RES MILITARIS
REVUE EUROPEENNE D ETUDES EUROPEAN JOURNAL OF MILITARY STUDIES
Social Science Journal

Design of River Floating Trash Traps Using Recycled Plastic Bottles and Characterization of Waste Collected in Odiongan, Romblon Philippines

By

Jerome G. Gacu*
Instructor I, Civil Engineering Department, College of Engineering and Technology, Romblon State University
Email: jeromegabuterogacu@rsu.edu.ph

Abstract

Accumulation of solid waste from rivers that hinder the quality and life below water is one reason for this pollution. Rivers and creeks in the Municipality of Odiongan are used as solid and liquid dumping sites, resulting in water pollution. In addition, the municipality also generates tons of waste every month. This project aims to design floating trash traps installed in the municipality's three (3) rivers, specifically Bangon River, Gabawan River, and Poctoy River. These plastic-made traps are strategically placed in rivers and streams to stop solid waste from floating further downstream without hampering aquatic life movements. The materials used in the proposed design consist of plastic bottles, poultry net, and nylons. Fieldwork was done at the rivers and characterized the collected wastes by their wet weight. The floating trash traps generated a total of 285.76 kilograms. A total of 68% (193.08 kilograms) of biodegradable waste were collected, consisting of leaves, twigs, driftwoods, and coconut husk. 14% (40.57 kilograms) of trash were gathered for recyclable, containing plastic bottles and cans. 12% (33.66 kilograms) is residual waste (plastic packaging, Styrofoam, miscellaneous plastics, cigarette butts, and mainly heavily soiled plastics), and 6% (18.45 kilograms) is special waste, mostly bulky waste from construction and logs were accumulated. The trash traps can hold 28.58 kg of solid waste for 5-days and 2.09 kg, 1.82 kg, and 1.8 kg per day for Trap 1, Trap 2, and 3, respectively. In conclusion, the design of the floating trash traps has been proven as a potential solution for collecting marine wastes, particularly in rivers.

Index Terms—marine waste, recycled plastic, Solid Waste Management, trash traps, waste characterization

Introduction

Marine Waste is described as any persistent solid substance produced or processed, disposed of, and abandoned in the marine environment purposefully or accidentally [1]. The most common kind of trash in the sea, which accounts for 80 percent of all marine debris from the surface to deep-sea sediments, is plastic waste. [2]. Plastic pollution in marine environments can also easily interact with aquatic life and threaten wildlife or habitat [3]. In the study [4], 80 percent of ocean plastic comes from rivers and coasts, and the remaining 20% is derived from maritime sources, such as fishing nets, ropes, and fleets. According to an evaluation by the nonprofit NGO Ocean Conservancy of 2017, Indonesia, the Philippines, Vietnam, Thailand, and China is the world's largest dumper of waste [5]. Asian rivers account for 81 percent of ocean trash, and one-third of the global total is from the Philippines alone [4]. The Philippines was reported as one of the top contributors of plastics to the oceanic environment, which demanded the development of imposing plastic regulation strategies [6].

Solid waste disposal has augmented concerns about resources, health, and environmental dilemma [7]. Waste recycling is considered a vital part of solid waste management worldwide. Recycling shows opportunities to reduce oil usage, carbon dioxide emissions, and the amount of waste that requires proper disposal [8]. Recycling plastic bottles helps conserve space for other debris and helps to preserve natural resources, such as oil, a limited nonrenewable natural resource [9].

The importance of environmental issues surges the response to develop such technology that does not burden the life below water [10]. Several technologies in river plastic waste collection operate in different river systems across the globe, from passive devices such as booms, traps, and barriers that rely on currents to integrated systems that actively collect or concentrate waste [11]. In the Philippines, the Department of Environment and Natural Resources (DENR) uses floating trash traps to prevent solid wastes from stretching the other water body of Manila Bay. The project's initial implementation has effectively collected about 30 tons of garbage [12].

