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Magnitudes and tourist perception of marine debris on small tourism island: Assessment of Tidung Island, Jakarta, Indonesia

Yusra Hayati[a,b,*], Luky Adrianto[c,f], Majariana Krisanti[c], Widodo S. Pranowo[d,e], Fery Kurniawan[c,f]

[a] Graduate School of Coastal and Marine Resources Management, Faculty of Fisheries and Marine Sciences, IPB University, Bogor, Indonesia
[b] Bureau of Public Relations and Foreign Cooperation, Ministry of Marine Affairs and Fisheries, Jakarta, Indonesia
[c] Department of Aquatic Resources Management, Faculty of Fisheries and Marine Sciences, IPB University, Bogor, Indonesia
[d] Marine and Coastal Data Laboratory, Ministry of Marine Affairs and Fisheries, Jakarta, Indonesia
[e] Department of Hydrography, Indonesia Naval Postgraduate School (STTAL), Jakarta, Indonesia
[f] Center for Coastal and Marine Resources Studies, IPB University (Bogor Agricultural University), Indonesia

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ABSTRACT

The sources of marine debris (MD) on a small island are largely dependent on the activities on and around the island, one of which is tourism. In this study, the magnitude and tourists' perceptions of MD on a small tourism island (Tidung Islands, Jakarta, Indonesia) were assessed. The results indicated that the tourism is one of the largest waste-generating sources. Plastic waste formed the major proportion of the solid waste, accounting for 83.86% of the total. The unmanaged tourism waste led to a clean-coastal index corresponding to the category "extremely dirty" and decreasing visitors' acceptance index. The resulting conditions will make the tourism unsustainable. In tourism, waste management should be focused on, including prevention and collaborative actions with residents and tourism actors. In addition, the tourist awareness campaigns must be conducted prior to tourist-visitation on the island.

1. Introduction

Tourism is an important and continuously growing economic sector in numerous coastal countries (Bergmann et al., 2017). However, the tourism causes various problems in the context of sustainable development, particularly regarding the balance between economic growth and socio-ecological conditions (Higgins-Desbiolles, 2018; Kurniawan et al., 2019). In recent years, the tourism industry has been rapidly increasing and continues to drive the local economy (UNWTO, 2014). However, it still impacts the environment (Lin et al., 2018; Kurniawan et al., 2016) through numerous factors, one of which is the solid waste (Chen, 2015; Diaz-Torres et al., 2017; Dileep, 2007; Gidarakos et al., 2006; Kuniyal et al., 2003; Nair and Jayakumar, 2008). The volume of waste generated by tourism activities can be twice that of the local waste production (Shamshiry et al., 2011; Manomaivibool, 2015). The beach users are a significant source of solid waste (de Araújo and Costa, 2006). Moreover, the tourism appears to be the largest single contributor to marine debris (MD) (Wilson and Verlis, 2017).

MD is a term used to describe "any persistent, manufactured or processed solid material, discarded, disposed, or abandoned in the marine and coastal environments" (UNEP - United Nations Environment Programme, 2003). The debris has become a serious problem, even in remote islands (Duhec et al., 2015; Krishnakumara et al., 2020). Globally, the tourism industry is responsible for 35 million tons of waste annually (UNEP, 2003). Hetherington et al. (2005) have reported that approximately 14 billion pounds or approximately 6 million tons of garbage thrown into the sea could affect the tourists.

The MD, both macro and micro, impacts not only the environment, ecosystem, marine life (Aguilera et al., 2018; Gall and Thompson, 2015; Lavers et al., 2020), food security, food safety, and human health (Barboza et al., 2018), but also the tourism industry. The MD can reduce the value of the benefits of ecosystem services and cause an economic loss. Beaumont et al. (2019) have reported that each ton of marine plastic can reduce the marine natural capital by approximately $ 3300 to $ 33,000 per year. In addition, Krelling et al. (2017) have reported that stranded litter at the beach may potentially reduce the local tourism income by 39.1% or lead to losses up to US$ 8.5 million per year in the municipality of Pontal do Paraná, Brazil. The low value of beach cleanliness significantly reduces the tourism revenue by 52% (Ballance et al., 2000). Similarly, the MD largely impacts the economy of the tourist island. In Geoje Island, South Korea, the tourism revenue loss is estimated to be US$ 29–37 million owing to the decreasing

* Corresponding author at: Ministry of Marine Affairs and Fisheries, Indonesia.
E-mail address: yusrahayati.yusri@gmail.com (Y. Hayati).

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number of visitors (Jang et al., 2014).

