

# Characterization of Plastic Waste in the Kebon Melati Reservoir, Central Jakarta and the Utilization Potential of Polyethylene Terephthalate (PET)

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Received: October 15, 2025

Approved: April 28, 2026

## Abstract

This study examines the characteristics and utilization potential of plastic waste, particularly Polyethylene Terephthalate (PET), collected from the Kebon Melati Reservoir in Central Jakarta. Urban reservoirs in Jakarta increasingly serve as accumulation points for floating waste, contributing to drainage obstruction and aquatic pollution. Waste samples were collected using a grab sampling method at multiple accumulation points, followed by manual sorting and moisture content analysis. The results showed that biodegradable waste accounted for 64.1% of total collected waste, while plastic waste represented 35.9%. Within the plastic fraction, PET was identified as the dominant polymer type, followed by High-Density Polyethylene (HDPE) and Low-Density Polyethylene (LDPE). Moisture analysis indicated that PET had the lowest moisture content (3.4%) compared with HDPE (5.3%) and LDPE (6.3%), while biodegradable waste had a significantly higher moisture content (78.1%). These findings demonstrate that PET has strong potential for mechanical recycling, pyrolysis, and Refuse-Derived Fuel (RDF) production due to its low moisture content and stable polymer structure. This study highlights the importance of reservoir-based plastic recovery as a strategy to support circular economy initiatives and improve urban waste management in Jakarta.

**Keywords:** *plastic waste, PET characterization, aquatic pollution, recycling potential, circular economy*

## Abstrak

Penelitian ini mengkaji karakteristik dan potensi pemanfaatan sampah plastik, khususnya Polyethylene Terephthalate (PET), yang dikumpulkan dari Waduk Kebon Melati, Jakarta Pusat. Waduk perkotaan di Jakarta semakin berfungsi sebagai titik akumulasi sampah terapung yang berkontribusi terhadap penyumbatan drainase dan pencemaran perairan. Sampel limbah dikumpulkan menggunakan metode grab sampling pada beberapa titik akumulasi sampah, kemudian dilakukan pemilahan manual serta analisis kadar air. Hasil penelitian menunjukkan bahwa sampah biodegradable menyumbang 64,1% dari total sampah yang terkumpul, sedangkan sampah plastik mencapai 35,9%. Pada fraksi plastik, PET merupakan jenis polimer yang paling dominan, diikuti oleh *High-Density Polyethylene* (HDPE) dan *Low-Density Polyethylene* (LDPE). Analisis kadar air menunjukkan bahwa PET memiliki kadar air terendah (3,4%) dibandingkan HDPE (5,3%) dan LDPE (6,3%), sementara sampah biodegradable memiliki kadar air yang sangat tinggi (78,1%). Temuan ini menunjukkan bahwa PET memiliki potensi besar untuk didaur ulang secara mekanis, diolah melalui pirolisis, maupun dimanfaatkan sebagai bahan baku *Refuse-Derived Fuel* (RDF) karena kadar airnya yang rendah dan struktur polimernya yang stabil. Penelitian ini menekankan pentingnya pemulihan sampah plastik berbasis waduk untuk mendukung ekonomi sirkular dan peningkatan pengelolaan sampah perkotaan di Jakarta.

**Kata Kunci:** *sampah plastik, karakterisasi PET, pencemaran perairan, potensi daur ulang, ekonomi sirkular*

## 1. Introduction

Plastic waste has become one of the most pressing environmental challenges in rapidly urbanizing cities around the world, including Indonesia [1], [2]. The combined effects of population growth, economic development, and increasing dependence on plastic-based products have led to a dramatic rise in waste generation. In Jakarta the most densely populated and industrially active metropolitan area in Indonesia

