



Waste Matters: Analysing Types and Volumes of Solid Waste in Palawan's Small Island Municipalities for Sustainable Disposal Solutions

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ABSTRACT

This study explored the types and volumes of solid waste generated in the small island municipalities of Araceli, Balabac, and Culion in Palawan, Philippines. Using the Waste Analysis and Characterization Study (WACS) approach, combined with data from the Ten-Year Solid Waste Management Plans of the island municipalities, waste from both household and non-household sources including biodegradable, recyclable, and residual materials were analysed. Findings revealed that biodegradable waste constitutes the largest proportion of waste across all study sites, followed by recyclables and residuals. These small islands face unique challenges in waste management due to their geographic isolation, limited access to disposal facilities, and minimal resources for infrastructure. The results aimed to inform local stakeholders and policymakers in implementing waste management strategies as alternatives to traditional landfill disposal as mandated in the Philippines RA 9003. By establishing a baseline dataset for waste production and composition, this research offers crucial data to support sustainable waste management practices in small island contexts, ultimately aiding in mitigating the environmental impact of increasing waste generation.

Keywords: Solid wastes, Small islands, RA 9003, Sustainable waste management strategies

Introduction

As urban populations grow and consumer consumption increases, waste generation is rising at a rapid and worrying pace. The World Bank (2024) estimates that global solid waste could reach 3.4 billion tons by 2050, almost double the amount produced in 2016, emphasizing the urgent need for efficient waste management solutions.

Solid waste consists of various materials, including household trash, industrial refuse, and construction debris. Waste composition varies significantly across regions, influenced by factors such as economic development, cultural practices, and local regulations. Developing countries like the Philippines face significant challenges in waste management, including the prevalence of organic waste, inadequate infrastructure, and economic constraints, which lead to health risks and environmental degradation. Engaging local communities and adopting innovative, sustainable practices are essential for improving waste management outcomes (Mazzotta, M., & Mazzotta, R. (2021).

Landfills, the most common method for waste disposal, pose significant threats to both human health and the environment, particularly in the fragile ecosystems of small island municipalities. These ecosystems are highly sensitive to environmental disturbances, and improper waste management can have long-lasting impacts on biodiversity, water quality, and community health. Decomposing waste in landfills emits harmful gases, including methane—a potent greenhouse gas that exacerbates climate change. Zhang and Tan's (2020) research emphasized the environmental hazards associated with landfills in China, particularly the release of methane during the decomposition of municipal solid waste, which mirrors the challenges faced by small islands.

Moreover, Alavi and Keshavarzi (2019) highlighted how landfill leachate contaminates groundwater, a critical concern for island communities where freshwater resources is scarce. The study of Mohee, et al, 2015, emphasizes the current status and challenges of solid waste management in small island developing states, highlighting the need for integrated approaches to address these issues effectively. They often face unique challenges, such as limited resources and geographical constraints, making reliable information on waste generation, composition, and disposal practices essential. Managing solid waste effectively in isolated municipalities, especially on small islands, relies heavily on the availability of accurate data to



identify trends, optimize resource allocation, and implement sustainable waste management practices. Furthermore, it enhances community engagement, facilitating informed decision-making. Investing in data collection and analysis is crucial for improving solid waste management in isolated municipalities, ultimately promoting a cleaner, healthier environment for residents.

These small island municipalities in Palawan with land area of not more than 50,000 hectares, often limited by infrastructure and financial resources, face compounded risks as they struggle to manage waste sustainably. Addressing these challenges requires urgent action to implement improved waste management strategies that prioritize ecosystem preservation and promote sustainable practices to protect both the environment and public health.

Hence, this study aimed to create a comprehensive baseline dataset on the generation, sources, and types of solid waste in selected small islands of Palawan, Philippines, to support efforts in addressing this environmental issue affecting the small islands fragile ecosystems. By analyzing waste production patterns, this research identifies key contributors to solid waste, including households, tourism, and commercial activities. Understanding these factors is essential for developing effective waste management strategies that suit the unique environmental and socio-economic contexts of these islands. Additionally, the findings from this study will serve as a basis for selecting suitable final disposal facilities for solid waste in these small island municipalities, ensuring that waste management solutions are both practical and environmentally sustainable.