Waste characterization defines how much paper, glass, food waste, etc., is castoff in your waste stream. Waste characterization figures help plan how to reduce waste, set up recycling programs, and conserve resources [13]. Characterization of municipal to county solid wastes and forecast waste-generation rates are essential to planning and implementing disposal and recycling activities [14]. However, in the Philippines, the lack of firm implementation of solid waste management regulations has directed mismanaged wastes, such as plastics, that end up floating in water bodies [15].

According to the Comprehensive Land Use Plan (CLUP) of the Municipality of Odiongan, rivers, and creeks in the said municipality are used as solid and liquid dumping sites. In addition, the municipality also generates tons of plastic waste every month.

This research aims to design, fabricate, and test the river floater trash traps using recycled plastic bottles and characterize the collected waste in selected rivers in Odiongan, Romblon. These plastic-made traps are strategically placed in rivers and streams to stop solid waste from floating further downstream without hampering aquatic life movements. Specifically, the study will: design a river floater trash trap using plastic bottles fabricated for each river; identify the target rivers suitable for the installation of river floater trash traps; fabricate the river floater trash traps using plastic bottles, and install the traps in selected streams and rivers, and; lastly, characterize the waste composition collected from the plastic-made trap.

Methodology

Design Phase

The first part of the methodology is to design the river floater trash traps. In this phase, necessary functions of trash traps are identified considering the design parameter and engineering concept to make the project perform well under expected and worse case scenarios. The following features of materials are used in the design of the traps:

Floating material – It serves as a floating barrier for the waste collected;

Tying material – It is used to tighten and hold together the floating material;

Net – It is used to cover the floating material, and this will serve as mesh for solid waste that passes the trap; and

Rope - It serves as the tension cable from the post connected on both sides of the river of the trash traps.

Material canvassing and selection were performed based on desired calculation, availability, and cost. The materials should be found anywhere, budget-friendly, and serve their purpose. 3D modeling of the river floater trash traps was drawn in SketchUp Software to visualize the final design.

Site Selection and Fabrication Phase

Identifying rivers and probable site locations are the following research method. However, to identify rivers and possible sites, researchers created and used decisive factors based on the function of installing traps. Table I shows the criteria considering the environment of the river.

Table 1. *Decisive factors in the selective water body for the river floater trash traps*

Factors	High Preference	Low Preference
Location	• Near Household Areas • Easily accessible • Secured/fenced	• Remote places
Weather	• Little wind or storms • Calm Flowing water	• Cold regions with freezing water • High winds and risk of natural disasters such as typhoons and tsunamis • Seasonal flooding • Drought events that lead to exposure to the water bed
Type of Water Body	• River and Streams • Artificial streams • Industrial water bodies such as canals and drainage • Irrigation	• Stable or stagnant water • Tourist or recreational sites
Water Characteristics	• Regular shape • Wide opening toward south or north	• Presence of islands/obstacle that hinders the flow of water
Water Body Ownership	• Single owner • Legal-entity owner	• Multiple owners • Individual private owners
Water Condition	• Freshwater or saltwater	• Dirty/corrosive water • Water prone to biofouling
Stream	• Middle Stream • Down Stream	• Upstream
Navigation	• No water activities such as recreation and farming • Near the open sea, large reservoirs of hydropower and dams	• Navigable of boats and ship
Ecology	• Simple and robust ecology	• Sanctuary for fish and bird habitats • Preserved water body
Others	• Polluted by solid waste • Easy water access	• Complicated banks

Rivers in Odiongan, Romblon were listed and had been validated using the factors. An actual site inspection of locations to see if the river fits the preferences have conducted. Also, initial investigation and measurement of river orientation have been performed for use in the fabrication phase of trash traps. In the fabrication method, engineering techniques suitable for each part and component of trash traps were applied.