plastic waste is a dominant component of urban solid waste, much of which remains unmanaged or improperly disposed of [3], [4], [5], [6], [7], [8]. Inefficient collection systems, lack of waste segregation, and limited public awareness have caused large quantities of plastic waste to enter urban drainage networks, rivers, and reservoirs. One of the most affected sites is the Kebon Melati Reservoir, located in Central Jakarta, which functions both as a water retention basin for flood control and as an unintended accumulation site for floating urban waste. The accumulation of plastic waste in urban water bodies has far-reaching environmental, hydrological, and public health implications [9]. Plastic debris obstructs water flow, reduces storage capacity, and disrupts aquatic ecosystems [10], [11], [12]. Over time, exposure to sunlight and physical abrasion fragments larger plastic items into microplastics, which can be ingested by aquatic organisms and potentially enter the human food chain. Global studies indicate that more than 80% of marine plastic pollution originates from land-based sources, with Southeast Asia identified as a major contributor [13], [14]. Indonesia alone is estimated to generate over 3.2 million tons of unmanaged plastic waste per year, much of which leaks into rivers and coastal waters. This situation underscores the urgent need for upstream interventions targeting collection, characterization, and valorization of plastic waste directly at its accumulation points.

Among various types of plastics found in aquatic environments, Polyethylene Terephthalate (PET) commonly used in beverage bottles and packaging represents one of the most abundant and environmentally persistent materials [15]. PET's popularity stems from its lightweight structure, chemical resistance, and recyclability, yet these same properties also make it durable and resistant to natural degradation. Unlike low-density plastics that degrade more easily or contain harmful additives, PET maintains stable chemical integrity over time, making it both a pollution concern and a valuable resource for recovery. PET contains a high proportion of carbon and hydrogen and has a high calorific value [16], comparable to low-grade coal. These characteristics make PET a promising feedstock for Refuse-Derived Fuel (RDF) production, pyrolysis, or carbonization, where it can be converted into fuel, char, or other high-value carbon materials.

Despite its potential, the recovery and utilization of PET from aquatic waste sources remain limited, particularly in Indonesia [17]. Most recycling efforts focus on clean, post-consumer PET collected from formal waste streams [18], while PET retrieved from polluted water bodies is often considered low-value due to contamination and variable quality. However, with proper pre-treatment and initial characterization, aquatic PET waste can be repurposed for both material and energy recovery applications. Key characterization parameters, including moisture content, carbon composition, and ash residue, are essential for evaluating technical feasibility and determining appropriate processing pathways such as mechanical recycling, pyrolysis, or Refuse-Derived Fuel (RDF) production. In addition, the characterization of PET waste from urban reservoirs can provide important baseline information for developing localized circular economy strategies that integrate waste recovery, renewable energy utilization, and community-based waste management systems.

The novelty of this study lies in three main contributions. First, unlike previous studies that primarily examine land-based municipal plastic waste, this research specifically focuses on floating plastic waste accumulated in urban reservoirs, an issue that remains underexplored in Indonesia. Second, this study provides quantitative characterization of PET waste collected from aquatic environments, particularly through moisture content analysis relevant to recycling and RDF feasibility. Third, this research connects environmental pollution assessment with circular economy approaches by identifying practical utilization pathways for PET waste within Jakarta's urban water infrastructure.

The Kebon Melati Reservoir was selected as a representative case study because it reflects broader urban waste challenges in Jakarta, including high population density, mixed waste inflows, and inadequate waste segregation practices. As one of Jakarta's urban reservoirs, it frequently receives floating waste transported through drainage systems, making it an appropriate location for examining aquatic plastic accumulation and recovery opportunities. Therefore, this study aims to characterize and evaluate the utilization potential of PET plastic waste collected from the Kebon Melati Reservoir in Central Jakarta. The findings are expected to provide scientific evidence for developing localized PET recovery systems that reduce aquatic pollution while promoting sustainable material utilization and low-carbon urban development in Indonesia.

