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Abundance and distribution of anthropogenic marine litter in Hatiya and Nijhum Dwip Island, Bangladesh

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Abstract

Marine litter is commonly found throughout the oceans, and creates a significant threat to the marine ecosystem. The purpose of the study was to investigate the abundance and distribution of marine litter in Hatiya and Nijhum Dwip Islands, Bangladesh during the post-monsoon and to determine beach cleanliness using the clean-coast index (CCI). A 100-meter line transect was established at each beach, divided into five sections of 20 meters each and positioned perpendicular to the shoreline at the water's edge. A total of 11 types of marine litter were observed. Namar Bazar, Nijhum Dwip Sea beach showed a higher density of litter (0.30 items/m^2) compared to Kamalar Dighi, Hatiya (0.13 items/m^2). Over 70% of marine litter originated from land-based sources. Plastics were abundant litter at the Kamalar Dighi (46.66%) and Namar Bazar (61.29%). Different size ranges of marine litter were exhibited at the Kamalar Dighi (1.27-25.4 cm) and Namar Bazar (2-74 cm). Based on the mean CCI value, Hatiya and Nijhum Dwip beaches were classified as clean (2.4) and moderate (4.96), respectively. This study, therefore, suggested the conceptual policy framework including short-term (i.e., cleanness of beaches, create awareness, establishment of storages, etc.) and long-term management approaches that would be implemented for sustainable management of marine litter to ensure the conservation of marine biodiversity in the Hatiya and Nijhum Dwip Island.

Keywords: Marine litter, plastics, clean-coast index, beach, Bay of Bengal

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Introduction

Marine litter is defined as "any materials (e.g. plastic, metal, paper, glass) which is persistent, processed or manufactured and abandoned in the coastal and marine environment" (UNEP, 2005). Litter settles down in marine environment from land and sea-based sources like rivers, illegal dumping, beach abandonment by visitors, disposal from ships, offshore installations, drainage systems, flooding, and wind action, all contributing to the transportation of marine litter (UNEP, 2012; Anfuso et al., 2015; Prevenios et al., 2018). The number of reports of marine litter contamination is rising these days all around the world (Schneider et al., 2018). For nations with low, middle, and high incomes, the buildup of marine litter along marine and coastal habitats has become a significant issue (UNEP, 2014; Jang et al., 2018). It is considered a major threat to biodiversity and one of the most serious problems affecting the coastal and marine ecology. Anthropogenic marine litter left in the ocean has been known to endanger human health, impede safe navigation, and harm marine life (Cheshire et al., 2009). Marine litter has been identified as a global concern, alongside other significant environmental issues such as ocean acidification, climate change, and biodiversity loss (Sutherland et al., 2011).

More than 80% of marine pollution originates from land-based activities (UNEP, 2009). Marine litter generally consists of slowly degradable waste materials from constructed plastic, polystyrene, various metals, and glass. Marine litter can thus persist and move in marine and coastal environments for long period of time, floating on the water surface, drifting through the water column, sink to the sea bed, or become caught along shallow coastline. Consequently, litter deposition along the marine water body and later the sea beach has become a significant problem for both developed and developing countries (UNEP, 2014; Jang et al., 2018), causing harm to marine ecosystems (Votier et al., 2011) and human health (Campbell et al., 2019; Anfuso et al., 2015, 2017). Marine creatures can easily ingest marine litter, which elevates them in the food chain. Marine litter poses a serious risk to both humans and wildlife as it moves up the food chain (Nadal et al., 2016; Van Emmerik & Schwarz, 2020). Furthermore, ingestion of plastics could impair the breathing of marine life, such as seabirds, dolphins, and turtles, and finally lead to their death (Senko et al., 2020). Kühn & van Franeker (2020) reported that entanglement and/or ingestion of marine litter has impacted 914 species. Moreover, over 15% of marine species are listed as endangered, mostly as a result of plastic consumption and entanglement (Jambeck et al., 2015; Kumar et al., 2021).

The abundance and distribution of marine litter have been reported (Hidalgo-Ruz et al., 2018; Zhao et al., 2020; Riberio et al., 2021), to explore numerous factors that affect marine litter deposition (Browne et al., 2010). There has been limited research done in Bangladesh to look into the presence and distribution of marine litter pollution along the coast of Cox's Bazar. (Islam et al., 2022; Rakib et al., 2022; Howlader et al., 2023) and Saint Martin Island (Al Nahian et al., 2022; Howlader et al., 2024). Hatiya and Nijhum Dwip are important islands situated at the mouth of the Meghna River estuary, which is adversely affected by different types of freshwater discharge and tidal flushing (Kabir et al., 2020; Islam, 2021). Hatiya and Nijhum Dwip have enormous ecological importance, serving as a critical spawning ground for hilsa fish (*Tenualosa ilisha*) and habitat for several endangered species (Haldar et al., 1992; Arefin et al., 2024). As a result of tourism, fishing, and coastal development, these islands have become more vulnerable to plastic pollution, while the growing threat of marine litter pollution poses a significant risk to the surrounding marine ecosystem (Hossain et al., 2021; Islam et al., 2021). Arefin et al. (2024) conducted a study on microplastics at Nijhum Dwip Island, revealing a mean concentration of 138.39 ± 34.15 pieces/kg in sediment and 72.83 ± 30.76 pieces/m^3 in water. It is also noted that wastewater effluents and atmospheric deposition are major contributors to the distribution of microplastics in both water and sediment. To our best knowledge, this is the first study on marine litter pollution at Hatiya and Nijhum Dwip. The purpose of the study was to investigate the distribution and abundance of marine litter at the Hatiya and Nijhum Dwip, and to determine the beach cleanliness using Clean-Coast Index (CCI). The research proposed the conceptual concept on management of marine litter in those areas. This study is important to conserved marine biodiversity and ecosystem.

