Plastic Predominance in Coastal Waste Streams: A Baseline Audit of a Secondary Urban Shoreline in the Philippines

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Abstract

Marine litter, particularly plastics, has been recognized as a global threat to ecosystems, economies, and human well-being, with Sustainable Development Goal (SDG) 14 calling for urgent action to reduce marine pollution by 2025. The Philippines, as an archipelagic nation, is especially vulnerable to plastic leakage due to its high coastal population density and limited solid waste infrastructure. This study conducted a coastal waste audit along a one-kilometer secondary urban shoreline using the International Coastal Cleanup (ICC) protocol, the Ocean Trash Data Form, and the Clean Swell application. A total of 2,314 debris items were collected, with plastics accounting for over 80% of the total. The most common items were plastic bags, beverage bottles, food wrappers, and sachets, complemented by fishing gear, diapers, construction debris, and electronics. Waste density was calculated at 2,314 pieces per kilometer, placing the site among highly impacted Philippine coastlines. The presence of entangled wildlife further emphasized ecological risks. These findings are congruent with national and international literature, which similarly document the predominance of plastics in marine litter. They also highlight gaps in the enforcement of Republic Act 9003 and the Extended Producer Responsibility Act of 2022 and point to the need for local monitoring systems as emphasized in the National Climate Change Action Plan (2011–2028) and the Harmonized National Research and Development Agenda (2022–2028). The study concludes that plastic predominance in secondary urban coastlines demands integrated responses involving policy enforcement, infrastructure development, and community-based monitoring. Recommendations include institutionalizing regular coastal audits, enhancing local compliance with waste laws, and expanding school- and community-led monitoring programs. By establishing a baseline dataset, this study contributes to advancing national research priorities and accelerating progress toward the targets of SDG 14: Life Below Water.

Keywords and phrases: *Marine litter; Plastic pollution; Coastal audit; Waste density; Philippines; Republic Act 9003; Extended Producer Responsibility Act; Environmental policy; Sustainable Development Goals; SDG 14; Community-based monitoring*

Introduction

Marine litter, particularly plastics, has emerged as one of the most pressing environmental challenges globally. In recognition of this threat, the United Nations Sustainable Development Goals (SDGs), specifically SDG 14: Life Below Water, emphasize the urgent need to prevent and significantly reduce marine pollution of all kinds by 2025 (United Nations, 2023). In parallel, the United Nations Environment Programme (2021) underscores that unmanaged land-based sources are the dominant contributors to marine litter, with plastics now infiltrating ecosystems, food webs, and economies. These global calls are echoed in the Philippine National Climate Change Action Plan (2011–2028), which prioritizes ecosystem resilience, and the Harmonized National Research and Development Agenda (2022–2028), which identifies marine litter monitoring and pollution reduction as critical research priorities (DOST-PCIEERD, 2022).

Within this context, the Philippines is particularly vulnerable due to its archipelagic geography, high population density along coastlines, and dependence on marine ecosystems for food security and livelihoods. National assessments show that single-use plastics, especially sachets and beverage bottles, dominate coastal waste streams (Fabres & Onda, 2021). These trends highlight the urgent need for localized data collection, especially in secondary urban shorelines, where coastal pressures are intensifying but systematic monitoring is often lacking. Such settings reflect a combination of consumer-driven waste, inadequate waste management systems, and marine-based inputs, but remain underdocumented compared with metropolitan beaches.

To address this knowledge gap, the present study conducted a coastal waste audit along a one-kilometer urban shoreline using standardized International Coastal Cleanup (ICC) methods. The methodology involved categorizing debris by type and quantifying the total volume and density of waste. The results revealed a predominance of plastics, accounting for more than 80% of the 2,314 debris items collected. Single-use plastics such as bags, bottles, and food wrappers emerged as the most frequent items, alongside fishing-related debris, diapers, construction waste, and electronics. Waste density was calculated at 2,314 pieces per kilometer, positioning the study shoreline among heavily impacted coastal sites in the Philippines.

The discussion situates these findings within national and global contexts, showing congruence with earlier studies (Celestial & Salmo, 2020; Greenpeace Philippines, 2017; UNEP, 2021) and highlighting both consumer practices and policy enforcement gaps under Republic Act No. 9003 and the Extended Producer Responsibility Act of 2022. The presence of entangled wildlife further demonstrates ecological risks consistent with the findings of Santos et al. (2018) on microplastics in Philippine fish.