## 2. Material and Methods

This study was designed to evaluate the utilization potential of plastic waste, with a particular focus on Polyethylene Terephthalate (PET) collected from the Kebon Melati Reservoir, Central Jakarta. The research aimed to provide a comprehensive understanding of the composition, physical characteristics, and

recovery potential of aquatic plastic waste using observational and analytical approaches rather than advanced laboratory analyses such as proximate or ultimate testing. The overall methodological framework consisted of site observation, field sampling, waste sorting and classification, drying and moisture content analysis, physical characterization, and evaluation of potential recovery pathways. The Kebon Melati Reservoir was selected as the study site because it represents a typical urban water body in Jakarta that continuously receives mixed waste from densely populated residential settlements, commercial activities, drainage canals, and surrounding urban runoff systems. The reservoir functions as both a flood control basin and sediment retention area, which causes floating waste to accumulate at specific locations before being transported downstream. This makes the reservoir an appropriate case study for evaluating urban aquatic plastic waste accumulation and recovery opportunities. The spatial distribution of the study site and sampling locations is presented in **Figure 1**, which illustrates five designated sampling points (S1–S5) distributed across the northern, central, and southern sections of the reservoir based on observed waste accumulation intensity, water flow direction, and accessibility for manual collection activities.



**Figure 1.** Study location map of Kebon Melati Reservoir, Central Jakarta (Google Maps, 2021), showing sampling areas and floating waste collection points used in this study.

To improve data reliability and account for temporal variations in floating waste accumulation, this study applied a repeated grab sampling approach rather than a single sampling event. Sampling was conducted over a four-week period from May to June 2025, with waste collection performed once every seven days, resulting in a total of four sampling rounds. Repeated sampling was necessary because floating waste accumulation in urban reservoirs can fluctuate significantly due to rainfall intensity, drainage discharge, public activities, and daily waste disposal behavior in surrounding communities. All sampling activities were conducted during morning periods between 08:00 and 11:00 AM to maintain consistency in water flow conditions and reduce variability caused by afternoon rainfall events, which are common in Jakarta. During each sampling round, waste was collected from all five sampling points shown in Figure 1. At each location, a 5 m × 5 m sampling plot was established within areas where floating waste visibly accumulated near reservoir edges, drainage inlets, and outlet retention zones. This resulted in a total observation coverage of 25 m<sup>2</sup> per sampling point and 125 m<sup>2</sup> per sampling round, with a cumulative observed area of 500 m<sup>2</sup> throughout the entire study period. The use of fixed sampling plots ensured consistency in spatial observation across repeated sampling periods.

Floating waste was collected using a floating waste interception system consisting of a mesh barrier, manual collection nets, and temporary storage containers installed near the reservoir outlet and high-accumulation zones. Waste collection was conducted once the floating collection container reached approximately 80–100% of its holding capacity, ensuring that representative samples were obtained during each sampling round without disrupting normal water flow conditions or damaging aquatic habitats. Across all sampling periods, a total of 209 waste samples/items were collected and analyzed. The collected waste

consisted of biodegradable waste (n = 134; 64.1%), PET plastic (n = 35; 16.7%), High-Density Polyethylene (HDPE) (n = 19; 9.1%), Low-Density Polyethylene (LDPE) (n = 9; 4.3%), and other plastic materials (n = 12; 5.8%). The repeated sampling approach allowed the study to capture both dominant waste patterns and variations in plastic accumulation across time and location.

Following collection, all waste materials were manually sorted into organic and inorganic categories. The inorganic fraction was further classified into plastics, metals, glass, textiles, rubber, and other residual materials. Because PET was the primary focus of this study, plastic waste was further categorized according to polymer type. PET identification was conducted through visual and physical inspection using several indicators, including transparency, rigidity, bottle shape, label characteristics, color, and the presence of resin identification code No. 1 commonly found on PET beverage containers. This classification process ensured accurate identification of PET waste prior to moisture analysis and utilization assessment.