Methods

Description of study area

The Hatiya and Nijhum Dwip Islands are situated at Hatiya Upazila of Noakhali District, in the northern part of the Bay of Bengal, close to the Meghna River Estuary (Figure 1). It is located in the middle of Bangladesh's coastal zone, which is very dynamic compared to other zones (Kabir et al., 2020). It is known for its dynamic geography and socio-economic activities. The total area of Hatiya Island is about 371 km^2 (Kabir et al., 2020). The population of Hatiya is diverse, with a mix of ethnic groups and a high density of inhabitants who primarily rely on natural resources for their livelihoods. Now-a-days, Nijhum Dwip is one of the attractive places for tourist. Several hotels and motels are established to accommodate travelers in the Nijhum Dwip.

Collection of marine litter

The collection of marine litter was carried out according to the standardized protocols of OSPAR (OSPAR, 2010). The marine litter was collected from two sites Namar Bazar (Nijhum Dwip) and Kamalar Dighi (Hatiya) Sea beach at low tide during post-monsoon (December) 2023. This season is famous for tourist activities. Different type of litter was determined and categorized according to the OSPAR photo guide.

A 100-meter line transect was established at each beach, divided into five sections of 20 meters each, positioned perpendicular to the shoreline at the water's edge. Due to the long coastlines of each beach, a 100 meter line was used for comparison, ensuring that the sampled areas were near human or tourist activities. Every section was a 5×5 m^2 quadrat transect located randomly toward the shoreland. Within the 5×5 m^2 area, the upper surface was scanned carefully, and visible size litter was collected carefully. Each transects contents were kept in distinct bin bags once the litter was categorized. After that, the litter was brought back to the lab and cleaned with pipe water to get rid of any sand or dirt that could have thrown off the weight reading. Before being weighed, each piece of debris was individually identified in the lab and allowed to air dry.

Identification of sources of marine litter

The marine litter is classified as land-based sources, water-based Sources, and unknown sources. Land-based sources

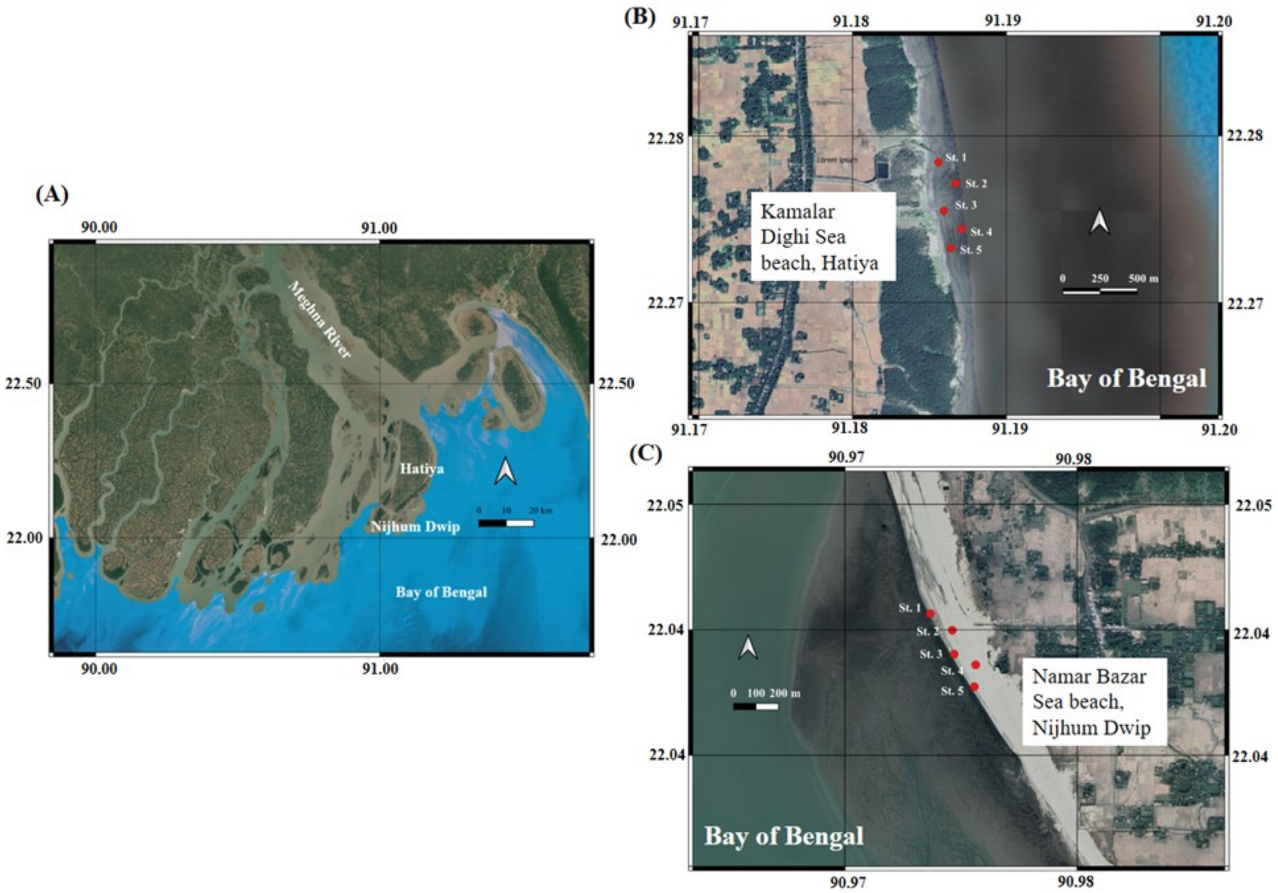

Figure 1. Maps showing (A) two study areas including Haitya and Nijhum Dwip Island, Bangladesh, (B) five different stations at the Kamalar Dighi Sea beach, Hatiya, and (C) five different stations at the Namar Bazar Sea beach, Nijhum Dwip, Bangladesh.

include marine litter that originated from land-related activity such as shore recreational use. It also includes some other land-based activities such as public littering, activity related to agriculture, and sewage-related litter (Derraik, 2002). Water-based marine litter may come through different media such as a river, fishing and boating activity, and also industrial discharge. The source of water-based marine litter derived from commercial shipping, fishing, and boating operations (such as buoys, fishing nets, and traps) (Derraik, 2002). Without markings identifying their origin, unknown sources can be found both on land and at sea (Gago et al., 2016).

