	780 mm	Max. driftwood length (65 cm) × 1.2 design allowance
Wall thickness	10 mm	HDPE structural/durability requirement
Total buried height	2,000 mm	Required capacity + burial concept
Height above surface	30 mm	Low-profile aesthetic requirement
Geometric volume	956 L	$V = (\pi/4)D^2H$
Effective capacity	765 L	80% of geometric volume
Mass capacity	45.9 kg	Effective capacity × bulk density (60 kg/m³)
Number of units	13	Annual accumulation ÷ effective capacity, rounded up
Total system capacity	9,945 L	13 × effective capacity
Unit spacing	142 m	Coastline length ÷ number of units
Body / lid material	Thick HDPE, UV- and corrosion-resistant	Seven-criteria material matrix
Color	Dark brown	Landscape/aesthetic integration
Hinge material	304 stainless steel	Corrosion resistance in coastal environment
Excavation diameter / depth	850 mm / 2,050 mm	Outer diameter + installation clearance; height + base drainage layer

The Proposed Detail Engineering Design

Shows the 3D view of the trash bin with the lid open, revealing the circular opening ready to receive waste, simulated on the beach sand surface.



Fig. 4: 3d view of open condition

Shows the condition when the lid is fully closed, where only the top lid is visible flush with the ground/sand surface, preserving the beach's visual aesthetics.



Fig. 5: 3d view of closed condition

Shows two views (top and side) of the bin body, indicating the diameter (Ø800/Ø790) and total height (2000 mm, width 780 mm) as the basic construction reference.

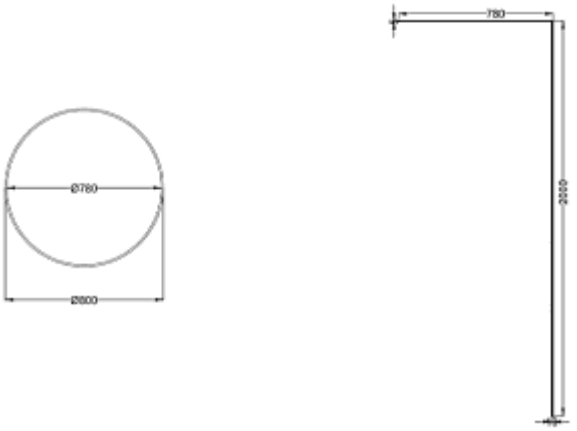


Fig. 6: Detail Body

A cross-sectional view showing the main labeled components: (1) hinge, (2) lid, (3) lifting (lifting hook), and (4) body trash bin, illustrating the internal layout of the cylinder.

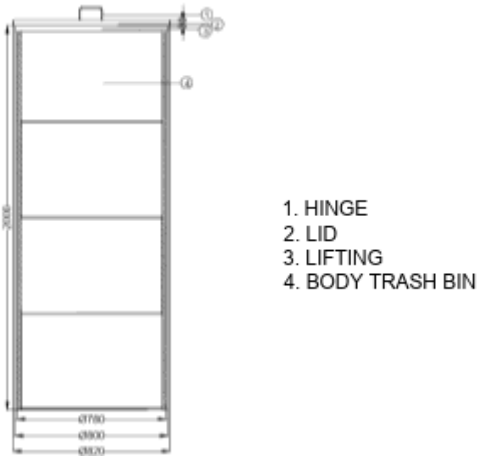


Fig. 7: Cross Section

Front view of the bin with horizontal lines indicating the buried height segmentation/levels and width dimensions and Side view with the same proportions and dimensions, completing the picture of the bin's cylindrical shape from another angle.

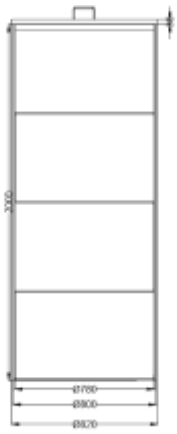


Fig. 8: Front view

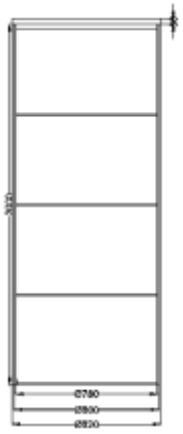
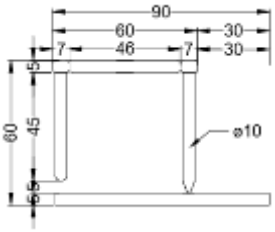


Fig. 9: Side view

Detail dimensions of the hinge (size 90×46 mm, bolt hole Ø10) connecting the lid to the body so it can be opened and closed and Detail of the handle/grip on the lid, used to make manual opening and closing easier.



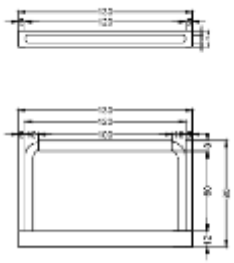
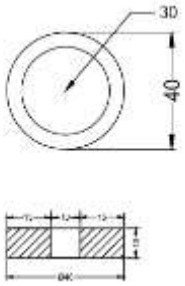


Fig. 10: Hinge Detail

Fig. 11: Handle Detail

Detail of the lifting hook (outer diameter Ø30, height 40 mm) used when lifting the bin for waste emptying and Top view of the circular lid (Ø820) with a pattern of small holes around its edge, likely serving as decorative ventilation.