Methodology

The study covered the small island municipalities of Araceli, Balabac, and Culion. As shown in figure 8, Araceli located in the northeastern part of mainland Palawan is a 4th class municipality, while Balabac in the southernmost part of Palawan is a 2nd class municipality, and Culion is found in the northernmost part of mainland Palawan is a 3rd class municipality (PSA, 2015). The province of Palawan has two types of climates and this has been considered in the selection of the study areas. The study sites conformed to the definition of small islands stipulated in DAO 2000-83 (2000).

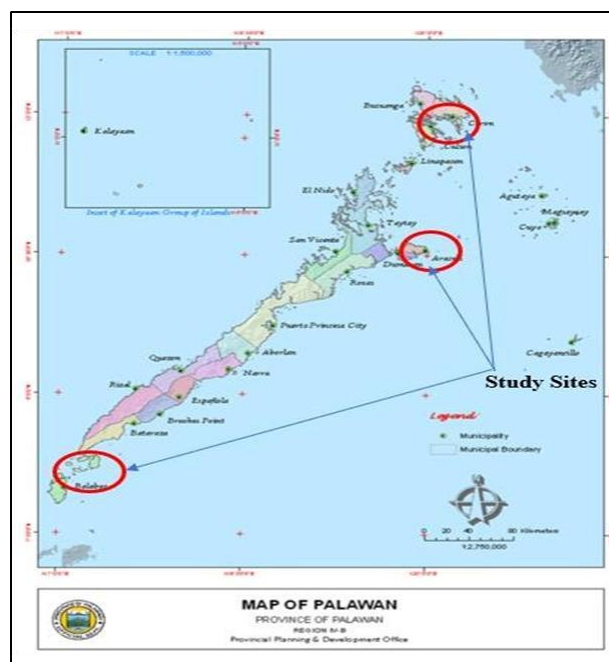


Figure 1. The map of the study showing the three small islands; Araceli, Balabac, and Culion (Source: Palawan-PPDO)



This research used a descriptive approach to examine the current state of waste generation in specific small island municipalities in Palawan. The descriptive method allowed the study to establish a clear overview of the waste management landscape by systematically observing and describing the types, quantities, and sources of waste without manipulating the environment in these small island municipalities.

Quantitative and qualitative methods were applied to achieve comprehensive insights on the waste generation situation and offer a more complete, multi-dimensional perspective, which is essential for crafting targeted and practical solutions for waste management in these small island communities. The quantitative approach involved collecting measurable data such as waste volume, types, and frequency for statistical analysis. This data enabled the researchers to quantify waste generation and categorize waste types, providing concrete figures that could serve as a basis for effective waste management strategies.

The qualitative approach, on the other hand, involved capturing contextual details through observations and possibly interviews, adding depth to the numerical data. This method provided a better understanding of local behaviors, practices, and perceptions related to waste management.

The Waste Analysis and Characterization Study (WACS) is an essential research tool used to evaluate the types and volumes of solid waste generated at specific target sites. Through systematic analysis of waste materials, WACS provides critical data that informs waste management decision-making. The study categorizes waste into various types, including organic, recyclable, hazardous, and non-hazardous, enabling a clearer understanding of the waste stream. This information is vital for determining the total volume of waste requiring management and disposal at designated solid waste facilities. Ultimately, WACS plays a foundational role in developing effective waste management strategies aimed at minimizing environmental impacts and promoting sustainability in the targeted areas (Yap et al., 2011).

In the conduct the study, a WACS Team was formed and trained according to the guidelines from the Provincial Government Environment and Natural Resources Office (PG ENRO). The team identified the WACS sites and randomly selected household (HH) and non-household (non-HH) samples/cooperators. Participants were informed that their solid waste would be collected on three designated sampling days, ensuring that the waste collected was only from that day and not mixed with prior waste. Two sets of garbage bags were provided to each participant for every sampling date, properly labeled to facilitate identification. These bags contained both biodegradable and other solid waste from the samples/cooperators

Result And Discussion

Types and Volume of Wastes Generated in the Municipality of Araceli, Palawan

The waste analysis and characterization in Araceli revealed that the municipal solid waste is composed of biodegradables (63.02%), recyclables (18.91%), and residuals (17.86%), while the special waste accounted for 0.21%. The mean HH solid waste generation is 0.46 kpd; this translates to around 0.095 kilograms of solid waste per capita per day, as reflected in Figure 2. Thirty household respondents and cooperators were randomly selected as participants in WACS. It has a total of 146 household members and an average of 4.86 household members.



