Thai Environmental Engineering Journal Vol. 40 No. 2 (2026) : 49-56
www.eeat.or.th

A Preliminary Study on the Composition, Quantity, and Management of Solid Waste from Tourism at Kaw Kwang Beach, Koh Lanta District, Krabi Province, Thailand

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Article History; *26 March 2026, Accepted: 13 July 2026, Published: 21 August 2026*

Abstract

This preliminary study explores the composition, quantity, and management of solid waste resulting from tourism activities at Kaw Kwang Beach, located in Ko Lanta District, Krabi Province, Thailand. The study area was divided into three zones: Zone A (pine forest), Zone B (central beach), and Zone C (hotel frontage). Field data were collected ten times during April–May 2024, following the International Coastal Cleanup (ICC) methodology. A total of 3,332 waste items, weighing 66.32 kilograms, were recorded. The majority of the waste was general waste, followed by recyclable and hazardous waste. Common items included wooden skewers, plastic bags, and cigarette butts, reflecting tourist behavior and coastal activities. Statistical analysis using ANOVA and Tukey HSD revealed a significant difference in waste quantity in Zone B compared to Zones A and C. The current waste management practices were found to be non-compliant with the Ministerial Regulation on Sanitation B.E. 2560 (2017), with issues such as lack of waste separation, uncovered bins, and uncontrolled landfill disposal. Despite these challenges, some waste items, such as plastic bottle caps, were creatively repurposed into flower pots by local schools. The study recommends promoting plastic reduction, enhancing community and tourist education, and improving waste management systems to protect the coastal environment and support sustainable tourism.

Keywords : Waste composition; Waste quantity; Solid waste management; Tourism; Kaw Kwang Beach

Introduction

The issue of marine debris along coastal beaches has long been a persistent environmental concern, reflecting the inefficiency of waste management policies in Thailand. Ultimately, much of this waste ends up in the ocean, carried by waves and tides, turning the sea into a vast receptacle for terrestrial waste and pollutants. This phenomenon poses serious threats to marine ecosystems, tourism activities, and the quality of life of coastal communities (Department of Marine and Coastal Resources, 2020) [1]. Thailand has been ranked among the top 10 countries contributing the most plastic waste to the ocean, with an estimated 22.8 million kilograms of plastic waste discharged into the sea as of 2021. Approximately 80% of marine debris originates from land-based sources, while the remaining 20% is generated at sea, such as from boat-based tourism and coastal recreational activities (Office of Natural Resources and Environmental Policy and Planning, 2022) [2]. Kaw Kwang Beach, located on Koh Lanta in Krabi Province, is a tranquil coastal area popular among tourists for sunset viewing and outdoor activities. The beach is surrounded by hotels and restaurants that cater to both domestic and international visitors (Krabi Provincial Administrative Organization, 2016) [3]. Most beach users are local residents, typically visiting in family groups, with around 50–100 people per day, while foreign tourists average 30–50 per day. During festivals, the number increases significantly to over 200 people per day, still mainly locals. In the monsoon season, beach use

declines noticeably; data were collected through field surveys

A preliminary site survey revealed a significant amount of solid waste along the beach, primarily resulting from food consumption in recreational areas. One of the key issues identified was the insufficient number of waste bins, which were also placed far from popular relaxation and dining spots. This led to improper disposal of waste directly on the beach, posing a threat to marine ecosystems (Saladan Subdistrict Municipality, 2020) [4]. During the tourist season, the volume of waste increases substantially. Without effective waste management, the environmental quality deteriorates, necessitating urgent intervention. Recognizing the severity of the issue, this preliminary study aims to examine the composition and quantity of solid waste, assess current waste management practices, and explore potential reuse strategies for waste materials at Kaw Kwang Beach, Ko Lanta District, Krabi Province.

Materials and Methods

Study Area

Kaw Kwang Beach is located in Moo 1, Saladan Subdistrict, Ko Lanta District, Krabi Province, Thailand. The beach features a crescent moon shape, stretching approximately 750 meters in length, with its narrowest section measuring 300 meters in width. Uniquely, Kaw Kwang Beachoffers views of the sea on both sides, and its shoreline is characterized by fine-grained sand, making it a scenic and tranquil location (Department of Marine and Coastal Resources, 2020) [1].