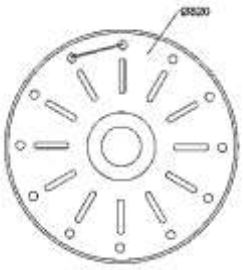
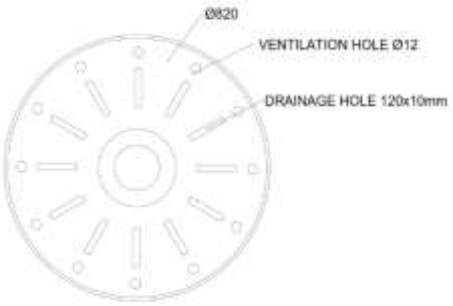


Fig. 12: Lifting Hook

Fig. 13: Top view

Detail of the layout of ventilation holes (Ø12) and drainage holes (120×10 mm) on the lid, functioning to maintain air circulation and drain water so the organic waste doesn't become overly damp and Cross-sectional illustration of the bin installed and buried in the sand, showing how the cylindrical body is buried underground with only the top (lid) visible at the beach sand surface.



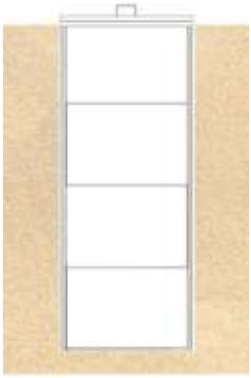


Fig. 14: Ventilation and drainage

Fig. 15: Installation in sand detail

Discussion

The 780 mm inner diameter provides sufficient clearance to accept the largest routinely observed driftwood (60–65 cm) without pre-cutting, while also accommodating the smaller twigs and bamboo segments (25–30 cm). This directly contrasts with conventional trash bins, whose 20–30 cm openings are unable to contain elongated coastal debris of this size [4], and is consistent with the general principle that a waste container's specification should be derived from the physical characteristics of the material it is intended to hold [8]. The result therefore extends earlier composition-focused coastal waste studies [2], [3], [11], which document what types of material accumulate on Indonesian beaches but stop short of translating

those characteristics into container-level specifications; this study's contribution is precisely that translation step, formalized as a repeatable design procedure (Table 2).

The design also responds to site-specific constraints. The gentle average slope (2.12%) simplifies excavation and reduces the risk of erosion-related settling, while a perforated base and a sand-filled annulus around the buried body allow rainwater and salt spray to drain rather than pool, a consideration that matters for structures installed in sandy, tidally influenced substrates [8]. The 30-mm above-ground profile and the dark-brown finish are direct responses to the Geopark's landscape-conservation mandate [7]: unlike a conventional above-ground bin, the buried format keeps almost the entire structure out of sight, which is consistent with the general rationale for underground waste containers in visually sensitive settings.

These results should be read as conceptual rather than as evidence of field-proven performance. The 765 L effective-capacity figure, the 9,240 L annual-accumulation estimate, and the 13-unit recommendation all rest on a literature-derived accumulation rate and an assumed bulk density, since no direct volumetric measurement of cleared waste was available at the study site. The design is therefore best understood as a morphology-driven specification that establishes plausible, defensible dimensions and quantities, pending empirical verification through a constructed prototype.

4. Conclusion

Natural organic debris on Palangpang Beach consists primarily of twigs and bamboo pieces (25–30 cm long, 1.5–2 cm in diameter) as well as driftwood (60–65 cm long, 10–12 cm in diameter), which primarily originates from casuarina, mangrove, coconut, and acacia vegetation. The current waste management infrastructure is limited to the parking area; it does not extend to the accumulation zones along the shoreline and is addressed only through a large-scale cleanup once a year, indicating a significant gap compared to the scale of natural organic waste accumulation along the 1,848-meter-long shoreline.

By applying a morphology-based design approach, this study produced a design for an underground trash bin with an outer diameter of 800 mm, an inner diameter of 780 mm, 10 mm-thick HDPE walls, and a total buried height of 2,000 mm (with 30 mm visible above ground level), resulting in an effective capacity of 765 L per unit. Based on an estimated annual accumulation of 9,240 L, the use of 13 units is recommended, spaced approximately 142 m apart, resulting in a total system capacity of 9,945 L (±108% of the estimated demand). Dark brown HDPE, selected through a seven-criteria material evaluation matrix, along with 304 stainless steel components, was specified to meet the requirements for resistance to coastal conditions and harmonization with the Geopark landscape. The key engineering implication of this study is that container specifications for natural organic waste in conservation-based coastal tourism areas can be systematically derived from the morphology of materials measured in the field, rather than from general urban waste container standards; validation of the resulting capacity and durability assumptions through prototyping and field testing remains a critical next step before implementation.