Discarded litter can reduce the natural aesthetics of tourist destinations (Williams et al., 2016). Rubbish on the beach can change the people's perception of the environment (Galgani et al., 2010), which is very closely related to the human behavior, both intentional and unintentional (Oigman-Pszczol and Creed, 2007; Slavin et al., 2012; UNEP - United Nations Environment Programme, 2003; Williams et al., 2013). The existence of debris is one of the reasons for not visiting the beach (Moore, 2009). In the tourism perspective, dirty and trashy beaches and seas reduce the tourists' interest. The visitors even will assume that garbage scattered offshore is an indication of a low water quality (NOAA - National Oceanic and Atmospheric Administration, 2013) and pollution (Marin et al., 2019). The MD influences the perception/satisfaction of beach users, particularly regarding the overall beach quality (Leggett et al., 2014). The tourists also deeply care about environmental issues and sustainability practices (Dodds et al., 2010). Thus, it is important to study the magnitudes and level of tourist acceptance of MD in the context of tourism on small islands, particularly in Indonesia. Numerous gaps and shortcomings related to the MD research in Indonesia exist (Purba et al., 2019).

Currently, the tourism in Indonesia's small islands is a developing activity. One of them is the Tidung Islands group, Seribu Island Regency, Jakarta. Tidung Islands have large tourism development opportunities because they are located not far from Jakarta, the capital of Indonesia (approximately 32 nautical miles) (Fig. 1). The islands consist of Tidung Besar and Tidung Kecil Islands, with a total area of approximately 84,53 ha. The islands can be reached with the express ferry from Marina Ancol jetty or Muara Angke seaport, Jakarta, within 1.5 h. Tidung Besar Island has been allocated to be a settlement island, while Tidung Kecil Island is plotted for conservation purposes. Therefore, Tidung Kecil Island is also called Conservation Island. Ecologically, the beaches at the Tidung Islands group are sandy with a supporting ecosystem, such as mangrove, seagrass, and coral reef. Wave breakers are built in some parts of the beaches considering the erosion, particularly in the southern parts, which are densely populated areas. In 2018, 4866 people were living on the island with a density of 22 people per ha, an increase of 6.08% compared to 2015 (4587 people) (Monograph of Tidung Island Village, 2018a. Initially, the islanders were fishermen and seaweed cultivators. The community-based tourism management has provided new business opportunities and improved the local people's economy (Khrisnamurti and Darmawan, 2016). Most of the residents have changed their professions by participating in tourism activities and tourism-related businesses. The widespread construction of homestays and tourist lodging has changed the land use, particularly in the coastline. Some parts of the beaches have also changed their functions into residential areas and lodging facilities for tourism purposes.

The visitors enjoy various activities, such as those on the white sandy beach including fun activities, swimming, fishing, snorkeling, diving, water sports, photography, beach walk, and camping. As one of the favorite tourist destinations, a total of 141,038 tourists have visited the islands in 2018, a decrease of 5.78% compared to 2017 (Fig. 2) (Primary Data Tidung Island Village, 2018b). The decrease in number of tourist visits is attributed to numerous factors, including overcrowding, which leads to uncomfortability, decreasing level of tourist satisfaction, caused by the poor sanitation at tourist attractions, and disruption of the carrying capacity of the island (Adrianto et al., 2019). The Jakarta Environmental Agency, 2018 has reported a very high