Figure 1 The Location of the Kaw Kwang Beach [5]

Methodology

1. Kaw Kwang Beach is located in the northwestern part of Koh Lanta Yai. Its coastline curves in a shape resembling a deer's head and antlers. Study Area Selection and Criteria The study was conducted at Kaw Kwang Beach, located in Moo 1, Saladan Subdistrict, Ko Lanta District, Krabi Province. Kaw Kwang Beach is approximately 750 meters long, with an estimated width of 30–50 meters. Using an average width of 40 meters, the total beach area is approximately 30,000 square meters. This estimation is based on the general coastal characteristics of Koh Lanta. The beach was divided into three zones:

Zone A: Pine forest area
Zone B: Central beach area
Zone C: Hotel frontage area

The site was selected based on the International Coastal Cleanup (ICC) criteria [6], which include: The area must be a sandy beach, Minimum length of 100 meters, No beach cleaning activities during the data collection period, Not located near river mouths or canals. Kaw Kwang Beach met all of these criteria.

2. Field Data Collection, A total of 10 sampling events were conducted between April and May 2024. In April, samples were collected on the 3rd, 16th, 18th, 24th, and 26th, while in May, they were collected on the 18th, 20th, 23rd, 25th, and 31st. Sampling was carried out during the lowest low tide to ensure easier access to the study area and to minimize data variability. The lowest low tide refers to the period when sea level drops to its lowest point, exposing the maximum extent of the coastal zone. [7] A total of 10 sampling events were conducted between April and May 2024 during the lowest tide periods to ensure efficient access to the sampling area. The lowest tide levels ranged from 1.04 to 1.78 meters, with the highest recorded on May 31 and the lowest on May 20. Sampling was carried out between 06:25 and 17:30 to ensure sufficient daylight. Each sampling session took approximately 2–4 hours, depending on tidal conditions and sunset time. Proper scheduling was essential for both efficiency and safety in fieldwork operations.

3. Tools and Equipment, the following tools and equipment were used for waste collection: Black garbage bags, Gloves, Face

masks, Trash pickers, Rubber boots, Weighing scale, Camera and data recording forms

4. Data Collection Process

1) Composition and Quantity of Solid Waste

(1) Waste Sampling, The beach was divided into three zones: Zone A (pine forest), Zone B (central beach), and Zone C (hotel frontage). Waste was collected using black garbage bags and sorted into three categories: General waste, Recyclable waste, Hazardous waste.

(2) Waste Measurement, each category of waste was weighed to determine its quantity and recorded using a prepared data form.

(3) Field Data Management, Field data collection and management followed the guidelines provided by the Saladan Subdistrict Municipality.

2) Local Waste Management System Analysis. The study also involved surveying and evaluating the local waste management system through collaboration with relevant agencies. The assessment focused on:

(1) Characteristics of waste containers available on the beach

(2) Waste collection procedures carried out by municipal staff

(3) Transportation methods, including the use of protective equipment and vehicles

(4) Waste disposal methods, such as incineration, landfilling, and composting

3) Waste Utilization Strategies, The study explored value-added approaches to waste utilization, including: Recycling, Upcycling or Agricultural applications

5. Data Analysis, collected data were analyzed using descriptive statistics, including percentages and averages of waste composition and quantity across zones and seasons. Additionally, ANOVA was used to examine statistical differences in waste quantities between zones. Results were presented in tables and charts to provide a clear overview of the waste situation in the study area.

Results and Discussion

Composition and Quantity of Solid Waste at Kaw Kwang Beach, Ko Lanta District, Krabi Province

Over a two-month data collection period (April–May 2024), conducted across 10 sampling sessions, a total of 3,332 waste items were collected, with a combined weight of 66.32 kilograms. These findings are consistent with the study by Sangkhana and Kamlom (2022), which reported seasonal and spatial differences in waste composition [8], and with Hardesty et al. (2016), who found significant variations in marine debris density depending on coastal zones and human activities [9]. The key findings are summarized as follows:

Types and Quantities of Waste

• General waste: 2,437 items, weighing 53.64 kg

• Recyclable waste: 797 items, weighing 14.13 kg

• Hazardous waste: 98 items, weighing 4.01 kg

These results indicate that general waste was the most prevalent category, suggesting a strong correlation with tourist behavior, particularly food consumption and recreational activities along the beach. The presence of recyclable and hazardous waste, although less in quantity, highlights the need for better waste segregation and disposal systems.