The characterization of plastic waste focused on determining the composition ratio and moisture content, as these are critical indicators for assessing its potential reuse and processing feasibility. The moisture content of the waste was measured using the gravimetric method, which involved weighing samples before and after drying in an oven at 105°C until a constant weight was achieved. This parameter is essential because moisture influences the recyclability and energy recovery potential of plastic waste. Plastics with low moisture levels, such as PET, are more efficient for reuse or conversion processes, while high-moisture organic materials require pre-drying or biological treatment before utilization. After drying, PET waste samples were evaluated based on their physical condition and material quality, including color, flexibility, and presence of impurities. These visual assessments helped determine the feasibility of different utilization pathways. Clean and structurally intact PET waste was identified as suitable for mechanical recycling through washing, shredding, and remolding processes, while more degraded PET fragments were considered for thermal recovery methods such as pyrolysis or Refuse-Derived Fuel (RDF) production.

The analysis of utilization potential was conducted descriptively, integrating field observations with literature references on plastic recycling and waste-to-energy applications. The evaluation criteria included availability, recoverability, process readiness, and environmental benefit. PET's relatively low water absorption, high energy density, and stable polymer structure made it a favorable candidate for both recycling and energy conversion. In contrast, mixed plastics and low-density materials showed less potential due to contamination and low structural stability. To complement the technical analysis, the study also incorporated a qualitative assessment of the environmental and socio-economic implications of PET recovery. Discussions with local waste handlers and informal recyclers provided contextual insights into collection challenges, material value, and community participation in recycling activities. This participatory approach helped assess whether small-scale PET recovery and reuse programs could be realistically integrated into the existing urban waste management framework. Data on waste composition, moisture content, and utilization potential were compiled and analyzed statistically to identify the dominant waste types and evaluate their relative contribution to the total waste stream. The results were then used to develop a preliminary framework for PET waste valorization, focusing on simple and scalable approaches that could be applied in Jakarta's local waste management systems.

### 3. Results and Discussion

The characterization of aquatic waste collected from the Kebon Melati Reservoir in Central Jakarta revealed a diverse composition of waste materials, primarily consisting of biodegradable organic waste and plastic debris. The findings illustrate the dual nature of pollution sources organic materials that originate from domestic activities and plastics that persist due to their durability and hydrophobic characteristics. Overall, the study site reflects the broader waste management challenges in Jakarta, where insufficient collection systems and improper waste disposal practices lead to the accumulation of floating waste in urban reservoirs. Field observations and sampling indicated that plastic waste dominated across all observation stations, surpassing other waste categories in both frequency and volume. The identified plastic items included nylon straps, plastic floats, straws, plastic bags, packaging films, and beverage bottles, which were found floating across various sections of the reservoir (Figure 2). The dominance of plastics can be attributed to their lightweight, buoyant, and persistent properties, allowing them to be easily transported by surface currents and wind before accumulating in stagnant bodies of water [19], [20], [21], [22].

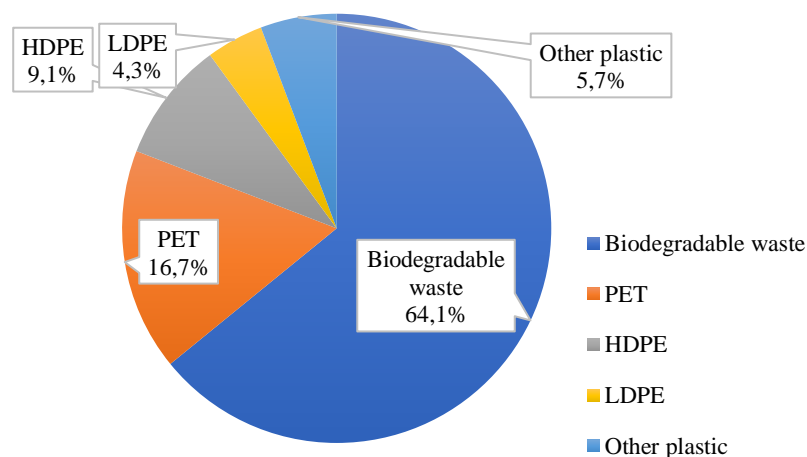
Further analysis revealed that the majority of the waste originated from upstream sources, particularly from rivers and drainage channels flowing into Jakarta, rather than from activities directly around the reservoir [23]. These water bodies act as conduits that transport discarded materials from residential and commercial zones, concentrating them at the reservoir. This finding aligns with previous studies that identify river-borne plastic pollution as the main contributor to aquatic waste accumulation in