A. Testing and Waste Characterization Phase

Traps were assembled and installed in selected river bodies for testing and waste characterization data gathering. The researcher performed actual monitoring to ensure that the floater was in good shape and well attached. Waste is manually collected in the traps and put in the trash bag for segregation. This step is done every five (5) days for two months and characterizes the samples by their classification: biodegradable, recyclable, residual, and special waste. The researchers documented the wet weights of the samples for each category and type. Finalization of the result was conducted by computing the waste generated by each trap and listing the possible factors for improving the design. The researcher performed proper waste disposal in collected marine debris as the final step of the methodology.

Result and Discussion

B. Designing River Floater Trash Traps

Solid waste management techniques for the marine body are essential and can significantly impact life below water. Functions and design parameters for the design of trash traps were determined from gathered information from related literature.

Table II. *Selected materials for the design of rive floater trash traps.*

Material	Description
1.5 Plastic Bottles	• Floating material that served as a barrier for trashes • Free and comes from reusable waste that can be found everywhere • Easy to merge by its size
Nylon String (Fishing line)	• Use to hold together the plastic bottles. • Synthetic material with excellent strength and abrasion resistance • Available in local hardware • Flexible and elastic • Resistant to heat and water
Poultry Net	• Used to cover the floating material, and this will serve as mesh for solid waste • Available in local hardware • Durable and easy to install • Tangle-free
Nylon Rope	• Serve as the tension cable from the post connected on both sides of the river of the trash traps • Most potent of all types of ropes • Synthetic material with excellent flexibility and stretch • Elastic and can absorb tremendous shock loads • Available in local hardware

Canvasing and selection of materials used in the study were performed considering the efficiency of components, availability in the local market, and cost of materials. As shown in Table II, the researcher chose the best materials needed in the design to serve its purpose.

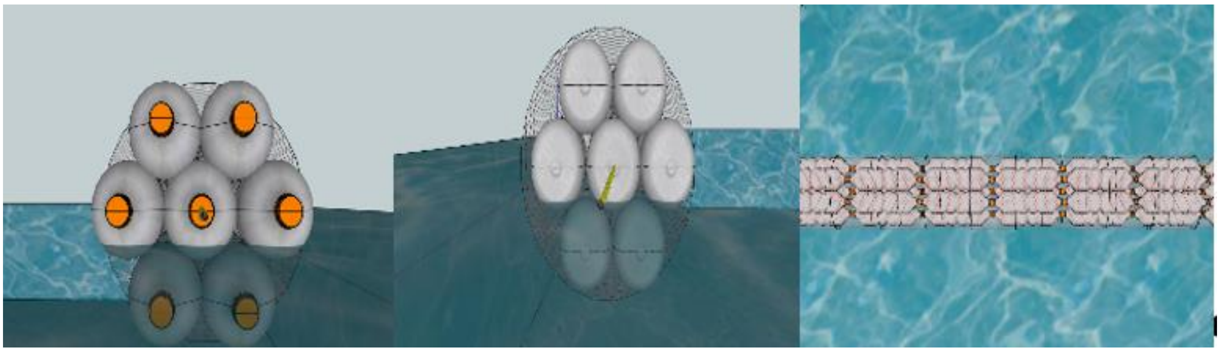

Fig. 1 *3D model of plastic-made river floater trash traps*

In planning for the design of the trash traps, the researchers used Sketchup to 3D model the composition of traps for better insights into what the project looks like. Also, the model helps the researchers to measure and calculate the materials needed in every traps.

C. Site Selection and Fabrication of River Floater Trash Traps

Decisive factors in selecting the best site location for installing the river floater trash traps were considered. After excessive evaluation of the river during on-site inspection and validation, three (3) rivers were selected and had a high preference for the suitability of settling trash traps. Traps were installed in the rivers of barangay Gabawan, Poctoy, and Bangon. During the site inspection, the river width and exact stream location were identified as the measurement basis for fabricating the trash traps.

Assemble parts and components of traps were done based on the steps in the fabrication of traps. All details were secured and surely firmed to avoid such problems during data gathering.