Determination of concentration of marine litter

The concentration of marine litter (item/m^2) per transect was determined (Lippiatt et al., 2013) using $C_i = n_i / (a_i \times b_i)$, where the concentration (C_i) of marine litter items is calculated as the number of items/m^2, n_i is total number of marine litter present per transect, and a_i is length (100m) and b_i is width (5m) of the transect, and i for the beach on which transects surveys took place.

Determination of clean-coast index (CCI)

Clean-coast index (CCI) is used to measure the cleanliness of a coast (Alkalay et al., 2007). The CCI was determined using the formula $CCI_i = C_i \times K$, where K is a constant (20 involved in the equation), to make the numerical value of the CCI comprehensible and K is a meaningless constant. According to the scale provided for the number of plastic particles on the coast, the beaches were classified as 'clean' to 'extremely dirty'.

The CCI value ranges from 0 to over 20, with 0–2 indicating a very clean beach with no visible debris, 2–5 showing scattered debris across a large area, 5–10 representing moderate cleanliness with a few pieces of debris, 10–20 indicating a dirty beach with considerable debris, and above 20 signifying an extremely dirty beach heavily covered with waste and plastic debris (Cole et al., 2011).

Data analysis

The analysis of the data-set was done using Microsoft Excel and IBM SPSS statistics 21. Difference in abundances of marine litter between Hatiya and Nijhum Dwip were tested using t-test ($p < 0.05$). A difference between $p < 0.05$ was considered statistically significant.

Results

A total of 11 types of marine litter (such as plastic packets, cigarette buds, cigarette packets, styrofoam, foam sponge, glass bottles, plastic net rope, rubber, food containers, plastic bottles, and plastic cups) were observed during the study period (Figure 2). The average litter density in terms of number and weight was 0.225 ± 0.115 items/m^2 and 4.02 ± 3.43 g/m^2, respectively (Table 1). The litter density varied between 0.15-0.30 items/m^2 and 2.22-5.52 g/m^2, with considerable variation between the two beaches. Higher density (0.30 items/m^2) of marine litter were observed at Namar Bazar compared to Kamalar Dighi (0.13 items/m^2) Sea beach (Table 1). The plastics were the most abundant litter at the Kamalar Dighi accounted for 0.05 items/m^2, and Namar Bazar comprised 0.08 items/m^2 of total marine litter (Table 1).

Land-based, water-based, and unknown sources were the primary sources marine litter found in along the Kamalar Dighi and Namar Bazar Sea beaches. Among these the land-based

Figure 2. Different types of marine litter found at the Kamalar Dighi, Hatiya and Namar Bazar Sea beach, Nijhum Dwip, Bangladesh. A) plastic packets, B) cigarette buds, C) cigarette packets, D) styrofoam, E) foam sponge, F) glass bottles, G) plastic net rope, H) plastic bottles, I) plastics cups, J) rubber, and K) food container.

Table 1. Total densities of marine litter at Kamalar Dighi, Hatiya and Namar Bazar Sea beach, Nijhum Dwip (items/m² and g/m²). L= land-based, W= water-based.

Materials	Sources	Kamalar Dighi		Namar Bazar		Mean (± SD)	
		items/m²	g/m²	items/m²	g/m²	items/m²	g/m²
Plastic packets	L	0.05	0.372	0.04	0.077	0.045 (0.005)	0.224 (0.147)
Cigarette buds	L	0.02	0.0028	0.02	0.077	0.020 (0.00)	0.039 (0.037)
Cigarette packets	L	0.03	0.0852	0.02	0.22	0.025 (0.005)	0.305 (0.067)
Styrofoam	W	0.01	1.42	0.03	0.25	0.020 (0.01)	0.835 (0.585)
Foam sponge	W	0.01	0.0022	0	0	0.005 (0.005)	0.001 (0.001)
Glass bottles	L	0.01	3.62	0	0	0.005 (0.005)	1.81 (1.81)
Plastic net rope	W	0	0	0.08	0.813	0.040 (0.04)	0.406 (0.406)
Rubber	L	0	0	0.04	0.114	0.020 (0.02)	0.057 (0.057)
Food container	L	0	0	0.01	0.006	0.005 (0.005)	0.003 (0.003)
Plastic bottles	L	0	0	0.03	0.478	0.015 (0.015)	0.239 (0.239)
Plastic cups	L	0	0	0.03	0.192	0.015 (0.015)	0.096 (0.096)
Total		0.13	5.5	0.3	2.22	0.215 (0.125)	4.01 (3.44)
t-value						-1.8612, *p = 0.077* (0.862, *p = 0.399*)	

sources made up the highest proportion of marine litter. At the Kamalar Dighi, land-based sources comprised of 100%, 50%, 80% and 100% at station 1,2,3 and 4, respectively, while water -based made up 50% and 20% at station 2 and 3, respectively (Figure 3). At the Namar Bazar, land-based sources contributed the most (100%) at station 5 and made up the least (33.33%) at station 1, whereas water-based sources constituted of 66.67% at station 1, followed by 44.4%, 14.29% and 20% at station 2, 3 and 4, respectively. The unidentified sources covered only 11.11% at station 2 (Figure 3).

Plastic packets, cigarette buds, cigarette packets, styrofoam were commonly found at the Hatiya and Nijhum Dwip (Figure 4). The highest proportion of plastic packets (20% at station 1 and 3), cigarette buds (13.33% at station 1), cigarette packets (13.33% at station 1) were observed at the Kamalar Dighi, Hatiya (Figure 5). Plastic cups, plastic net rope, rubber, food container and plastic bottles were observed at different stations of the Namar Bazar, Nijhum Dwip (Figure 5).

According to the size distribution, the percentage of marine litter varied between the two beaches (Figure 6 A, B). At the Kamalar Dighi, smaller size of marine litter (size range 0-15 cm) was recorded at stations 1, 3, and 4, while the largest size, measuring 25.4 cm, was found at station 2. At the Namar Bazar, smaller size (0-30 cm) of marine litter was observed across all stations, and stations 3, 4 and 5 comprised larger size of marine litter.

