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Occurrence of macroplastics on selected beach areas in Surigao Del Norte and Dinagat Islands, Philippines

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Abstract

Beaches that provide recreational services are becoming seriously threatened by the presence of plastic litter. Their build-up in beach areas comes from different sources, such as recreational activities, improper solid waste management, the behavior of the nearby residents, and ocean currents carrying plastic waste from distant locations. Thus, the purpose of this study is to assess the macroplastics or plastic litter present in selected beaches in Surigao Del Norte and Dinagat Island and to determine the clean coast index per area. A 50-meter line transect was laid out in each station parallel to the shoreline with three (3) quadrats measuring 4x4 m located at 0-4 m, 23-37 m, and 46-50 m, and three stations were established in each sampling site. A visual identification of the type of plastic was done and the clean coast index (CCI) was then calculated to qualitatively describe the quality or the cleanliness of each beach. As a result, Mabua Beach in Surigao City (n=136) was found to have the most number of plastic litters, while Duyos Beach (n=56) had the least count. HIPS which is composed mostly of food packing dominated the beaches of Surigao del Norte, while HDPE is in Dinagat Islands. Humans are the major contributors to the plastic litter found on the beaches of Surigao and Dinagat. Mitigating the microplastic pollution on the beaches of Surigao and Dinagat requires a comprehensive and collaborative approach that involves raising awareness, improving waste management systems, implementing policies, and fostering community participation.

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Introduction

With its scenic beauty and ecological significance, beaches provide recreational spaces and important ecosystems worldwide. However, these pristine coastal environments are becoming seriously threatened by the existence of macroplastics. Macroplastics, defined as plastic debris larger than 5 millimeters, have appeared as a critical environmental concern in recent years due to their widespread distribution and continual presence on beaches worldwide (Ryan *et al.*, 2020). The build-up of macroplastics in beach areas comes from different sources, such as recreational activities, improper solid waste management, the behavior of the nearby residents, and ocean currents carrying plastic waste from distant locations (Taibi *et al.*, 2021; Van Emmirik *et al.*, 2020). This made the beaches dumping sites for a multitude of macroplastic items such as bottles, bags, fragments, fishing gear, and packaging materials, which pose significant risks to both marine life and human well-being.

The Philippines is no exception to this global crisis of marine microplastic pollution. A home with rich marine biodiversity and pristine coastlines, the country faces a crucial challenge as macroplastics continue to increase and pose a serious threat to its fragile ecosystems. The country having a unique geographical location, with its massive coastline and abundant marine resources, makes it particularly vulnerable to the influx of macroplastics (Van Ryan Kristopher *et al.*, 2021). As a developing nation, the country has witnessed a surge in plastic production and consumption, resulting in an alarming increase in plastic waste generation. Inadequate waste management systems, poor infrastructure, and limited public awareness compound the problem, allowing macroplastics to find their way into rivers, streams, and ultimately, the ocean. The country has been tagged as among the major marine polluters discharging annually for about 0.75 million tons of plastic debris into the ocean (Paler *et al.*, 2020). The consequences of macroplastic pollution on the Philippines' marine ecosystems are far-reaching. Coral reefs, vital for biodiversity and coastal protection, suffer from physical damage caused by entangled plastic debris and the release of toxins. Marine mammals, birds, and sea turtles mistake plastics for food, leading to choking, entanglement, and often fatal consequences (Sajome *et al.*, 2021).

Additionally, the tourism industry, a significant contributor to the country's economy, faces potential decline as the once-pristine beaches become marred by plastic waste.

Surigao Del Norte and Dinagat Islands, located in the beautiful Philippines, are home to some of the most breathtaking beaches in the country. These enchanting destinations offer a perfect blend of stunning natural landscapes, crystal-clear waters, and warm hospitality. Whether you're seeking thrilling adventures, relaxation by the shore, or a taste of local charm, Surigao Del Norte and Dinagat Islands' beaches are a paradise waiting to be discovered, offering a truly unforgettable experience for every traveler. Thus, the purpose of this study is to assess the macroplastics or plastic litter present in selected beaches in Surigao Del Norte and Dinagat Island and to determine the clean coast index per area.

Materials and methods

Study area

Surigao Del Norte is surrounded by myriad picturesque beaches that could satisfy every beach lover's dream. One of the most sought and is on the bucket list of almost everyone is Siargao Island, known as the surfing capital of the Philippines. Its world-renowned Cloud 9 wave attracts surfers from all around the globe. Besides surfing, Surigao Del Norte also offers idyllic white sandy and pebble beaches, including Star Beach and Mabua Beach along the Surigao Straight.