D. Installation and Waste Characterization

River floater trash traps were installed in identified rivers of Gabawan, Poctoy, and Bangon. Extensive site monitoring was done every five (5) days was performed. Detailed listing and recording of data were indeed prepared for the collected waste of traps.

Fig. 2 *Installation of river floater trash traps in (a) Gabawan River, (b) Poctoy River, and (c) Bangon River.*

Trap 1, 2, and 3 were labeled in traps installed in Gabawan, Poctoy, and Bangon, respectively. Waste was collected and recorded its total wet weight in kilograms using a weighing scale and characterized according to its classification every five (5) days for ten (10) days.

Table III. *Waste generated and characterization of Trap 1 (Gabawan River) in wet weight (kilograms).*

Day	Bio-degradable (kg)	Recyclable (kg)	Residual waste (kg)	Special waste (kg)	Total
1	15.8	6.8	1.13	0	23.73
2	3.4	2.8	0.45	1.23	7.88
3	4.5	1.54	0.56	0.1	6.7
4	7.8	1.32	1.46	0	10.58
5	5.67	1.2	1.34	0.14	8.35
6	2.54	2.6	0.23	0	5.37
7	2.87	0.45	1.16	0	4.48
8	0.6	0.9	0.16	0.14	1.8
9	7.8	3.2	1.15	2.6	14.75
10	4.78	1.3	1.43	0	7.51
Sub Total	55.67	22.11	9.07	4.22	
			Grand Total		91.07

Table III shows the overall waste collected in the Trap 1 (Gabawan). The floating trap installed catches 91.16 kg of garbage in the river. 61% of the catch is Biodegradable waste (55.76kg.). Recyclables followed the second most waste catch with 22.11 kilograms, followed by the residual waste weighing 9.07 kg. The least amount taken was Special waste with only 4.22 kg. The floating trap in this river can hold 1.82 kilograms of waste per day.

Table IV. Waste generated and characterization of Trap 2 (Poctoy River) in wet weight (kilograms)

Day	Bio- degradable (kg)	Recyclable (kg)	Residual waste (kg)	Special waste (kg)	Total
1	20.4	0.25	1.3	5.6	27.55
2	3.8	1.45	0.9	0	6.15
3	4.5	2.3	1.2	0.12	8.12
4	3.56	1.2	0.8	0	5.56
5	0.9	1.3	1.12	0.24	3.56
6	0.65	0.2	0.19	0	1.04
7	11.28	3	0.12	2.45	16.85
8	9.91	1.5	1.13	0	12.54
9	12.42	1	0.11	0	13.53
10	7.2	1.35	1.12	0	9.67
Sub Total	74.62	13.55	7.99	8.41	
			Grand Total		104.57

Table IV shows data recorded in monitoring Trap 2 (Poctoy) with 104.57 kg of waste collected. 71% of overall waste is Biodegradable waste (74.62 kg.). Recyclable waste weighed 13.55 kg, Special waste was 8.41 kg, and the least waste collected was Residual at 7.99 kg. The average waste trap per day in the Poctoy River is 2.09 kg.

Table V. Waste generated and characterization of Trap 3 (Bangon River) in wet weight (kilograms).

Day	Bio-degradable (kg)	Recyclable (kg)	Residual waste (kg)	Special waste (kg)	Total
1	18.2	1	1.2	0.2	20.6
2	6.7	0.12	3.2	0	10.02
3	5.3	1.6	2.7	0	9.6
4	1.4	0.12	1.35	5.45	8.32
5	0.9	0	1.12	0	2.02
6	11.8	1.35	2.15	0	15.3
7	8.6	0	1.3	0	9.9
8	5.82	0.12	1.31	0	7.25
9	2.4	0.6	1.15	0	4.15
10	1.58	0	1.12	0.17	2.87
Sub Total	62.7	4.91	16.6	5.82	
			Grand Total		90.03