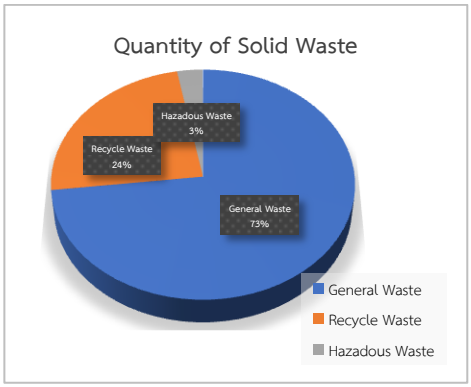

Figure 2 Quantity of Solid Waste

Waste Composition

The analysis of waste composition revealed the following:

Figure 3 Type of waste in each 3 group of waste [10]

• General Waste: The most frequently found item was wooden skewers, followed by plastic straws, cigarette butts, and food wrappers, respectively.

• Recyclable Waste: The most common item was plastic bottle caps, followed by plastic cups, plastic beverage bottles, and aluminum cans, respectively.

• Hazardous Waste: The most prevalent item was face masks, followed by lighters, diapers, and glass shards, respectively.

These findings indicate that the majority of waste originates from coastal recreational activities, particularly those involving food consumption and relaxation by tourists. This observation aligns with the studies conducted by Huabnarin (2017) [11] and Prasatkaew (2021) [12], which also reported similar patterns of waste types and sources in coastal areas.

Comparison by Zone

The waste data collected were analyzed based on three designated zones at Kaw Kwang Beach:

• Zone A (Pine Forest Area)

A total of 636 items were collected. The most common types of waste were ropes and fishing nets, which are typically associated with coastal and fishing activities. These findings are consistent with the studies by Arunsrimorakot (2021) [13] and Pransin (2015) [14].

• Zone B (Central Beach Area)

This zone had the highest amount of waste, with 2,152 items recorded. The most prevalent items were wooden skewers and cigarette butts, originating from food vending, exercise activities, and tourist transportation. These results align with the findings of Pramarn et al. (2022) [15] and Bantiwiwatkul (2016) [16]. The main sources are food vending, leisure activities, and tourism. This area has the highest usage intensity, resulting in the greatest amount of waste.

• Zone C (Hotel Frontage Area)

A total of 543 items were collected, with foam materials being the most common. The waste in this zone was linked to coastal recreation, hotel activities, fishing boats, and marine debris washed ashore. This pattern corresponds with the research of Prasatkaew (2021) [12] and Thammavicharn et al. (2014) [17]. These comparisons highlight the spatial variation in waste types and sources, emphasizing the influence of human activities and land use patterns on coastal waste accumulation.

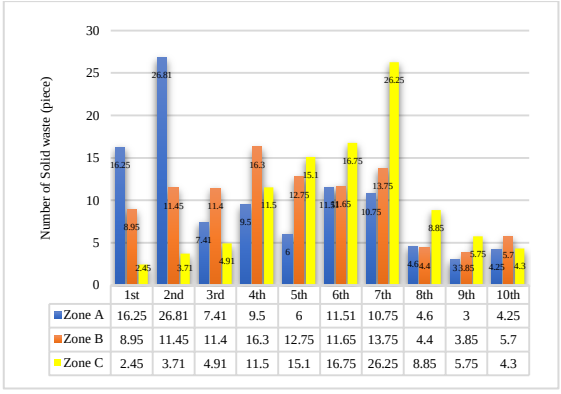

Figure 4 Waste Quantities from Sampling 1–10 in Each Zone

The data were collected over two months representing different seasons. Samples 1–5 were collected in April (summer season), and samples 6–10 were collected in May (monsoon season).