developing urban areas. The result emphasizes that effective interventions must begin at the catchment level, addressing improper disposal behaviors and lack of waste infrastructure in upstream communities. The visual pollution caused by floating plastics is evident, but the environmental impact extends beyond aesthetics. Plastic waste interferes with aquatic ecosystems, obstructs water flow, and serves as a vector for contaminants and microorganisms. Over time, larger plastics undergo fragmentation into microplastics, increasing their mobility and ingestion potential among aquatic organisms, thereby posing risks to human health through the food chain.



**Figure 2.** Distribution of floating waste across sampling points in the Kebon Melati Reservoir, showing dominant accumulation of plastic materials such as bottles, films, and packaging residues.

The compositional analysis of the collected samples (**Figure 3**) showed that plastic waste constituted 35.9% of the total waste mass, while biodegradable organic waste made up 64.1%. These proportions are consistent with studies conducted at the Pluit Reservoir in North Jakarta [1], [24], indicating a recurring waste profile within Jakarta’s urban aquatic systems. The predominance of biodegradable organic materials reflects the influence of domestic and market-related waste streams, while the large fraction of plastic underscores the persistent issue of non-degradable pollutants in the city’s waterways. Within the plastic fraction, PET was identified as the most dominant polymer type, followed by HDPE, LDPE, and mixed plastics. The high occurrence of PET is primarily linked to its widespread use in beverage bottles and consumer packaging, which are heavily consumed and frequently discarded in urban settings. The PET items collected were typically transparent or light-colored bottles, consistent with commercial packaging waste.



**Figure 3.** Composition of aquatic waste in the Kebon Melati Reservoir, Central Jakarta. Plastic waste accounts for 35.9% of total waste, while biodegradable organic matter constitutes 64.1%.

The prevalence of PET waste is influenced by both its market value and physical resilience. In Jakarta, the informal recycling sector plays an important role in waste management, collecting and processing recyclable materials that have economic value. PET bottles are particularly sought after due to their high resale price and recyclability, often collected by informal waste pickers before reaching landfill sites [25]. This collection network contributes to the visible presence of PET in urban waterways, as not all discarded bottles are captured through formal or informal recovery chains. Comparatively, studies in other

Asian cities, such as the Saigon River in Vietnam, found that active recycling initiatives significantly influence the composition and abundance of plastic debris in aquatic environments [26]. In those cases, enhanced collection systems and local recycling efforts resulted in decreased PET waste concentrations in waterways. These parallels suggest that community-based recycling can substantially mitigate plastic accumulation when supported by effective policy and infrastructure. The presence of PET in Kebon Melati Reservoir thus serves as both a challenge and an opportunity. While it highlights the persistence of unmanaged waste, it also identifies a recoverable material stream with high potential for economic reuse. Integrating PET recycling into Jakarta's formal waste system would contribute to reducing aquatic pollution while simultaneously supporting local livelihoods and circular economy objectives.