Kamalar Dighi Sea beach displayed litter distribution per station ranging from 0 to 7 items, with an average of 3 items, a concentration of 0 to 0.28 items/m^2, and CCI value ranging from 0 to 5.6 (average of 2.4), indicated this beach was clean (Table 2). At the Namar Bazar Sea beach, the concentration of litter varied from 0.12 to 0.36 items/m^2, and the CCI values ranged from 2.4 to 7.2 (average of 4.96), which indicated that the beach was clean to moderate (Table 3).

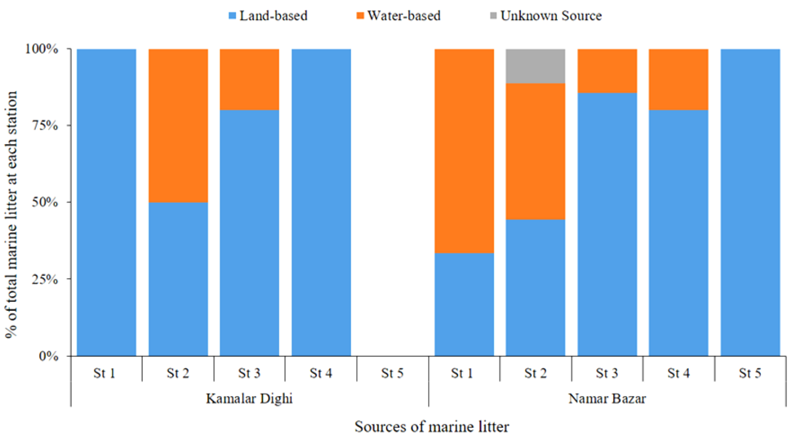

Figure 3. Relative proportion of potential sources of marine litter at the Kamalar Dighi, Hatiya and Namar Bazar Sea beach, Nijhum Dwip, Bangladesh.

Discussion

The present study revealed that plastic was dominate and frequent marine litter material at the Kamalar Dighi, Hatiya and Namar Bazar, Nijhum Dwip beaches. Globally, excessive use of plastic products creates environmental hazardous issues. In this study, over 70% of marine litters originated from land-based sources. The majority of the litter items were derived from domestic and recreational

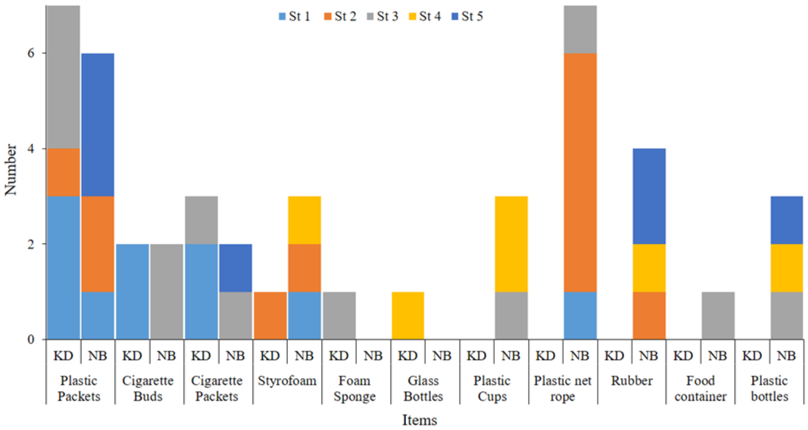

Figure 4. Abundances of marine litter at different stations of the Kamalar Dighi (KD), Hatiya and Namar Bazar (NB) Sea beach, Nijhum Dwip, Bangladesh.

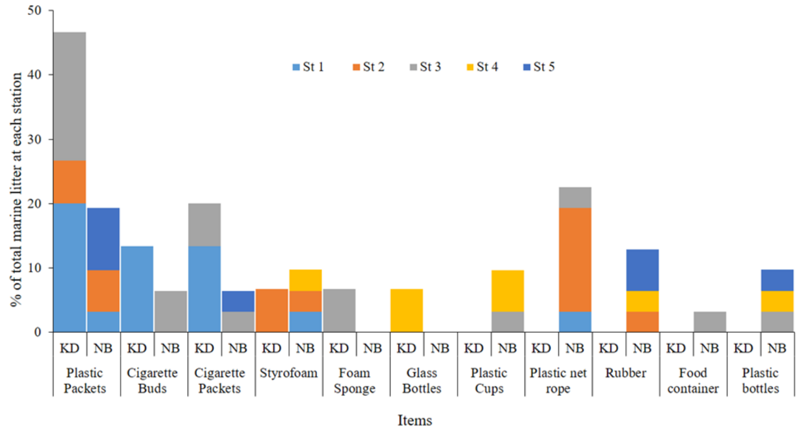

Figure 5. Relative proportion of marine litter at different stations of the Kamalar Dighi (KD), Hatiya and Namar Bazar (NB) Sea beach, Nijhum Dwip, Bangladesh.

activities suggesting a large degree of anthropogenic pressure on beaches. The average density of marine litter at the Kamalar dighi and Namar Bazar was 0.13 and 0.30 item/m^2, respectively. This are consistent with previous studies on the Bay of Bengal coast including Saint Martin Island (0.02-0.51 items/m^2; Al Nahian et al., 2022), Cox's Bazar coast (0.14-0.58 items/m^2; Islam et al., 2022) and Sonadia Island (0.71 items/m^2; Howlader et al., 2024), Cilician Basin, Turkey (0.92 items/m^2; Aydin et al., 2016) and Japan Sea (0.2 items/m^2; Kusui and Noda, 2003). Those variability in litter densities (items/m^2) may be attributed to variations in coastal land use, which can impact both the density and types of litter (Jafari et al., 2021). The relatively higher marine litter density at the Nijhum Dwip beaches was likely due to a large number of tourist activities. Moreover, another reasons for density of marine litter in coastal areas that are impacted by port operations, industry, and population (Binetti et al., 2020; Anastácio et al., 2023).