5. Acknowledgment

The author would like to thank the Environmental Engineering Program at President University for the academic support, guidance, and facilities provided throughout this research. Thanks are also extended to the management of the Ciletuh Palabuhanratu UNESCO Global Geopark and the local community around Palangpang Beach for their permission and assistance during the field survey. Thanks are also extended to colleagues who assisted with data collection and waste morphology measurements at the study site. It is hoped that the results of this study will contribute to the development of waste management in conservation-based coastal tourism areas.

6. Abbreviations

HDPE	High-Density Polyethylene
QGIS	Quantum Geographic Information System
HPSN	Hari Peduli Sampah Nasional (National Waste Awareness Day)
UNESCO	United Nations Educational, Scientific and Cultural Organization
SNI	Standar Nasional Indonesia (Indonesian National Standard)

7. References

[1] Kementerian Lingkungan Hidup dan Kehutanan RI, “Data Komposisi Sampah Nasional 2022,” 2023.

[2] F. El Haq *et al.*, “Jenis dan komposisi sampah laut di pesisir Pantai Randusanga, Brebes,” *J. Ilmu dan Teknol. Klautan Trop.*, vol. 16, no. August, pp. 149–161, 2024.

[3] D. N. Arifianti *et al.*, "Komposisi Sampah Laut di Pesisir Pantai Kabupaten Banyuwangi, Jawa Timur," *J. Mar. Coast. Sci.*, vol. 13, no. September, 2024, doi: 10.20473/jmcs.v13i3.59631.
[4] A. S. Jayantri, M. A. Ridlo, U. Islam, and S. Agung, "Strategi pengelolaan sampah di kawasan pantai," *J. Kaji. Ruang*, vol. 1, no. 2, pp. 147–159, 2021.
[5] H. Hikmah, A. Asrial, and A. Sanusi, "Measuring tourist satisfaction with facilities and cleanliness at beach destinations: A case study of Air Cina Beach Tourism, Lifuleo Village, Kupang Regency, East Nusa Tenggara, Indonesia.," *Int. J. Sustain. Dev. Plannis*, 2024.
[6] N. Ardiansyah, K. Sena, A. Nugraha, R. Ikhram, and U. Padjadjaran, "Gediversity of Ciletuh-Palabuhanratu UNESCO Global Geopark, Sukabumi, West Java," *Bul. Sumber Daya Geol.*, no. 44, pp. 11–18, 2019.
[7] U. Khasanah, D. N. Martono, and Supriatna, "The Role and Effectiveness of the Ciletuh-Palabuhanratu Geopark in Acceleration Achievement of Sustainable Development Goals Pillars of Economic Development," *J. Penelit. Pendidik. IPA*, vol. 9, no. 10, pp. 8034–8039, 2023, doi: 10.29303/jppipa.v9i10.5403.
[8] Dinas Lingkungan Hidup Kabupaten Sukabumi, "Laporan Kegiatan Hari Peduli Sampah Nasional 2025: Aksi Bersih-Bersih Pantai Palangpang Geopark Ciletuh." [Online]. Available: https://arahbicara.com/dlh-dorong-pelestarian-lingkungan-dalam-rangka-hpsn-2025/
[9] F. Zahra and T. P. Damanhuri, "Kajian komposisi, karakteristik, dan potensi daur ulang sampah di TPA Cipayung, Depok," *J. Tek. Lingkung.*, vol. 17, no. April, pp. 59–69, 2011.
[10] Badan Standardisasi Nasional, "SNI 3242:2008: Pengelolaan sampah di permukiman." [Online]. Available: https://upstdlh.id/files/SNI_3242-2008.pdf
[11] T. Wahyuningsih and R. Jati, "Perencanaan Pengelolaan Sampah di Objek Wisata Pantai Pulau Datok," *J. Teknol. Lingkung. Lahan Basah*, vol. 12, no. 3, pp. 740–748, 2024.
[12] Z. Hilman, D. Awfa, L. Fitria, and I. W. K. Suryawan, "Problematika Sampah di Sektor Perjalanan dan Pariwisata : Kajian Literatur," *J. Teknol. Lingkung. Lahan Basah*, vol. 11, no. 3, pp. 896–903, 2023.
[13] Pemerintah Republik Indonesia, "Peraturan Presiden Nomor 83 Tahun 2018 tentang Penanganan Sampah Laut," 2018. [Online]. Available: https://peraturan.bpk.go.id/Home/Details/94716
[14] D. A. Pangestu and Indrawati, "Analisa Kebersihan Wisata Watu Jonggol di Kecamatan Sine Kabupaten Ngawi (Kajian Perilaku dan Sebaran Tempat Pembuangan Sampah)," *SIAR II Semin. Ilm. Arsit.*, vol. 8686, pp. 324–328, 2021.
[15] P. Manuel *et al.*, "Reinforced Polymer & High Density Polyethylene," *JMTS J. Mitra Tek. Sipil*, vol. 6, no. 3, pp. 545–556, 2023.