The moisture content analysis of collected waste components (**Table 1**) revealed clear differences between organic and plastic materials. The biodegradable organic fraction exhibited very high moisture content (78.1%), typical of food waste, plant residues, and other putrescible materials. This high-water content presents challenges for thermal processing or energy recovery because it lowers the calorific value and requires additional drying, increasing energy costs (García et al., 2005; Suryawan et al., 2022a, b). In contrast, plastic fractions such as PET (3.4%), HDPE (5.3%), and LDPE (6.3%) showed significantly lower moisture levels, making them suitable for recycling and Refuse-Derived Fuel (RDF) applications. The contrast in moisture content provides valuable insight into waste management strategies. Organic waste, due to its high-water content, should be prioritized for biological treatment such as composting or Black Soldier Fly (BSF) conversion. The use of BSF larvae (*Hermetia illucens L.*) offers a sustainable pathway to convert organic waste into high-protein biomass and organic fertilizer, though processing efficiency declines when substrate moisture exceeds 80% [27]. Conversely, the low moisture content and high carbon composition of plastic waste make it ideal for recycling, pyrolysis, or RDF production. PET, in particular, stands out due to its stable polymer structure and low contamination level, making it the most viable candidate for energy and material recovery. This finding aligns with previous work emphasizing PET's dual potential as both a recyclable material and an energy feedstock [28], [29], [30].

**Table 1.** Moisture content measurement of waste components in Kebon Melati Reservoir

Waste Component	Description	Moisture Content (%)	Remarks / Utilization Potential
Biodegradable organic waste	Includes food residues, leaves, and natural fibers derived from household and market activities.	78.1	High water content indicates the need for pre-drying before biological processing.
PET (Polyethylene Terephthalate)	Transparent and rigid plastic commonly used in beverage bottles and packaging materials. Easily identified by resin code No. 1.	3.4	Low moisture content makes PET highly suitable for mechanical recycling, pyrolysis, or as a feedstock for RDF.
HDPE (High-Density Polyethylene)	Opaque and sturdy plastic typically used for containers, bottle caps, and detergent packaging.	5.3	Slightly higher moisture content than PET; suitable for recycling after washing and drying.
LDPE (Low-Density Polyethylene)	Flexible plastic found in plastic bags, wrappers, and films; tends to float widely on the water surface.	6.3	Moderate moisture level; recycling potential is lower due to contamination and thin structure.
Other plastics	Includes mixed polymers such as polypropylene (PP), polystyrene (PS), and multilayer packaging materials.	0.5	Very low moisture content, but poor recyclability due to heterogeneity and contamination; often directed toward RDF or energy recovery applications.

**Table 2** compares the technical and environmental suitability of various waste components as feedstocks for Refuse-Derived Fuel (RDF). The results highlight that PET plastic exhibits superior performance compared to other waste materials, primarily due to its low moisture content, and stable combustion characteristics. These factors make PET an ideal candidate for energy recovery through co-firing or RDF pellet production. In contrast, biodegradable organic waste, while abundant in the Kebon Melati Reservoir, is unsuitable for RDF applications because of its very high moisture content (78.1%) and low heating value. The excess moisture requires substantial energy input for drying, reducing overall energy efficiency. However, their processing requirements differ. HDPE, being denser and more rigid, burns efficiently and is easier to pelletize. LDPE, due to its flexibility and thinness, tends to cause feeding

inconsistencies in RDF combustion systems and often needs to be blended with PET or HDPE to maintain stable burning conditions.