Table V shows the total waste collected in Trap 3 (Bangon) for ten days of monitoring. The highest waste collected is Biodegradable waste (62.7 kg), comprising 70% of the total waste collected, followed by Residual Waste with 16.6 kg. Next is Special waste with 5.82 kg. Lastly, Recyclable waste weighing 4.91 kg. The trash accumulated in the Trap 3 is 90.03 kg. The floating trap in this river can catch an average of 1.8 kg of waste per day

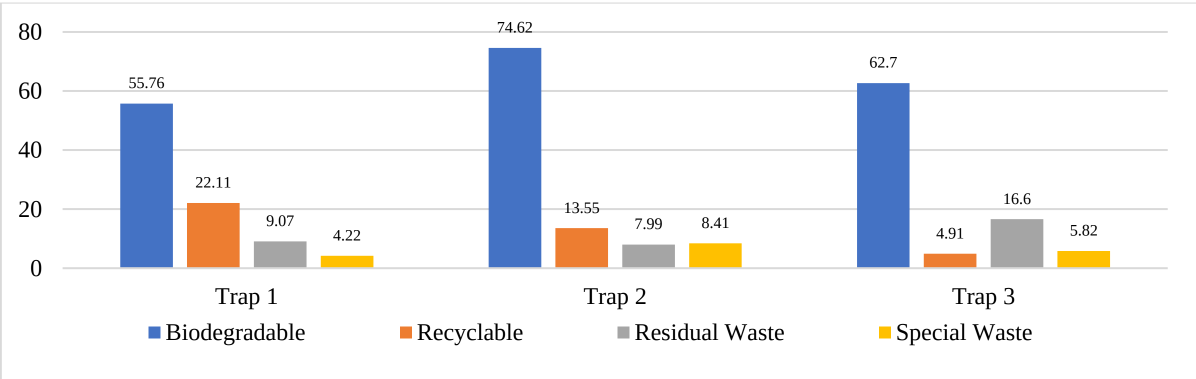

Fig. 3 *Wet weights in kilograms of waste generated in three installed traps in Poctoy, Gabawan, Bangon, respectively.*

Fig 3 Indicates an overview of solid waste collected from the three rivers: Trap 1 (Gabawan), Trap 2 (Poctoy), and Trap 3 (Bangon), classified into Biodegradable, Recyclable, Residual, and Special waste. It shows that 68% of the waste is Biodegradable (193.08 kg), recyclable (40.57) is 14%, residual (33.66 kg) is 12%, and lastly, special waste (18.45 kg) is 6%.

The float traps that collected the most waste are in Trap 2, which has a total of 104.57 kg, having 37% of the overall catch, followed by the Trap 1 with 91.16 kg (32%), and the least is in the Trap 3, with 90.03 kg (31%). The floating traps in these rivers had accumulated 285.76 kg of waste. The capacity of Trap 1 (Poctoy), Trap 2 (Gabawan), and Trap 3 (Bangon) holds an average of 2.09 kg, 1.82 kg, and 1.8 kg per day, respectively. The trash traps can hold an average of 28.58 kilograms of solid waste for 5-days.