The ANOVA analysis revealed a statistically significant difference in the quantity of waste among Zones A, B, and C, with an F-statistic of 8.78 and a P-value of 0.00017. Since the P-value is less than 0.05, it can be concluded that there is a significant difference in waste quantities between the zones. To further

investigate these differences, a Tukey HSD Post-hoc Test was conducted to compare the waste quantities between each pair of zones. The results are presented in **Table 1**.

Table 1 Tukey HSD Post-hoc Test Results.

Comparison Between Zones	Mean Difference	P-value	95% Confidence Interval	Statistically Significant
A vs B	122.2	0.000	68.31 to 176.09	YES
A vs C	-1.8	0.996	-55.69 to 52.09	NO
B vs C	-124.0	0.000	-177.89 to -70.11	YES

Summary of Statistical Findings and Supporting Literature

The results of the ANOVA analysis indicated that Zone B had a statistically significant difference in waste quantity compared to both Zone A and Zone C, while Zones A and C showed no significant difference.

These findings are consistent with the study by Goldstein et al. (2013) [18], which reported high spatial variability in plastic debris across the Northeast Pacific Ocean, primarily influenced by ocean currents and human activities. Similarly, Pasternak et al. (2017) [19] found statistically significant differences ($p < 0.05$) in marine debris composition and quantity across coastal areas and seasons.

Furthermore, Galgani et al. (2015) [20] emphasized that the global distribution of marine litter varies by region and coastal characteristics, supporting the notion that marine waste management should be location-specific.

In the context of Thailand, the study by Prasatkaew (2021) [9] revealed seasonal and spatial differences in marine debris at Bang Pu seaside resort, which aligns with the current findings. The majority of waste observed in this study originated from human activities, particularly coastal recreation, tourism, and fishing. The dominant waste type was general waste, especially plastic packaging and single-use materials in summer season.

Table 2 the difference of type of waste in difference season

Comparison Aspect	**Summer Season**	**Monsoon Season**
Prominent Waste	Skewers, straws, cigarette butts	Plastic bottles, bottle caps, food containers
Main Sources	Beach tourists	Tourists + marine debris transported by water
Waste Characteristics	Single-use, immediate consumption waste	Packaging waste and floating plastics
Related Activities	Tourism, leisure, smoking	Tourism combined with rainwater runoff
Environmental Trend	Direct accumulation on the beach	Dispersion by water currents and rainfall

The diversity of waste across zones reflects the relationship between local activities and the types of waste generated, highlighting the need for targeted waste management strategies based on specific land use and tourist behavior.

Table 3 Clean Coast Index (CCI) Summary

Zone	**Waste (items)**	**Area (m^2)**	**CCI Value**	**Cleanliness Level**
A	639	10,000	1.28	Very Clean
B	639	10,000	1.28	Very Clean
C	635	10,000	1.27	Very Clean

The CCI values for all three zones range between 1.27 and 1.28, classified as “Very Clean.” This indicates a low density of waste per unit area on the beach. However, single-use plastic waste such as straws, plastic bags, and cigarette butts is still present. These wastes are mainly associated with tourism and recreational activities. Continuous waste management is necessary to maintain environmental quality. There is no official data on waste collection costs and frequency for Koh Lanta. The island generates about 45 tons of waste per day, mostly from tourism areas. Waste management faces high costs due to off-island transportation for disposal.

Collection is estimated to occur at least once per day, with increased frequency during peak tourist seasons. As a result, waste management on the island involves relatively high expenses compared to typical areas.

Study of Solid Waste Management at Kaw Kwang Beach, Ko Lanta District, Krabi Province

Table 4 Summary of Solid Waste Management at Kaw Kwang Beach, Ko Lanta District, Krabi Province

Aspect	Observed Practices	Regulations (Ministerial Regulation on Sanitation B.E. 2560)	Deficiencies
1. Waste Containers	Blue bins (200–240 liters), no lids, no waste separation	Must be durable, tightly sealed, and support waste separation	No lids / No separation
2. Waste Storage	Waste placed in front of houses/hotels by residents and businesses	Must have designated storage areas with structures to prevent access by animals/insects	Unsystematic / No sanitary control
3. Waste Collection	One 6-wheel truck, 4 staff members, collection starts at 00:00 hrs	Vehicles must be sealed, equipped with leachate prevention systems and warning lights	Possibly no leachate control / No warning lights
4. Protective Equipment	Staff do not wear masks or gloves; wear sandals	Must wear full PPE including gloves, masks, and closed-toe shoes	No protective equipment used
5. Waste Disposal	Landfilling without leachate control; no waste separation before disposal	Must use engineered landfills with leachate protection and proper closure systems	No groundwater protection / No waste separation