HH Waste Composition, Municipality of Araceli,
Palawan, 2020

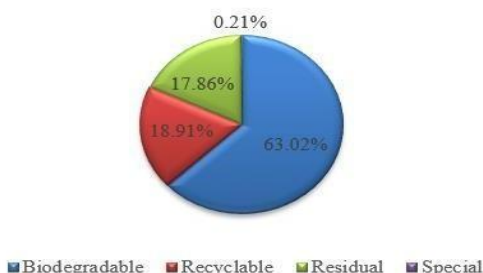


Figure 2. HH waste composition, Municipality of Araceli, Palawan, 2020

Aside from WACS, household interviews (HHI) were also conducted and the respondents were asked to quantify their solid waste generation in one day. This was done to validate the composition of waste at the household level. The interview revealed that the biodegradable waste is the most in terms of quantity with 0.89 kilograms or 60.96% of the total solid wastes followed by the reusable and recyclables while the residual waste accounted for 0.13 kgs. The estimated value of HH waste is much greater than the measured value during the conduct of the WACS, as can be seen in Table 1.

Table 1. Comparative HH waste generation based on HHI and WACS, 2020, Municipality of Araceli, Palawan

HH WASTE COMPOSITION BASED ON INTERVIEW			HH WASTE COMPOSITION BASED ON WACS	
Composition	Weight (kg)	%	Weight (kg)	%
Biodegradable	0.89	60.96	0.292	63.02
Recyclable	0.44	30.14	0.167	36.30
Residual	0.13	8.9	0.001	0.22
Special	0	0	0.292	0.21
Total	1.46	100	0.46	100

Biodegradable Waste

Vegetables and fruit residues represent a little more than two-thirds (67.58%) of the biodegradable waste, followed by yard-wastes (19.70%) while food/kitchen waste and fish cleanings are in almost similar quantities as reported in Figure 3. In most of the restaurants/eateries as well as the household, scrap food, vegetable and fruit residues are segregated outright because it is fed to hogs, dogs and other domestic animals.

This result confirms with the findings from Guidelines for Municipal Solid Waste Planning in Small Island Developing States in the Pacific Region that island waste streams can be low in organic kitchen waste



(vegetable peelings, food scraps) where very little food scraps of large numbers of households or restaurants find its way to the landfill. In some parts of the municipality where *Bisogo* fish is abundant, residents who are mainly fisher folks process their catch by sun drying. The fish cleanings are disposed of back to the sea that makes the nearshore seawater itchy, as reported by the Barangay Captain of Calandagan.