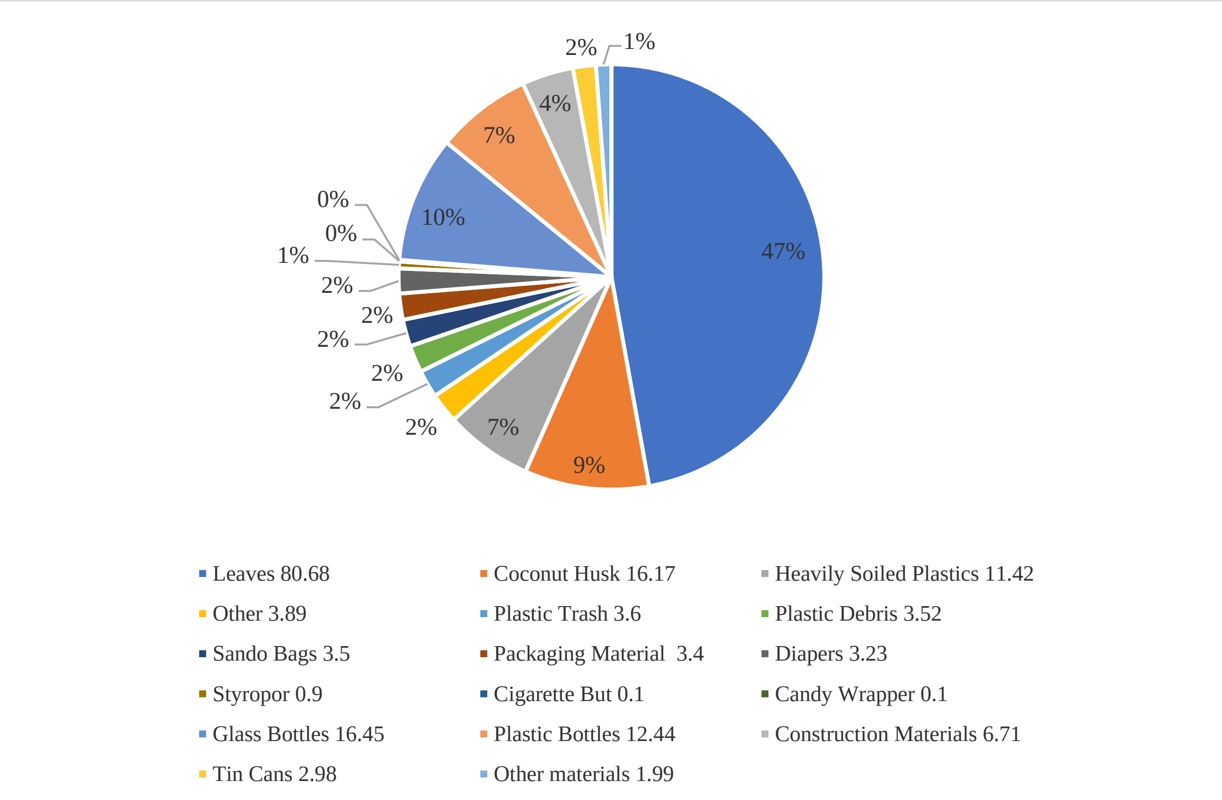

Fig. 4. *Trash characteristics breakdown by wet weight (kg)*

The figure shows the analysis of classified waste collected from floating traps. The type of waste with an enormous contribution to the generated trash in these rivers is Biodegradable, which mainly comprises twigs, leaves, and coconut husks. The breakdown of the garbage collected is shown in Fig. 4.

The study highlights that river floater trash traps are a potential solution for collecting floating debris in rivers. However, future researchers must improve and develop the design of trash traps. This idea also can be recommended among the various government, private sector, and informal sectors to participate in waste management.

Conclusion

The design of the river floating trash traps has been proven as a potential solution for collecting floating marine wastes, particularly in rivers. The traps generated a total of 285.76

kilograms. A total of 68% (193.08 kilograms) of biodegradable waste were collected, consisting of leaves, twigs, driftwoods, and coconut husk. 14% (40.57 kilograms) of trash were gathered for recyclable, containing plastic bottles and cans. 12% (33.66 kilograms) is residual waste (plastic packaging, styrofoam, miscellaneous plastics, cigarette butts, and mainly heavily soiled plastics), and 6% (18.45 kilograms) is special waste, mostly bulky waste from construction and logs were accumulated. It was also found out that the Poctoy River gathered the most trash collected among the three rivers, followed by Gabawan and Bangon. The trash traps can hold 28.58 kg of solid waste for 5-days and 2.09 kg, 1.82 kg, and 1.8 kg per day for Trap 1, Trap 2, and 3, respectively. Further studies are suggested to develop the design of trash traps and waste characterization of marine wastes. This idea also can be recommended for government, private sector, and informal sectors to partake in marine waste management.