Larger items like plastic wrappers, styrofoam, and paper from food packaging are types of litter that rapidly break down into small fragments, often becoming too small to be effectively collected during beach clean-ups (Lee et al., 2015). The small sizes of the litter collected primarily result from the breakdown of larger items. The amount of time the trash has been in the ocean, the materials it is made of, the strength of the UV light, and the physical features of the shoreline are some of the external elements that affect this fragmentation (Smith & Turrell, 2021). The physical oceanographic parameters could also have possible influence for the number of small pieces of marine litter.

According to CCI values, Kamalar Dighi and Namar Bazar beaches were considered as clean to moderate, with the highest value of 7.2. This value is comparatively lower than Saint Martin's Island, Bay of Bengal (Nahian et al., 2022), Cox's Bazar coast of Bangladesh (Islam et al., 2022), and the beach of Southwestern Luzon, Philippines (Paler et al., 2019). These beaches are still considered clean due to the low number of tourists and their remote location away from populated areas. Remote beaches contained less litter and were considered cleaner based on the CCI value than touristic beaches (Salazar et al., 2022). Conversely, beaches connected to nearby villages were categorized as extremely dirty. Similarly, the more remote Kamalar Dighi Sea beach was less polluted, while the Namar Bazar Sea beach, which is closer to populated areas and visited more frequently, was comparatively dirtier.

Although there was no beach management approaches available at present, this study attempts to propose a conceptual policy framework for sustainable management of marine litter of the Hatiya and Nijhum Dwip Island (Figure 7). Existing studies on waste management should be aligned with short-term and long-term management approach to resolve ongoing uncertainties in the assessment and characterization of marine litter. For short-term approaches, different activities such as regular cleanness of beaches, create awareness among local inhabitants and tourist, establishment of litter storages (i.e. dustbin) could be suggested. For the best possible management of marine debris throughout Bangladesh's coast, fishermen must be trained about the issues surrounding marine litter and how to handle it responsibly (Islam et al., 2022). Effective long-term strategies should be adopted by local governments to increase action and interaction between all stakeholders. Furthermore, eco-friendly

Table 2. Area (m^2), total number and concentration of marine litter (items/m^2), clean-coast index (CCI), and grade at the Kamalar Dighi Sea beach, Hatiya, Bangladesh.

Station	Area (m^2)	Items of marine litter	Concentration (item/m^2)	CCI	Grade
1	25	07	0.28	5.6	Moderate
2	25	02	0.08	1.6	Very clean
3	25	05	0.20	4.0	Clean
4	25	01	0.04	0.8	Very clean
5	25	00	00	00	Very clean

Table 3. Area (m^2), total number and concentration of marine litter (items/m^2), clean-coast index (CCI), and grade at Namar Bazar Sea beach, Nijhum Dwip, Bangladesh.

Station	Area (m^2)	Items of marine litter	Concentration (item/m^2)	CCI	Grade
1	25	03	0.12	2.4	Clean
2	25	09	0.36	7.2	Moderate
3	25	07	0.28	5.6	Moderate
4	25	05	0.20	4.0	Clean
5	25	07	0.28	5.6	Moderate

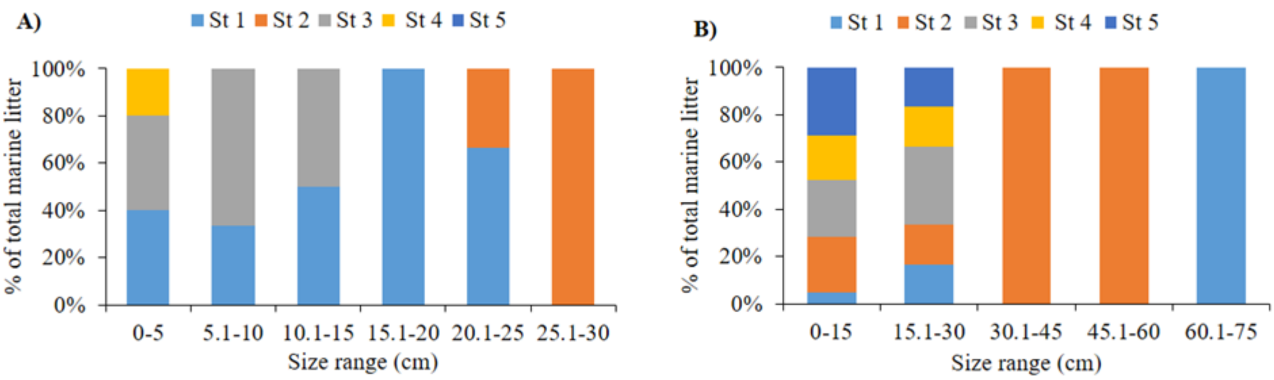

Figure 6. Size distribution of marine litter at the Kamalar Dighi, Hatiya (A) and Namar Bazar Sea beach, Nijhum Dwip (B), Bangladesh.

and sustainable management technologies should be integrated with an advanced global framework to reduce marine litter on natural sea beaches. Existing research gaps on marine litter pollution and global litter management policies should be addressed and implemented by both government bodies and non-government stakeholders to ensure the conservation of marine biodiversity.

Conclusions

This study shown that the Hatiya and Nijhum Dwip Islands exposed to marine litter pollution mainly originated from land-based sources. The results of the clean-coast index (CCI) highlight the disparities in pollution levels between the two locations, with Namar Bazar, Nijhum Dwip showing a moderate degree of contamination. Most of the litter was made up of plastics. The amount of plastic waste that ends up in the marine environment is increasing due to the increased use of plastics. This research also proposed on conceptual framework to manage marine litter pollution in the region. Applying preventive measures along with raising awareness and funding community-level plastic recycling would help to maintain the current state of beach cleanliness and promote tourism. This study restricted limited space and particular seasons. Further research is, therefore, recommended to address this issue.