**Table 2.** Comparative potential of PET and other waste components for RDF applications

Waste Component	Moisture Influence	Combustion Efficiency	Processing Requirement	Environmental Impact	Utilization Potential as RDF
Biodegradable organic waste	Very high moisture (>70%), requires pre-drying	Low; incomplete combustion due to moisture and high volatile gases	Needs dehydration and stabilization before any energy recovery	Produces odor and CO <sub>2</sub> during decomposition; low energy yield	Low – not suitable for RDF; better suited for composting or biological conversion
PET (Polyethylene Terephthalate)	Very low moisture (3–4%), minimal pre-treatment required	Very high; burns efficiently with consistent flame temperature	Requires basic cleaning and shredding; can be co-fired with coal or processed into RDF pellets	Generates low ash and minimal emissions when burned with proper control	Very High – excellent RDF feedstock due to high energy density and stability
HDPE (High-Density Polyethylene)	Low moisture (5–6%), easy to process	Very high; stable combustion, slightly higher melting temperature	Requires sorting and washing; can produce high-quality RDF pellets	Produces higher NO <sub>x</sub> if combustion is uncontrolled; moderate ash content	High – suitable RDF component; complements PET for energy recovery
LDPE (Low-Density Polyethylene)	Low moisture (6%), but light and thin, causing feeding issues	Moderate; uneven burning due to variable thickness	Requires compaction or blending for uniform combustion	Can emit more particulates if not controlled; low ash residue	Moderate – usable after blending with higher-density plastics
Other plastics (PP, PS, multilayer)	Very low moisture (0.5%), mixed composition	Variable; inconsistent due to polymer heterogeneity	Requires sorting; mixed plastics reduce RDF quality	May emit toxic compounds (e.g., styrene or chlorine) if not separated	Moderate to Low – usable only after segregation and controlled incineration

Other mixed plastics (such as polypropylene, polystyrene, and multilayer laminates) show moderate calorific values comparable to PET, but their heterogeneous composition introduces complexity. Some of these materials may contain additives, coatings, or chlorine-based compounds that produce toxic gases during combustion, necessitating advanced fuel-gas cleaning systems. This limits their usability in small-scale RDF facilities typically used in developing countries. From an environmental perspective, PET and HDPE are the cleanest-burning plastics when processed properly, producing minimal ash and limited gaseous pollutants. Their low nitrogen and chlorine content reduce the risk of forming dioxins or furans, making them environmentally safer RDF components. LDPE and mixed plastics, however, can produce particulate matter and volatile organic compounds if burned without emission controls. Furthermore, PET's physical uniformity (density, rigidity, and thermal behavior) gives it a distinct advantage for pelletization and co-firing with conventional fuels such as coal or biomass [16], [31].

At the national level, Indonesia has established a number of strategic policies aimed at addressing marine and urban plastic waste. Presidential Regulation No. 83 of 2018 on the National Action Plan for Marine Debris Management targets a 70% reduction in marine plastic leakage by 2025, yet its operational focus remains largely on coastal and downstream interventions, with limited mechanisms addressing urban reservoirs and river systems where waste accumulates [32], [33], [34], [35], [36]. The Kebon Melati case highlights the necessity of extending this policy to inland aquatic environments as upstream containment zones. Similarly, the National Waste Management Policy and Strategy (Jakstranas, Presidential Regulation No. 97 of 2017) sets the target of reducing waste by 30% and managing 70% by 2025. However, municipal implementation remains heavily oriented toward collection and landfill disposal rather than resource recovery and waste-to-energy utilization [37], [38].

While this study provides valuable insights into the composition, characteristics, and potential utilization of PET waste, several limitations should be acknowledged. First, the study relied on field sampling and visual characterization rather than advanced laboratory analyses such as proximate, ultimate, or thermal degradation testing. As a result, the findings primarily reflect qualitative and semi-quantitative assessments of PET's potential rather than full physicochemical profiles. Second, the study covered only a single reservoir (Kebon Melati) within Jakarta. Waste characteristics can vary seasonally and spatially across different reservoirs or rivers, particularly during heavy rainfall or dry periods that affect waste accumulation and transport dynamics [39], [40]. Third, the research did not include a life cycle assessment (LCA) or emission analysis to evaluate the environmental trade-offs of RDF utilization compared with recycling or landfill disposal. Such data would be necessary to guide sustainable decision-making at the policy level. Moreover, the study did not account for economic feasibility and social acceptance factors associated with scaling up PET recovery and RDF production in Jakarta. Understanding the cost-effectiveness of RDF systems, market incentives, and community willingness to participate would strengthen future policy recommendations.