Acknowledgement

The author wishes to thank Mr. Van Russel Fajilan, Micca Izza A. Cawaling, Jet Michael B. Fruelda, Yollie Mae G. Merano, and Blasé M. Fontillar for the help in the conduct of the study. Thanks are also due to Engr. Kahlen Ze Montoya for serving as a partner in the initiation of the study.

References

"What is Marine Debris? | OR&R's Marine Debris Program." https://marinedebris.noaa.gov/discover-marine-debris/what-marine-debris (accessed May 22, 2022).

"Marine plastic pollution | IUCN." https://www.iucn.org/resources/issues-briefs/marine-plastic-pollution (accessed May 22, 2022).

L. G. A. Barboza, A. Cózar, B. C. G. Gimenez, T. L. Barros, P. J. Kershaw, and L. Guilhermino, *Macroplastics pollution in the marine environment*, Second Edi. Elsevier Ltd., 2018.

"Where does the plastic in our oceans come from? - Our World in Data." https://ourworldindata.org/ocean-plastics (accessed May 22, 2022).

"Southeast Asian countries pledge to tackle marine plastic waste crisis." https://news.mongabay.com/2019/06/southeast-asian-countries-pledge-to-tackle-marine-plastic-waste-crisis/ (accessed May 22, 2022).

V. R. K. R. Galarpe, C. M. B. Jaraula, and M. K. O. Paler, "The nexus of macroplastic and microplastic research and plastic regulation policies in the Philippines marine coastal environments," *Mar. Pollut. Bull.*, vol. 167, no. April, p. 112343, 2021, doi: 10.1016/j.marpolbul.2021.112343.

K. S. Mulya, J. Zhou, Z. X. Phuang, D. Laner, and K. S. Woon, "A systematic review of life cycle assessment of solid waste management: Methodological trends and prospects," *Sci. Total Environ.*, vol. 831, no. November 2021, p. 154903, 2022, doi: 10.1016/j.scitotenv.2022.154903.

E. Okyere, "No Title p," *Phys. Rev. E*, vol. 4, no. June, p. 53, 2011.

"What Are Different Ways That People Waste Water?" https://sciencing.com/what-are-different-ways-that-people-waste-water-4857111.html (accessed May 22, 2022).

G. K. A., A. K., H. M., S. K., and D. G., "Review on plastic wastes in marine environment – Biodegradation and biotechnological solutions," *Mar. Pollut. Bull.*, vol. 150, no. May 2019, p. 110733, 2020, doi: 10.1016/j.marpolbul.2019.110733.

J. Silva, M. Morse, and V. Tamayo-Cañadas, "Plastic waste capture in rivers An inventory of

current technologies,” *Benioff Ocean Initiat.*, pp. 1–50, 2021.
“DENR trash traps to reduce solid waste in Manila Bay.” https://ani.seafdec.org.ph/handle/20.500.12174/9682 (accessed May 22, 2022).
“What is Waste Characterization?” https://www2.calrecycle.ca.gov/WasteCharacterization/General (accessed May 23, 2022).
B. A. E. Gay, T. G. Beam, and B. W. Mar, “COST-EFFECTIVE SOLID-WASTE CHARACTERIZATION METHODOLOGY By Alan E. Gay, ~ Thomas G. Beam,-’ and Brian W. Mar, 3 Member, ASCE,” vol. 119, no. 4, pp. 631–644, 1994.
M. B. L. D. Diola, M. A. N. Tanchuling, D. R. G. Bonifacio, and M. J. N. Delos Santos, “Characterization of Plastic Pollution in Rivers: Case of Sapang Baho River, Rizal, Philippines,” *Eguga*, no. May, p. 22467, 2020, [Online]. Available: https://ui.adsabs.harvard.edu/abs/2020EGUGA..2222467D/abstract.