Meanwhile, Dinagat Islands, situated northeast of Surigao Del Norte, is a hidden gem waiting to be explored. This group of islands is known for its unspoiled beauty and secluded beaches. Among its many treasures is Pangabangan Island, a serene paradise with powdery white sands and turquoise waters. The stunning Cagdianao Beach, with its towering rock formations and vibrant marine life, is perfect for snorkeling and diving enthusiasts.

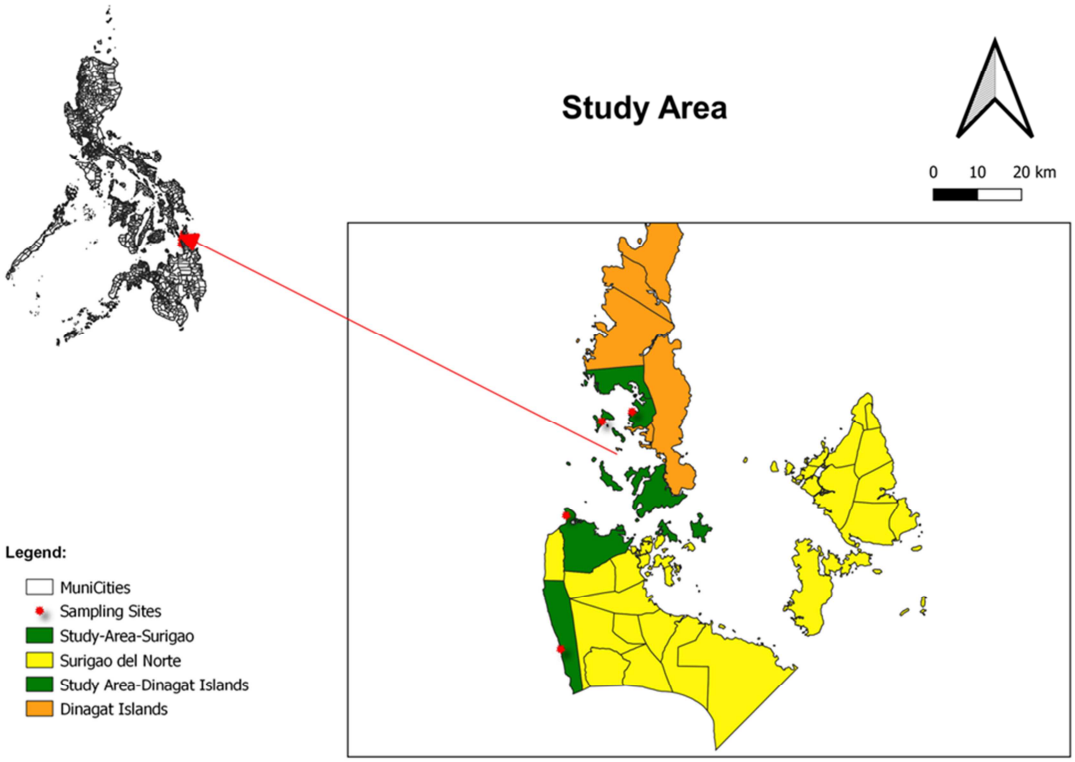

Fig. 1. Map of the study area

Table 1. Location and description of the sampling sites

Sampling sites	Station	Location (Coordinates)	Beach description
Star Beach, Malimono,	S1	9.534110195443786, 125.4278227878919	Private beach resort in the mainland
	S2	9.53315529132045, 125.42812051309141	
	S3	9.532207669768754, 125.4283334484544	
Mabua pebble beach, Surigao city	S1	9.80987306861377, 125.43902180141603	Public beach area in the mainland
	S2	9.807970109452315, 125.4393275732476	
	S3	9.806680319836556, 125.43954214996718	
Duyos beach, Basilisa, Dinagat Islands	S1	10.005421784881177, 125.51309427078631	Private beach resort in the island
	S2	10.00477927784026, 125.51289920351294	
	S3	10.00477927784026, 125.51289920351294	
Santa Cruz beach, Dinagat Islands	S1	10.026028102348448, 125.57540273484418	Public beach area in the island
	S2	10.025143282940496, 125.57539737042515	
	S3	10.024224124696037, 125.5750419777219	

Four (4) beach sites were chosen for this study, two (2) in each site of Surigao Del Norte and Dinagat Islands classified into public and private beaches (Fig. 1). The description of each site is shown in Table 1.