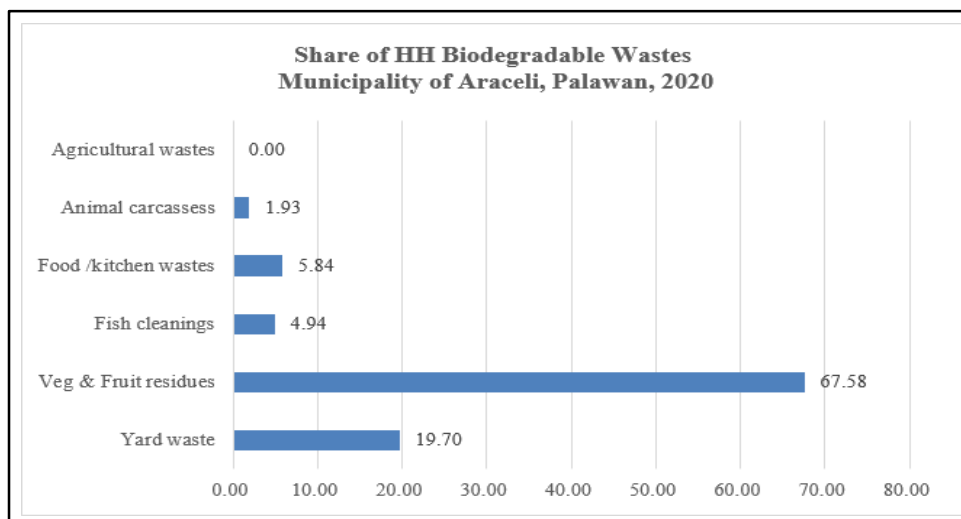


Figure 3. Biodegradables composition, Municipality of Araceli, Palawan, 2020

Recyclable Waste

The recyclables component of the solid waste of the island municipality is the second largest next to the biodegradables, as shown in Figure 4. Among the recyclable materials, *sibak* (*tabo, upuan*, bottle caps) is the most recorded waste, a little less than two- thirds of a kilogram or 62.03%. Assorted papers follow 0.11 kg or 13.92%. The other recyclable wastes come in smaller amounts. This result also conforms to the Guidelines for Municipal Solid Waste Planning in Small Island Developing States in the Pacific Region, where small island wastes have a low content of paper. The total recyclable waste per HH per day is 0.085 kg.

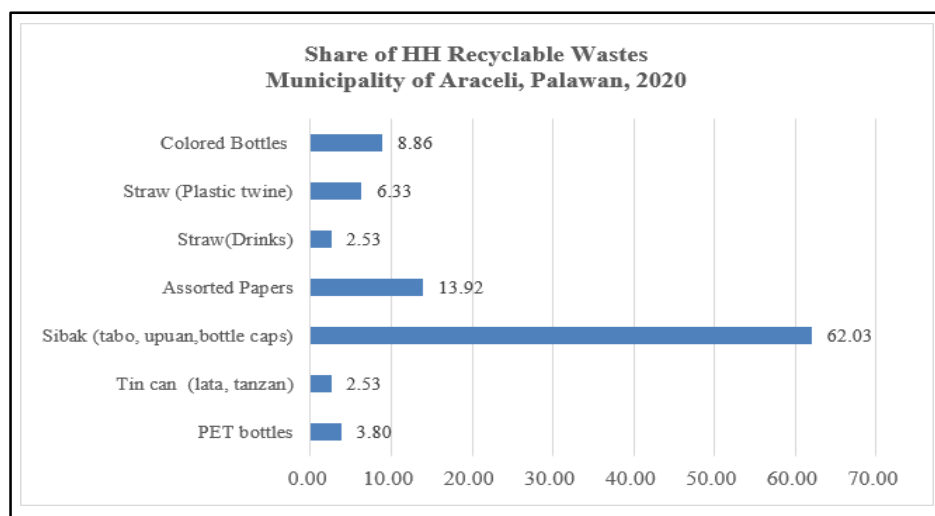


Figure 4. Recyclable composition, Municipality of Araceli, Palawan, 2020



Residual Waste

The residual waste accounted for a little lesser in weight with the recyclables or 0.078 kg per HH per day. This translates to 0.010 kg per capita per day. The sando bag is the most common among the residual waste, which accounted for 33.33%, while PP (food wrappers, candy and biscuit wrappers) followed with 26.92% and composites with 17.95%, as can be gleaned in Figure 5. Sando bags and shampoo and coffee sachets are the most prevalent residuals.