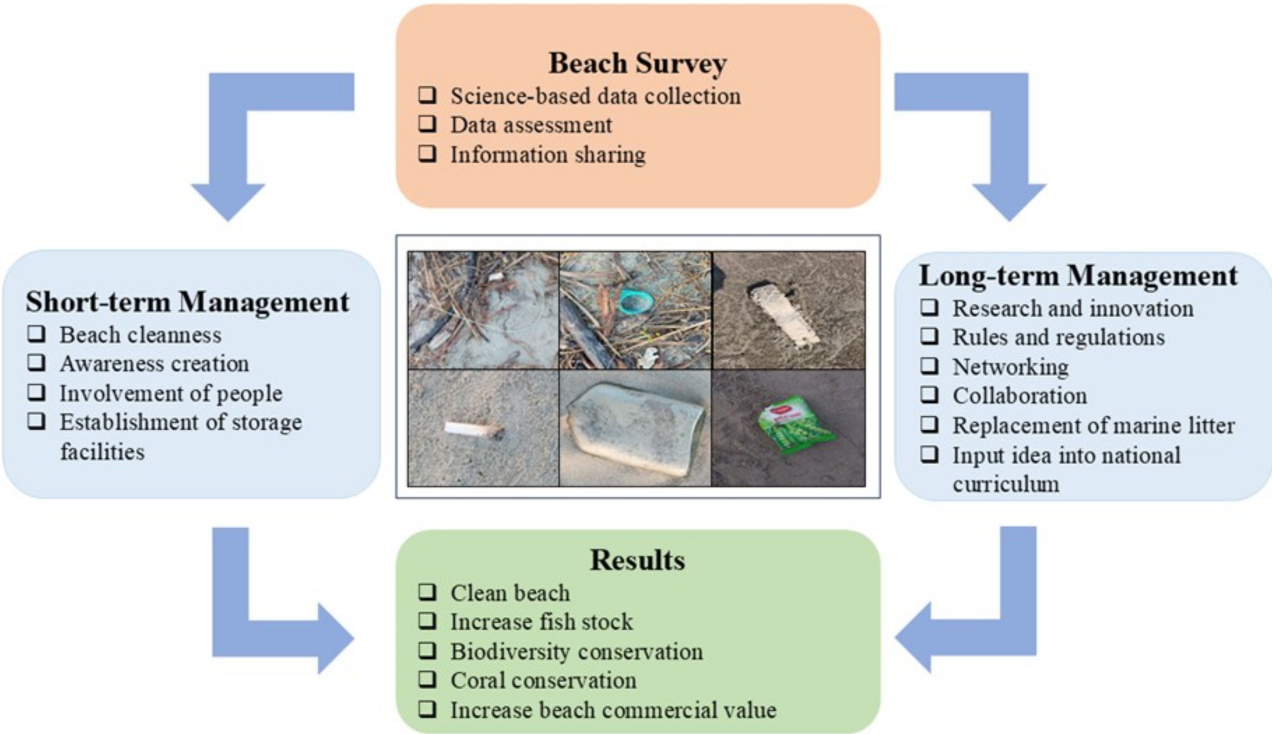

Figure 7. Conceptual policy framework for sustainable management of marine litters at the Kamalar Dighi, Hatiya and Namar Bazar Sea beach, Nijhum Dwip, Bangladesh.

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Authorship contribution

Md. Nasim Mahmud: Data curation (equal); methodology (equal); writing – original draft (equal); writing – review and editing (equal). **Md. Obaidur Rahman**: Data curation (equal); methodology (equal); writing – original draft (equal); writing – review and editing (equal). **Roksana Jahan:** Conceptualization (lead); data curation (lead); investigation (lead); methodology (lead); supervision (lead); writing – original draft (lead); writing – review and editing (lead). Authors gave final approval for publication and agreed to be held accountable for the work performed therein.

Data availability

Datasets generated during and/or analysed throughout the present study are available from the corresponding author upon reasonable request.

Conflict of interest

The authors declare no conflict of interest.

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References

Al Nahian, S., Rakib, M. R. J., Haider, S. M. B., Kumar, R., Walker, T. R., Khandaker, M. U., & Idris, A. M. (2022). Baseline marine litter abundance and distribution on Saint Martin Island, Bay of Bengal, Bangladesh. *Marine Pollution Bulletin, 183*, 114091. https://doi.org/10.1016/j.marpolbul.2022.114091.

Alkalay, R., Pasternak, G., & Zask, A. (2007). Clean-coast index -a new approach for beach cleanliness assessment. *Ocean and Coastal Management, 50*(5-6), 352-362. https://doi.org/10.1016/j.ocecoaman.2006.10.002.

Anastácio, J., Candeias, J. M., Cabral, H., & Domingos, I. (2023). Relationships between marine litter and type of coastal area, in Northeast Atlantic sandy beaches. *Marine Environmental Research. 183*, 105827. https://doi.org/10.1016/j.marenvres.2022.105827.

Anfuso, G., Lynch, K., Williams, A. T., Perales, J. A., Pereira da Silva, J. A., Nogueira Mendes, R., & Veiga, J. (2015). Comments on marine litter in oceans, seas and beaches: characteristics and impacts. *Annals of Marine Biology Research, 2*, 1008-1012.

Anfuso, G., Williams, A. T., Martínez, G. C., Botero, C. M., Hernández, J. C., & Pranzini, E. (2017). Evaluation of the scenic value of 100 beaches in Cuba: Implications for coastal tourism management. *Ocean and Coastal Management, 142*, 173-185. https://doi.org/10.1016/j.ocecoaman.2017.03.029.

Arefin, S., Islam, A. R. M. T., Hasan, M., Mubin, A. N., Rahman, M. A., Ali, M. M., & Senapathi, V. (2024). Microplastics contamination through a mighty estuarine island: Distribution, influencing factors, and risk assessment. *Regional Studies in Marine Science*, 79, 103841. https://doi.org/10.1016/j.rsma.2024.103841.

Aydin, C., Guven, O., Salihoglu, B., & Kideys, A. (2016). The influence of land use on coastal litter: an approach to identify abundance and sources in the coastal area of Cilician Basin, Turkey. *Turkish Journal of Fisheries and Aquatic Sciences, 16*(1), 29-39. https://doi.org/10.4194/1303-2712-v16_1_04.