Plastic litter collection and identification

The method of collection of the plastic litter was adapted from Sajorne *et al.* (2021) wherein three sampling stations were established in each study area.

A 50-meter line transect was laid out in each station parallel to the shoreline. Along the transect line, there were three (3) quadrats measuring 4×4 m which were located at 0-4 m, 23-37 m, and 46-50 m.

The collected plastic litters were put in a sack for proper identification and plastic classification. A visual identification of the type of plastic was done in accordance with the study of Barboza *et al.* (2019). The clean coast index (CCI) was then calculated to qualitatively describe the quality or the cleanliness of each beach area (Sajorne *et al.*, 2021) using the formula;

$$\text{CCI} = \frac{\text{Total items in quadrat}}{\text{Total area of quadrat}} \times 20$$

The qualitative description of the CCI value as stated in Table 2 was adapted from Vlachogianni *et al.* (2018).

Table 2. The CCI value and its qualitative description

CCI value	Qualitative description
0-2	Very clean
2-5	Clean
5-10	Moderately clean
10-20	Dirty
>20	Extremely dirty

Results and discussion

Plastic litters at the selected beaches

Among the four (4) sampling stations, Mabua Beach in Surigao City found to have the most number of plastics present in the area with 136 counts, while Duyos Beach has the least number of plastic litters with 56 counts (Table 3).

Table 3. Plastic litters in the sampling locations

Sampling Location	Total plastic litter collected	Mean density, m²	Standard deviation
Star beach	127	0.88	0.32
Mabua beach	136	0.94	0.34
Duyos beach	56	0.39	0.15
Santa Cruz beach	80	0.56	0.21

Considering that Mabua Pebble Beach is a public beach area in Surigao City no entrance fee is imposed. The sampling was conducted during weekdays, thus it is expected that more plastic litter can be collected during weekends and holidays. Start Beach is a rising beach area located in Malimono, Surigao Del Norte which is recently the most visited during holidays because of its natural coarse sandy beach with tranquillity that is perfect for relaxing. The sampling was conducted during holidays in which a greater number of visitors were the area, plus there were also those who spent overnight along the beach using tents. Thus, it was expected that more tourists visited that area during the time of the sampling. Duyos Beach has the lowest count of plastic litter and the lowest in terms of waste density due to its location. Though there are also visitors who are fond of doing overnight stays in the area it is least visited. This result implies that the contributors to plastic litter in beach areas are the visitors or humans.

The same findings were revealed in the study of Sajorne *et al.* (2021) on the beach of Puerto Princesa, Palawan wherein it was emphasized that the visitors are the biggest contributors to the plastic litter along the sandy beaches. The majority of the wastes that can be found on beaches are plastics which are referred to as marine litter that comes from diverse sources but is contributed mostly by human activities (Lohr *et al.*, 2017).

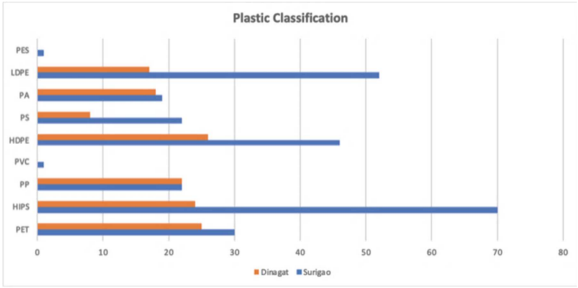

Fig. 2. Plastic occurrence in the study areas according to its classification

Types of plastics presents in the area

As gleaned in Fig. 2, the High Impact Polystyrene (n=70) which is composed mostly of food packing (Table 4) has the highest number of counts on the beaches of Surigao Del Norte. This is followed by LDPE (n=52) and HDPE (n=46). While, PVC (n=1) and PES (n-1) have the least number of counts which

area composed of fiber and textiles, and, plumbing pipes, and cosmetics containers, respectively. However, in the case of Dinagat Islands, HDPE (26) has the highest plastic count which has a close count with PET (26) and HIPS (24). While, PES and PVC in Dinagat Islands, both got zero count.