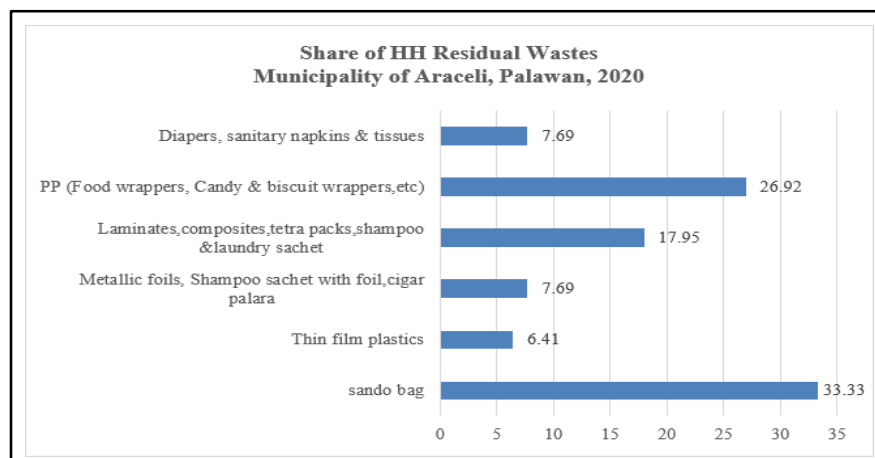


Figure 5. Residual waste composition, Municipality of Araceli, 2020 Source: Ten Year Solid Waste Management Plan, Araceli, 2018 – 2028

The waste generation by source extracted from the TYSWMP showed that the residential sector dominates the production of waste in the municipality with 97.28% or 620.52 metric tons per year. The commercial combined with the institutions' accounts for around 17.35 metric tons annually or 2.72% of the municipal waste. It is interesting to note that there was no representation from the industrial sector, while the commercial establishments reflected minimal waste production. This suggests that the municipality's economic driver was largely based on agriculture and no industrial entities while the commercial establishments are small scale "sari-sari" or variety stores. These small-scale business establishments are considered as the source of most of the consumer goods that compose the residual waste.

Table 2. Waste generation by source in the Municipality of Araceli, Palawan, 2018

SOURCE OF WASTE	WASTE GENERATION	
	Kg per day	Share (%)
Residential	1,700.06	97.28
Commercial	38.11	2.18
Institutions	9.45	0.54
Industries	0.00	0.00
Total	1,747.60	100.00



Source: Ten Year Solid Waste Management Plan, Araceli, 2018 – 2028

The total volume of waste generated from all sources was 1,747.60 kpd shown in Table 2. The solid waste bound for the final disposal facility is 646.62 kpd. The municipal solid waste was calculated using the waste generation per capita multiplied by the population. The Census of Population in 2015 conducted by the Philippine Statistics Authority was used to project the population.

Types and Volume of Wastes Generated in the Municipality of Balabac, Palawan

The WACS conducted by the Provincial Government Environment and Natural Resources Office in 2018 was the reference for the composition and volume of solid waste generated within the municipality of Balabac. The results of the WACS, as indicated in Table 9, reflect the residential sector generates the most wastes, 99.55%, while the rest of the sources or the non-households contribute to 0.45% of the municipal solid wastes (see Table 3).

Table 3. Waste sources, waste generation, and share (%), Municipality of Balabac, Palawan, 2018

SOURCE OF WASTE	WASTE GENERATED(*kpd)	SHARE (%)
Residential	40,131.84	99.55
Non Residential	180.22	0.45
Total	40,311.99	100.00

Source: 10 Year Ecological Solid Waste Management Plan, 2018- 2027, Municipality of Balabac, Palawan

The waste generated by composition is calculated as reflected in Table 4 shows that the biodegradable waste has the most in terms of volume with 22,127.26 kpd or 54.89% followed by the recyclables with 8,683.20 kpd and the least in volume are the special wastes 1,023.92 kpd or 2.54%.

Table 4. Waste distribution by composition, Municipality of Balabac, Palawan, 2018

COMPOSITION	WASTE GENERATION (kpd)	SHARE (%)
Biodegradable	22,127.26	54.89
Recyclable	8,683.20	21.54
Residual	8,477.61	21.03
Special	1,023.92	2.54
Total	40,311.99	100.00

Source: 10 Year Ecological Solid Waste Management Plan, 2018- 2027, Municipality of Balabac

In the conduct of the household interview (HHI), the respondents were asked to calculate their solid waste generation in one day. The interview revealed that the biodegradable waste is the most in terms of quantity with 0.89 kg per capita per day (kcpd) that translate to a total of 6,640.86 kpd for the whole municipality, followed by the reusable and recyclables, while the residual waste accounted for 0.043 kcpd or 2,054.47 kpd for the whole town. The estimated value of HH waste is much smaller than the measured value during the conduct of the WACS, as can be seen in Table 5.