From these results, the study concludes that secondary urban coastlines experience significant plastic predominance, underscoring the need for improved monitoring, policy enforcement, and community engagement. Recommendations include the institutionalization of regular coastal audits, enhanced implementation of waste management laws, infrastructure improvements for hazardous and non-plastic waste, and

school-based environmental education programs to sustain citizen participation. Together, these measures contribute to the achievement of national research priorities, legal mandates, and the global targets of SDG 14.

Materials and Methods

This study employed a descriptive quantitative research design to examine the type, volume, and density of coastal debris along a one-kilometer secondary urban shoreline. The approach was chosen because it allows the systematic documentation of observable waste items and the calculation of density using standardized monitoring tools. The audit was conducted on September 21, 2024, in compliance with the International Coastal Cleanup (ICC) protocol, using the Ocean Trash Data Form and the Clean Swell mobile application to ensure consistency, accuracy, and comparability of results across studies.

The study was guided by several objectives that directed both data collection and analysis. Specifically, it sought to identify and categorize the types of coastal debris collected using standardized tools, determine the total volume and density of waste per kilometer with emphasis on plastic-based items, assess the environmental implications of debris in relation to biodiversity and observed wildlife impacts, correlate the audit findings with existing Philippine environmental laws such as Republic Act 9003 and Republic Act 11898 as well as global commitments under Sustainable Development Goal 14, and recommend evidence-based strategies for improving solid waste management and environmental education in coastal communities.

The objectives of this study were grounded in related literature, ensuring congruence between the research design and prior findings. For the objective of categorizing debris, Celestial and Salmo (2020) as well as Fabres and Onda (2021) documented that plastics dominate marine litter in Philippine coastlines, particularly in the form of sachets, wrappers, and beverage bottles. Greenpeace Philippines (2017) further emphasized that sachets and plastic bags remain widespread in coastal environments due to weak enforcement and heavy reliance on single-use consumer packaging. For the objective of determining waste density, the United Nations Environment Programme (2021) highlighted that unmanaged land-based waste is the leading source of marine debris globally, while the National Climate Change Action Plan (2011–2028) stressed the importance of community-based monitoring for climate-resilient ecosystems. Similarly, the Harmonized National Research and Development Agenda 2022–2028 of the Department of Science and Technology identified marine debris monitoring as a national research priority. Finally, Salazar and Santiago (2021) demonstrated that student-led waste audits not only generate useful empirical data but also promote environmental education and local stewardship, which is consistent with the participatory nature of the present study.

Data collection involved the participation of Grade 11 Earth Science students who were organized into small groups and assigned to segments of the shoreline to prevent overlap. Participants used gloves, masks, and reusable bags to ensure safety, while faculty members and volunteers from partner organizations supervised the process. Each debris item was collected, sorted, and recorded according to standardized ICC categories.

Hazardous items, such as diapers and electronics, as well as unusual findings, including entangled marine life, were documented separately. After the cleanup, the data were aggregated into a central database for analysis.

Data analysis relied on descriptive statistics to summarize the types of debris, their relative proportions, and their densities per kilometer. The frequency and percentage distributions were calculated for each category, and the total count was standardized to provide a waste density estimate expressed as pieces per kilometer. Observational notes on ecological impacts were incorporated into the interpretation of findings. By presenting both quantitative and qualitative insights, the methodology ensured that the results not only provided a numerical baseline but also contextualized the ecological and policy implications of marine litter in secondary Philippine coastlines.

Ethical Considerations

This study adhered to ethical standards for research involving student participants and community-based activities. Prior to the audit, informed consent was obtained from student participants and their parents or guardians, with the assurance that participation was voluntary and that no personal identifiers would be disclosed in any reports or publications. The activity was coordinated with the school administration to ensure alignment with institutional guidelines and curricular objectives, particularly in relation to environmental science education.

To safeguard participants, all individuals were required to wear gloves, masks, and appropriate footwear during the cleanup to minimize health risks and potential exposure to hazardous materials. Debris handling protocols were based on the International Coastal Cleanup guidelines, and hazardous items such as diapers, electronics, and sharp objects were collected separately and disposed of properly to ensure safety. The presence of faculty members and partner organization volunteers provided further oversight to guarantee both procedural integrity and the well-being of participants.