Future studies should build upon this foundation by adopting a multi-dimensional research framework that integrates technical, environmental, socio-economic, and adaptive management perspectives. From a technical perspective, more detailed physicochemical characterization of PET and other plastic fractions, including calorific value, carbon composition, ash content, and pollutant emissions, should be conducted to validate Refuse-Derived Fuel (RDF) potential and ensure compliance with environmental standards. In addition, pilot-scale RDF, pyrolysis, or mechanical recycling trials using locally collected PET waste should be implemented to evaluate energy yield, emissions performance, and operational feasibility under Indonesian conditions. From an environmental management perspective, future studies should conduct spatial-temporal monitoring of floating waste accumulation across multiple urban reservoirs to identify high-priority intervention zones and better understand seasonal variations caused by rainfall, drainage flows, and urban activities. Such monitoring systems can serve as an important component of adaptive management by enabling continuous assessment of waste accumulation trends and supporting evidence-based decision-making.

From a governance perspective, future research should incorporate stakeholder perspectives, particularly from informal waste collectors, local communities, policymakers, reservoir management authorities, and private recycling industries, to better understand institutional barriers and opportunities for scaling circular economy initiatives. Applying an adaptive management framework would allow policymakers to implement flexible and iterative strategies through continuous monitoring, stakeholder feedback, policy learning, and periodic adjustment of environmental management interventions based on changing environmental conditions [41], [42], [43], [44], [45], [46]. At a broader strategic level, future research should align with Indonesia's Sustainable Development Goals (SDGs) 11, 12, and 13, which emphasize sustainable cities, responsible consumption, and climate action. By integrating scientific evidence, technological innovation, stakeholder collaboration, and adaptive policy mechanisms, PET waste recovery can evolve from an environmental burden into a resilient component of sustainable urban resource management and low-carbon energy transition.

#### 4. Conclusion

This study provides a comprehensive assessment of aquatic waste characteristics and utilization potential, with a specific focus on PET waste collected from the Kebon Melati Reservoir in Central Jakarta. The findings reveal that biodegradable waste accounted for the largest proportion of total collected debris (64.1%), while plastic waste represented a substantial share (35.9%), with PET identified as the dominant plastic fraction. Among the major plastic types, PET demonstrated the lowest moisture content (3.4%) compared to HDPE (5.3%) and LDPE (6.3%), indicating strong suitability for material recovery and energy conversion processes. Its low moisture content and structural stability make PET a promising feedstock for mechanical recycling, pyrolysis, and Refuse-Derived Fuel (RDF) production. In contrast, biodegradable organic waste showed limited thermal conversion potential due to its high moisture content (78.1%) and rapid decomposition characteristics, making it more appropriate for biological treatment pathways such as composting or Black Soldier Fly (BSF) conversion.

Beyond the technical findings, this study offers important practical implications for urban waste management in Jakarta. Urban reservoirs should no longer be viewed solely as passive flood control infrastructure but also as strategic intervention points for recovering valuable waste materials before they enter downstream rivers and coastal ecosystems. Local governments can integrate reservoir-based waste

recovery into existing waste management systems through decentralized sorting facilities, partnerships with recycling industries, and RDF development initiatives. Furthermore, applying adaptive management approaches through continuous monitoring, periodic evaluation, and stakeholder collaboration can improve the long-term effectiveness of aquatic waste recovery systems. These findings contribute to circular economy strategies, urban pollution mitigation, and low-carbon waste management policies in rapidly growing cities such as Jakarta.

## 5. Acknowledgment

The authors would like to express their sincere gratitude to the Universitas Pertamina through the UPEResearch 2023 Grant Program, managed by the Directorate of Research, Community Service, and Innovation (DPPM), for providing financial and institutional support for this study. This research was made possible through the facilities and resources provided by the Department of Environmental Engineering, Faculty of Infrastructure Planning, Universitas Pertamina. The authors also extend appreciation to the field and laboratory teams for their valuable assistance during data collection and experimental analysis.

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