The solid waste management practices at Kaw Kwang Beachdo not comply with the Ministerial Regulation on Sanitation B.E. 2560. Waste containers lack lids and are not categorized by type. There is no designated sanitary storage area for waste. The waste collection process lacks leachate control systems, and workers are not equipped with adequate protective gear. Waste disposal is carried out through uncontrolled landfilling, without pollution prevention measures and without prior waste separation. These deficiencies pose risks to both the environment and public health.

Utilization of Solid Waste

One notable initiative involved plastic bottle caps, which were collected and donated to Lanta Rajapracha Uthit School as part of a collaborative project with the Thailand Environment Institute. The school processed the caps by melting and molding them into flower pots, demonstrating a practical approach to plastic waste recycling.

Plastic straws and plastic bags can be recycled depending on their type and cleanliness. Straws are harder to recycle due to their small size and contamination risk, while clean plastic bags are more recyclable. Effective recycling requires proper sorting, cleaning, and processing, and depends on material condition.

This initiative aligns with the work of Arunsrimorakot (2020), who explored value-based design using marine debris to develop public spaces at Wonnapha Beach. Her study found that common beach litter, such as plastic bottles and bags, contributed to environmental degradation. To address this, plastic waste was thermally processed at 230°C, allowing it to be reshaped into useful products.

The ISWM-based analysis shows that waste management on Koh Lanta faces increasing pressure due to tourism. Technical issues include insufficient bins, inconsistent collection frequency, and high transport costs. Social aspects reveal improper disposal behavior and limited public participation. Policy and management lack strict enforcement and effective incentive measures.

Therefore, an integrated approach is needed to improve waste management sustainably.

These examples highlight the potential for community-based waste transformation, especially in coastal areas affected by tourism. They also emphasize the importance of creative and sustainable waste management solutions that add value while reducing environmental impact.

Hazardous Waste Risk Assessment

Hazardous waste totaled 98 items (3% of all waste collected). 4 types of hazardous

waste were identified, along with their associated risks

1) Face masks (21%) Risk of pathogen contamination and microplastic shedding

2) Lighters (10.5%) Risk of fire hazards and chemical (fuel) leakage

3) Diapers (7.9%) High risk, as they may harbor pathogens and contaminate leachate

4) Glass shards High risk, causing injury to barefoot beachgoers, particularly in Zone B

The elevated risk stems from the absence of waste segregation at the source, resulting in hazardous waste being mixed with general waste. Collection staff also lack personal protective equipment (PPE).

Recommendations include: clearly separating hazardous-waste bins, providing PPE for collection staff, conducting periodic sweeps to remove glass debris, and educating tourists on the proper disposal of these waste items.

Recommendations

It is recommended to implement source-level waste control measures, such as reducing the use of plastic and foam materials. Efforts should be made to educate tourists and local communities about proper waste management practices. Continuous support for beach cleanup activities should be encouraged, and the waste management system should be further developed to enhance its efficiency and sustainability.

Conclusions

The study found that Kaw Kwang Beach faces significant waste accumulation, especially in Zone B, due to tourism-related activities. Most waste items were general waste, such as wooden skewers and plastic bags. The waste management system was found to be inefficient and non-compliant with sanitation regulations. However, some waste, like plastic bottle caps, was successfully repurposed by local schools. The findings highlight the need for better infrastructure, public awareness, and sustainable waste management practices.

Acknowledgments

The researcher would like to express sincere gratitude to Mr. Pongsawat Damrongongtrakul, Mayor of Saladan Subdistrict Municipality, Ko Lanta District, Krabi Province, as well as the municipal staff and officers for their kind support in providing information and facilitating access to the study area for data collection.

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