The study involved only the collection of non-biological waste and incidental field observations; no interventions with living organisms or experimental manipulations were conducted. Observations of entangled wildlife were documented in a non-invasive manner, with no handling or disturbance of specimens. These safeguards ensured that the research remained consistent with ethical principles of beneficence, respect, and non-maleficence.

Finally, the study observed transparency and accountability in reporting. Data were anonymized to avoid attributing negative publicity to the host community while ensuring scientific accuracy. The findings are intended to contribute to environmental awareness, policy development, and Sustainable Development Goal 14, consistent with both local legal frameworks (RA 9003, RA 11898) and global commitments to ocean sustainability.

Results and Discussion

This section presents the findings of the coastal waste audit conducted along the one-kilometer study shoreline. Data are summarized in tabular form to provide a clear profile of debris composition and waste density. Each table is followed by a description of how data were collected, an interpretation of the results, and their relation to the reviewed literature and existing policy frameworks.

Table 1: Debris categories and quantities collected along the study shoreline (1 km, September 21, 2024)

#	Waste category	Quantity (pieces)	% of total debris
1	Plastic bags – grocery	204	8.80%
2	Plastic bags – other	290	12.50%
3	Plastic beverage bottles	287	12.40%
4	Plastic bottle caps	159	6.90%
5	Plastic straws	70	3.00%
6	Food wrappers	240	10.40%
7	Plastic sachets	84	3.60%
8	Other plastic bottles	74	3.20%
9	Foam/Styrofoam containers	58	2.50%
10	Foam packaging	16	0.70%
11	Plastic/foam fragments	153	6.60%
12	Fishing lines	38	1.60%
13	Fishing nets	25	1.10%
14	Diapers	62	2.70%
15	Construction materials	52	2.20%
16	Electronics	10	0.40%
17	Masks and gloves	20	0.90%
18	Cotton bud sticks	14	0.60%
19	Tires	13	0.60%
20	Clothing	22	0.90%
21	Footwear	33	1.40%
22	Cigarette butts	17	0.70%
23	Balloons	3	0.10%
24	Dead fish (observed)	1	—
Total	—	**2,314**	**100%**

The data in Table 1 were generated during a structured cleanup and audit using the International Coastal Cleanup (ICC) protocol, the Ocean Trash Data Form, and the Clean Swell mobile app. Student participants recorded each debris item by category across assigned shoreline segments. Non-plastic and unusual items were documented separately, including construction materials, electronics, and wildlife interactions.

The audit yielded a total of 2,314 debris items, of which over 80% were plastics. Single-use consumer plastics dominated, particularly plastic bags (494 combined), beverage bottles (287), food wrappers (240), and caps (159). The presence of fishing lines and nets suggests contributions from marine-based activities, while diapers, construction debris, and electronics point to improper disposal and drainage inputs. An observed dead fish entangled in debris highlighted direct ecological impacts.

The predominance of plastics mirrors national and international findings. Celestial and Salmo (2020) documented a similar pattern in Metro Manila beaches, with plastics making up 82% of litter. Fabres and Onda (2021) confirmed that beverage bottles and sachets are widespread across Philippine coastlines, reinforcing that secondary urban shorelines face pressures similar to major cities. Greenpeace Philippines (2017) linked such persistent waste types to inadequate enforcement of Republic Act No. 9003, while the observation of entangled marine life supports Santos et al. (2018), who found microplastics in the guts of commercially important fish in the Philippines. Together, these results underscore both consumer-driven waste generation and governance gaps in waste management.

Table 2: Waste density and summary metrics

Metric	Value
Cleanup area	1 km shoreline
Total debris collected	2,314 pieces
Waste density	2,314 pcs·km^{-1}
Dominant waste type	Plastics (>80% of total)
Top item groups	Plastic bags, beverage bottles, wrappers
Notable non-plastic items	Diapers, construction debris, electronics
Wildlife impact	1 dead fish observed

Waste density was calculated by dividing the total debris count (2,314 pieces) by the 1 km cleanup area, yielding 2,314 pieces per kilometer. This metric allows comparison across different coastal zones and provides a standardized baseline for monitoring trends over time.