The plastic litter collected on the beaches of Surigao was predominantly food packaging, pieces from appliances, and electronics, followed by garbage bags, detergent bottles, shampoo containers, juice bottles, etc. This is probably due to the inhabitants present in the sampled beaches, more so that the area is considered urbanized. More beach litter will be collected in an area where there are nearby residents and built environments such such seaports (Esquinas *et al.*, 2020). Both beach in Surigao a docking area for fishermen where a several middle businessmen go to the area to buy their catch. The result of this study is further substantiated by the result of Navarro *et al.* (2022) along Butuan Bay where the marine plastic debris found in the area where mostly contributed by the community and from fishing activities that have accumulated. The same study was conducted by Requiron and Bacosa (2022) in the Pulauan River in Dapitan where it was likewise found that human activities are the major contributor to the presence of plastic litter in the area.

Table 4. Types of plastic commonly found in the natural environment: Specific gravity (g cm^{-3}) and common uses (Barboza *et al.*, 2019

Type of plastic	Acronym	Specific gravity (g cm^{-3})	Common uses
Polypropylene	PP	0.83–0.85	Dip bottles and ice cream tubs, potato chip bags, microwave dishes, kettles, garden furniture, lunch boxes, blue packing tape
Polyethylene	PE	0.91–0.96	Wide range of inexpensive uses including supermarket bags, plastic bottles
Low-density polyethylene	LDPE	0.91–0.93	Glad wrap, garbage bags, squeeze bottles, clack irrigation tube, black mulch film, garbage bins
High-density polyethylene	HDPE	0.94–0.96	Freezer bags, milk bottles, juice bottles, shampoo, chemical and detergent bottles, rigid agriculture pipe
Polyethylene terephthalate	PET	1.37	Soft drink and water bottles, salad domes, biscuit trays, salad dressing, and peanut butter containers
Polystyrene	PS	1.04	CD cases, plastic cutlery, imitation cristal glassware, low cost brittle toys, video cases
High impact polystyrene	HIPS	1.04–1.07	Refrigerator liners, food packaging, vending cups, electronics
Polyamides	PA	1.13–1.35	Fibers, toothbrush bristles, fishing line, under-the-hood car engine moldings, making films for food packaging
Polyester	PES	1.38–1.40	Fibers and textiles
Polyvinyl chloride	PVC	1.37–1.39	Plumbing pipes and fittings, cosmetic containers, electrical conduit, wall cladding, roof sheeting, garden hose, blood bags, and tubing
Polycarbonate	PC	1.20–1.22	Compact discs, eyeglasses, riot shields, security windows, traffic lights, lenses, construction materials

When it comes to cleanliness, the clean coast index was calculated and as a result, only Duyos Beach (CCI=7.78) was classified as moderately clean, while the three other areas Star Beach (CCI=17.64), Mabua Pebble Beach (CCI=18.89), and Santa Cruz beach (CCI=11.67) were all “dirty” as per its qualitative description (Table 5).

Both Star beach and Mabua Pebble beach are considered more urbanized than Santa Cruz and Duyos, thus it is expected to have a higher amount of litter collected. Moreover, it was a holiday during the sampling at Star beach, which means more visitors were in the area. Although Mabua was sampled during weekdays the area is highly residential and more built environments are present in the area, such as schools, fishing ports, restaurants, and business establishments. The study of Acot *et al.* (2022) in Sarangani Bay showed that the plastic litter in the urban areas is two times higher than that of the rural areas. While, a study in Surigao Del Sur was conducted during the Pandemic comparing the

microplastic litter between island and mainland beach areas and it was found that more plastics were found on island beaches (Inocente and Bacosa, 2022).

Table 5. The cleanliness of the selected beaches

Area	CCI	Description
Star beach resort	17.64	Dirty
Mabua Pebble beach	18.89	Dirty
Duyos beach	7.78	Moderately clean
Santa Cruz beach	11.67	Dirty

Conclusion

Humans are the major contributors to the plastics litter found on the beaches of Surigao and Dinagat. The Mabua Pebble beach which is one of the prides of Surigao is slowly deteriorating, thus intervention program for the sustainability of the area is a must. Duyos Beach which is still qualitatively described as "moderately clean" according to its CCI also needs to be taken care of for its preservation. This issue of macroplastic litter on the beaches of Surigao and Dinagat islands poses important environmental and socio-economic challenges. The presence of plastic debris negatively impacts the coastal ecosystem, marine life, and the overall beauty of the beaches, which are key attractions for tourists. To mitigate the microplastic pollution on the beaches of Surigao and Dinagat requires a comprehensive and collaborative approach that involves raising awareness, improving waste management systems, implementing policies, and fostering community participation. With these, it is possible to preserve the natural beauty of the beaches, protect marine life, and sustain the economic activities dependent on a clean and thriving coastal environment.

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