Table 5. Waste generation by composition based on the HHI, Municipality of Balabac, Palawan, 2020
n=30

COMPOSITION OF WASTE	PER CAPITA GENERATION (PCG) IN KGS	TOTAL WASTE GENERATION (KPD)	SHARE (%)
Biodegradable	0.139	6,640.86	44.27
Recyclable	0.132	6,306.43	42.04
Residual	0.043	2,054.47	13.69
Outright for Disposal	0	0	0.00
Special	0	0	0.00
Total	0.314	15,001.66	100.00

Types and Volume of Wastes Generated in the Municipality of Culion, Palawan

The waste analysis and characterization study conducted by the Provincial Government Environment and Natural Resources Office did in 2018, as reported in the municipality's 10-year ecological Solid Waste Management Plan, 2019 - 2028, is the reference for the composition and volume of solid waste generated within the municipality of Culion.

Table 6 shows that a little more than half or 52.57% of the municipal wastes are biodegradable, while 29.05% are recyclables, and 2.78% were recorded as s special wastes. The residuals accounted for 15.60% of the total wastes. The per capita waste generations from all sources were calculated to 0.42 kpd.

Table 6. Distribution of waste by composition, Municipality of Culion, Palawan, 2018

COMPOSITION	WASTE GENERATION (KPD)	SHARE (%)
Biodegradable	4,921.5	52.57
Recyclable	2,719.6	29.05
Residual	1,460.44	15.60
Special	260.26	2.78
Total	9,361.8	100.00

Source: 10 Year Ecological Solid Waste Management Plan, 2018- 2027, Municipality of Culion

Since the WACS was conducted in 2018, household interviews were done to update the composition and quantities of the waste generated at the household level. The respondents were asked to calculate their solid waste generation in one day. The interview revealed that biodegradable waste is the most in terms of quantity with 0.90 kg per capita generation per day that translates to a total of 20,061 kilograms



(kgs). This was followed by the reusable, 0.263 kpd per individual or 5,862.27 kgs, and the recyclables, 0.087 kpd or 1,939.23 kgs, while the residual waste accounted for 0.126 kpd or 2,808.54. kgs. The total municipal solid waste based on HHI interviews was 30,671.74 kpd, as shown in Table 7.

Table 7. Waste generation by composition based on the HHI, Municipality of Culion, Palawan, 2020
n=30

COMPOSITION OF WASTE	PER CAPITA GENERATION (PCG) IN KGS	TOTAL WASTE GENERATION (KPD)	SHARE (%)
Biodegradable	0.90	20,091.00	65.41
Reusable	0.263	5,862.27	19.11
Recyclable	0.087	1,939.23	6.32
Residual	0.126	2,808.54	9.16
Outright for Disposal	0	0	0.00
Special	0	0	0.00
Total	1.376	30,671.74	100.00

The estimate of the respondents is more conservative than the value computed from WACS. However, the amount that will be used in the design of landfill capacity is the values taken from WACS.

Conclusion

The study's findings highlight a pressing need for improved waste management practices tailored to the unique conditions of Palawan's small island municipalities. The predominance of biodegradable waste suggests an opportunity for initiatives such as composting, which could reduce waste volume significantly while benefiting local agriculture. The substantial presence of recyclables indicates that recycling programs, if effectively implemented, could further decrease the waste burden. Residual waste, including non-recyclable plastics and other materials, continues to pose a significant challenge, highlighting the need for innovative strategies to lessen plastic reliance and enhance waste disposal methods. Given the limited resources and infrastructure on these islands, developing community-based waste management strategies is essential. Education campaigns to encourage waste segregation at the source and policies that support waste reduction, such as bans on single-use plastics, could play a vital role. Policymakers should consider integrating waste-to-resource strategies that align with the environmental and socio-economic realities of these areas. Furthermore, findings of this study offer a preliminary insight into the waste profiles of these small island municipalities, empowering stakeholders to develop effective, localized strategies that harmonize waste reduction with environmental conservation. By embracing sustainable waste management practices, these small island communities can determine suitable solid waste final disposal methods without the need for costly sanitary landfill construction, which is further complicated by the limited land available on the islands. This approach positions them to progress toward a cleaner and more resilient future, safeguarding their delicate ecosystems while simultaneously improving the quality of life for their residents.



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