The density of 2,314 pcs·km^{-1} indicates a heavily impacted shoreline relative to national averages. Plastics were the overwhelming majority, while diapers, construction debris, and electronics highlight systemic waste management failures. The single wildlife impact observed further illustrates ecological vulnerability.

The density observed supports UNEP's (2021) assessment that unmanaged land-based sources are the primary contributors to marine litter globally. It also confirms the implementation gap of RA 9003 and the newer RA 11898, where segregation-at-source and EPR systems remain weakly operational at the community level. The NCCAP (2011–2028) emphasizes local monitoring for climate-resilient ecosystems, and the HNRDA (2022–2028) prioritizes research on plastic pollution, validating the importance of this dataset. Furthermore, Salazar and Santiago (2021) highlighted the role of school-based

audits in bridging data gaps while building civic responsibility, demonstrating that the present study not only contributes empirical data but also aligns with educational and governance priorities.

Conclusions

The coastal audit along a one-kilometer secondary urban shoreline documented a total of 2,314 debris items, with plastics constituting more than 80% of the total. The composition data confirmed that single-use consumer plastics—including plastic bags, beverage bottles, and food wrappers—dominated the waste stream, while non-plastic items such as diapers, construction debris, and electronics revealed gaps in waste disposal and collection systems. The presence of fishing gear further indicated marine-based inputs, while the observation of a dead fish entangled in debris highlighted ecological risks.

The calculated waste density of 2,314 pcs·km^{-1} situated the study shoreline among heavily impacted coastal sites in the Philippines. This density reflects both consumer-driven waste patterns and systemic governance gaps in implementing Republic Act 9003 and the Extended Producer Responsibility Act of 2022. The results are consistent with global assessments (UNEP, 2021) and Philippine studies (Celestial & Salmo, 2020; Fabres & Onda, 2021) that emphasize plastics as the predominant component of marine litter.

Overall, the study provides baseline empirical evidence for secondary urban coastlines, an underdocumented setting compared with major metropolitan beaches. By aligning with the NCCAP (2011–2028), the HNRDA (2022–2028), and SDG 14, the findings confirm the urgency of local monitoring and community engagement as critical strategies for addressing marine plastic pollution.

Based on the conclusions, the following recommendations are proposed:

1. Regular coastal monitoring. Institutionalize quarterly or biannual waste audits to track trends and evaluate interventions, ensuring the data feeds into local environmental planning and compliance monitoring.
2. Strengthen policy enforcement. Improve local implementation of RA 9003 and RA 11898 through stricter regulation of single-use plastics, support for barangay-level materials recovery facilities, and accountability mechanisms for producers.
3. Enhance infrastructure for waste management. Invest in drainage management, proper disposal systems for diapers and electronics, and facilities for handling bulky or hazardous waste to reduce non-plastic inflows to shorelines.
4. Promote community-based education. Expand school- and community-led waste audits (as shown effective by Salazar & Santiago, 2021) to increase environmental awareness, foster civic responsibility, and create youth-driven monitoring networks.
5. Integrate findings into climate and sustainability planning. Use the dataset as evidence for updating local climate change action plans (LCCAPs) and aligning coastal management strategies with NCCAP priorities and SDG 14 targets.
6. Support further research. Conduct longitudinal studies to assess seasonal variation in debris density and explore the ecological impacts of plastics on local biodiversity,

including potential risks to fisheries and food security.

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Disclosure: Use of AI Tools

In compliance with Threshold's guidelines for the ethical use of artificial intelligence (AI) and automated tools in academic research, the authors disclose the use of OpenAI's ChatGPT for enhancing the quality and clarity of the manuscript. ChatGPT was utilized to assist in refining the language, structure, and formatting of the text, ensuring a high level of academic rigor and coherence. The authors confirm that all data analysis, critical interpretations, and conclusions presented in this manuscript were conducted independently by the research team. The AI tool was employed strictly for editorial assistance and did not influence the scientific content or ethical considerations of the study. All intellectual contributions from the AI tool are in accordance with the authors' original intentions and have been reviewed and approved by all co-authors. The use of ChatGPT complies with Threshold's ethical standards and guidelines for transparent reporting of AI involvement in research. The authors remain fully responsible for the integrity and accuracy of the content presented in this paper.

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