Binetti, U., Silburn, B., Russell, J., Van Hoytema, N., Meakins, B., Kohler, P., & Maes, T. (2020). First marine litter survey on beaches in Solomon Islands and Vanuatu, South Pacific: Using OSPAR protocol to inform the development of national action plans to tackle land-based solid waste pollution. *Marine Pollution Bulletin, 161*, 111827. https://doi.org/10.1016/j.marpolbul.2020.111827.

Browne, M. A., Galloway, T. S., & Thompson, R. C. (2010). Spatial patterns of plastic debris along estuarine shorelines. *Environmental Science and Technology, 44 (9),* 3404-3409. https://doi.org/10.1021/es903784e.

Campbell, M. L., Peters, L., McMains, C., de Campos, M. C. R., Sargisson, R. J., Blackwell, B., & Hewitt, C. L. (2019). Are our beaches safe? Quantifying the human health impact of anthropogenic beach litter on people in New Zealand. *Science of the Total Environment, 651*(2), 2400-2409. https://doi.org/10.1016/j.scitotenv.2018.10.137.

Cheshire, A., & Adler, E. (2009). UNEP/IOC guidelines on survey and monitoring of marine litter. UNEP regional seas reports and studies, No. 186; IOC Technical Series No. 83: xii, 120 pp.

Cole, M., Lindeque, P., Halsband, C., & Galloway, T. S. (2011). Microplastics as contaminants in the marine environment: a review. *Marine Pollution Bulletin*, *62*(12), 2588-2597. https://doi.org/10.1016/j.marpolbul.2011.09.025.

Derraik, J. G. B. (2002). The pollution of the marine environment by plastic debris: a review. *Marine Pollution Bulletin. 44*(9), 842–852. https://doi.org/10.1016/s0025-326x(02)00220-5.

Gago, Jesús., Cronin, Richard., Sobral, Paula., Vlachogianni, Thomais., Nilsson, Per., Kinsey, Susan., Fleet, David., Mira Veiga, Joana., Dagevos, Jeroen., Thompson, R. C., Galgani, François., Werner, Stefanie., & European Commission. Joint Research Centre. (2016). Identifying Sources of Marine Litter, 41. https://doi.org/10.2788/956934.

Haldar, G. C., Rahman, M., & Haroon, A. K. Y. (1992). Hilsa, *Tenualosa ilisha* (Ham.) fishery of the Feni River with reference to the impacts of the flood control structure. *Journal of Zoology, 7*(5), 51-56.

Hidalgo-Ruz, V., Honorato-Zimmer, D., Gatta-Rosemary, M., Nuñez, P., Hinojosa, I. A., & Thiel, M. (2018). Spatio-temporal variation of anthropogenic marine debris on Chilean beaches. *Marine Pollution Bulletin. 126*, 516-524. https://doi.org/10.1016/j.marpolbul.2017.11.014.

Hossain, M. B., Banik, P., Nur, A. A. U., & Rahman, T. (2021). Abundance and characteristics of microplastics in sediments from the world's longest natural beach, Cox's Bazar, Bangladesh. *Marine Pollution Bulletin, 163*, 111956. https://doi.org/10.1016/j.marpolbul.2020.111956.

Howlader, M., Selim, A., Shohan, M. H., Shuvo, S. N. A., Al-Humaidi, J. Y., Islam, M. M., & Rahman, M. M. (2024). Exploring cigarette butts pollution in Saint Martin Island: A marine protected area. *Marine Pollution Bulletin, 203*, 116439. https://doi.org/10.1016/j.marpolbul.2024.116439.

Howlader, M., Selim, A., Shuvo, S. N. A., Islam, M. M., Sultana, T., Moniruzzaman, M., & Rahman, M. H. (2023). Evaluating cigarette butt pollution: Insights from Cox's Bazar Sea beach of Bangladesh. *Marine Pollution Bulletin, 197*, 115705. https://doi.org/10.1016/j.marpolbul.2023.115705.

Islam, M. R., Khan, M. N. I., Khan, M. Z., & Roy, B. (2021). A three-decade assessment of forest cover changes in Nijhum dwip national park using remote sensing and GIS. *Environmental Challenges*, *4*, 100162. https://doi.org/10.1016/j.envc.2021.100162.

Islam, M. S. (2021). Assessing the dynamics of land cover and shoreline changes of Nijhum Dwip (Island) of Bangladesh using remote sensing and GIS techniques. *Regional Studies in Marine Science*, *41*, 101578. https://doi.org/10.1016/j.rsma.2020.101578.

Islam, M. S., Phoungthong, K., Islam, A. R. M. T., Ali, M. M., Ismail, Z., Shahid, S., & Idris, A. M. (2022). Sources and management of marine litter pollution along the Bay of Bengal coast of Bangladesh. *Marine Pollution Bulletin, 185*, 114362. https://doi.org/10.1016/j.marpolbul.2022.114362.

Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., & Law, K. L. (2015). Plastic waste inputs from land into the ocean. *Science. 347*(6223), 768-771. https://doi.org/10.1126/science.1260352.

Jang, Y. C., Ranatunga, R. R. M. K. P., Mok, J. Y., Kim, K. S., Hong, S. Y., Choi, Y. R., & Gunasekara, A. J. M. (2018). Composition and abundance of marine debris stranded on the beaches of Sri Lanka: Results from the first island-wide survey. *Marine Pollution Bulletin, 128*, 126-131. https://doi.org/10.1016/j.marpolbul.2018.01.018.

Kabir, M. A., Salauddin, M., Hossain, K. T., Tanim, I. A., Saddam, M. M. H., & Ahmad, A. U. (2020). Assessing the shoreline dynamics of Hatiya Island of Meghna estuary in Bangladesh using multiband satellite imageries and hydro-meteorological data. *Regional Studies in Marine Science, 35*, 101167. https://doi.org/10.1016/j.rsma.2020.101167.

Kühn, S., & Van Franeker, J. A. (2020). Quantitative overview of marine debris ingested by marine megafauna. *Marine Pollution Bulletin, 151*, 110858. https://doi.org/10.1016/j.marpolbul.2019.110858.

Kumar, R., Verma, A., Shome, A., Sinha, R., Sinha, S., Jha, P. K., & Vara Prasad, P. V. (2021). Impacts of plastic pollution on ecosystem services, sustainable development goals, and need to focus on circular economy and policy interventions. *Sustainability, 13*(17), 9963. https://doi.org/10.3390/su13179963.

Kusui, T., & Noda, M. (2003). International survey on the distribution of stranded and buried litter on beaches along the Sea of Japan. *Marine Pollution Bulletin, 47*(1-6), 175-179. https://doi.org/10.1016/S0025-326X(02)00478-2.

Lee, J., Lee, J. S., Jang, Y. C., Hong, S. Y., Shim, W. J., Song, Y. K., & Hong, S. (2015). Distribution and size relationships of plastic marine debris on beaches in South Korea. *Archives of Environmental Contamination and Toxicology, 69*, 288-298. https://doi.org/10.1007/s00244-015-0208-x.

Lippiatt, S., Opfer, S., & Arthur, C. (2013). Marine debris monitoring and assessment: NOAA Technical Memorandum NOS-OR & R-46.

Nadal, M. A., Alomar, C., & Deudero, S. (2016). High levels of microplastic ingestion by the semipelagic fish bogue *Boops boops* (L.) around the Balearic Islands. *Environmental Pollution, 214,* 517-523. https://doi.org/10.1016/J.ENVPOL.2016.04.054.

OSPAR (2010). OSPAR Guideline for Monitoring Marine Litter on the Beach in the OSPAR Maritime Area, Agreement Number 2010-02. 84 pp.

Paler, M. K. O., Malenab, M. C. T., Maralit, J. R., & Nacorda, H. M. (2019). Plastic waste occurrence on a beach off southwestern Luzon, Philippines. *Marine Pollution Bulletin, 141*, 416-419. https://doi.org/10.1016/j.marpolbul.2019.02.006.

Prevenios, M., Zeri, C., Tsangaris, C., Liubartseva, S., Fakiris, E., & Papatheodorou, G. (2018). Beach litter dynamics on Mediterranean coasts: distinguishing sources and pathways. *Marine Pollution Bulletin*, 129(2), 448-457. https://doi.org/10.1016/j.marpolbul.2017.10.013.

Rakib, M. R. J., Ertaş, A., Walker, T. R., Rule, M. J., Khandaker, M. U., & Idris, A. M. (2022). Macro marine litter survey of sandy beaches along the Cox's Bazar Coast of Bay of Bengal, Bangladesh: land-based sources of solid litter pollution. *Marine Pollution Bulletin, 174*, 113246. https://doi.org/10.1016/j.marpolbul.2021.113246.

Ribeiro, V. V., Harayashiki, C. A. Y., Ertaş, A., & Castro, Í. B. (2021). Anthropogenic litter composition and distribution along a chemical contamination gradient at Santos Estuarine System—Brazil. *Regional Studies in Marine Science, 46*, 101902. https://doi.org/10.1016/j.rsma.2021.101902.

Salazar, J. A., González, R., Navarrete, A. L., Calle, P., Alava, J. J., & Domínguez, G. A. (2022). A temporal assessment of anthropogenic marine debris on sandy beaches from Ecuador's southern coast. *Frontiers in Marine Science, 9*, 977650. https://doi.org/10.3389/FMARS.2022.977650/BIBTEX.

Schneider, F., Parsons, S., Clift, S., Stolte, A., & McManus, M. C. (2018). Collected marine litter-a growing waste challenge. *Marine Pollution Bulletin, 128*, 162-174. https://doi.org/10.1016/j.marpolbul.2018.01.011.

Senko, J. F., Nelms, S. E., Reavis, J. L., Witherington, B., Godley, B. J., & Wallace, B. P. (2020). Understanding individual and population-level effects of plastic pollution on marine megafauna. Endanger. *Species Research, 43*, 234-252. https://doi.org/10.3354/esr01064.

Smith, L., & Turrell, W. R. (2021). Monitoring plastic beach litter by number or by weight: the implications of fragmentation. *Frontiers in Marine Science, 8*, 702570. https://doi.org/10.3389/fmars.2021.702570.

Sutherland, W. J., Bardsley, S., Bennun, L., Clout, M., Cote. I. M., Depledge, M. H., & Fleishman E. (2011). Horizon scan of global conservation issues for 2011. *Trends in Ecology and Evolution, 26*(1), 10-16. https://doi.org/10.1016/j.tree.2010.11.002.

UNEP (2005). Marine Litter, An Analytical Overview. United Nations Environment Programme, Nairobi, Kenya, 58.

UNEP (2009). Marine litter: A global challenge. United Nations Environment Programme, Nairobi, Kenya, 232.

UNEP (2014). Valuing Plastics: The Business Case for Measuring, Managing and Disclosing Plastic Use in the Consumer Goods Industry.

UNEP/MAP (2012). State of the Mediterranean Marine and Coastal Environment, UNEP/MAP – Barcelona Convention, Athens.

van Emmerik, T., & Schwarz, A. (2020). Plastic debris in rivers. *Wiley Interdisciplinary Reviews, Water, 7*(1), e1398. https://doi.org/10.1002/wat2.1398.

Votier, S. C., Archibald, K., Morgan, G., & Morgan, L. (2011). The use of plastic debris as nesting material by a colonial seabird and associated entanglement mortality. *Marine Pollution Bulletin, 62*(1), 168-172. https://doi.org/10.1016/j.marpolbul.2010.11.009.

Zhao, W., Huang, W., Yin, M., Huang, P., Ding, Y., Ni, X., & Cai, M. (2020). Tributary inflows enhance the microplastic load in the estuary: a case from the Qiantang River. *Marine Pollution Bulletin, 156*, 111152. https://doi.org/10.1016/j.marpolbul.2020.111152.