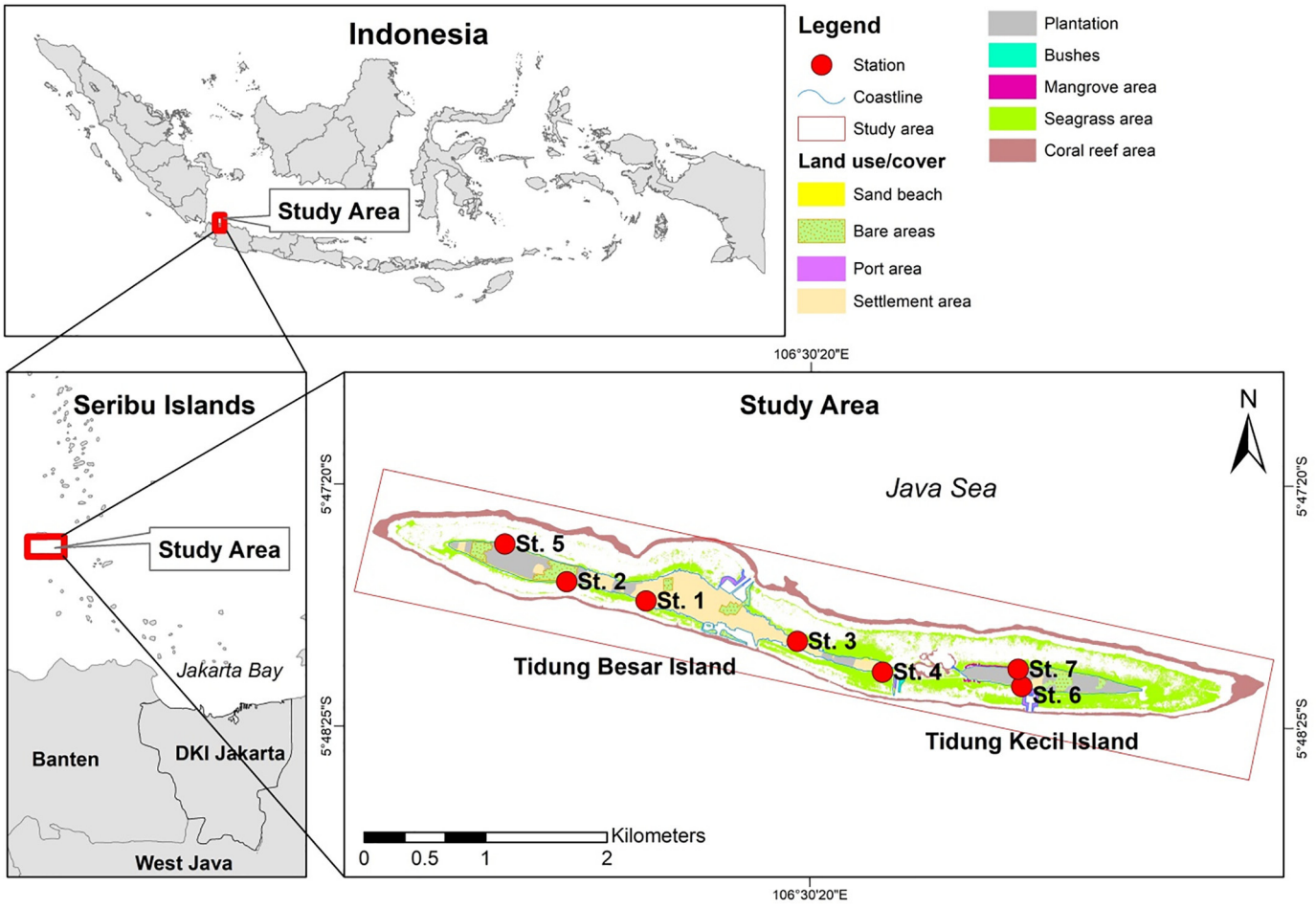

Fig. 1. Study area on Tidung Islands, Jakarta, Indonesia.

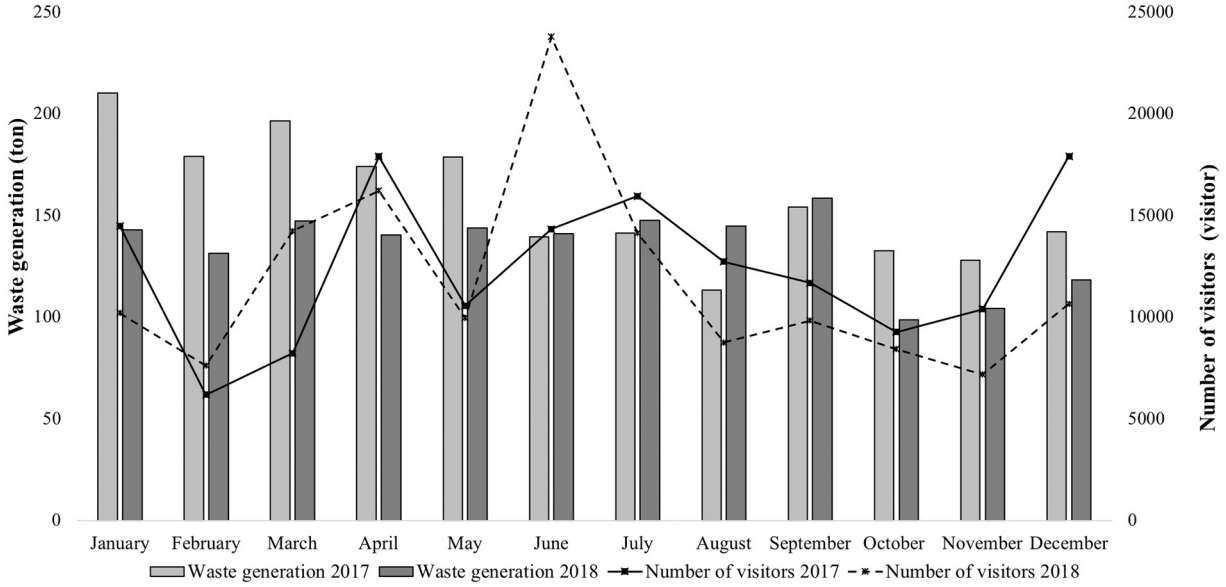

Fig. 2. Waste generation and number of monthly visitors in 2017–2018. The waste generation data were sourced from Jakarta Environmental Agency in 2017–2018, while visitor data were collected from Pulau Tidung Subdistrict in 2017–2018.

amount of waste, 12,006.43 tons in 2018, increased by 12.59% compared to that in 2017 of 10,494.48 tons (Fig. 2). The numbers show a reciprocal relationship between the number of tourists and existing pile of garbage, which fluctuates in line with the number of tourists (Fig. 2), including the rapid growth of the population in Tidung Islands. Furthermore, Tidung Islands do not have a special waste management system for tourism. Island garbage cleaners manage the waste under the Tidung Island Subdistrict administration. The rubbish is collected from each resident's house and tourist accommodation, dumped in temporary shelters, and then transported to Jakarta using garbage transport vessels. The amount of waste that can be transported to the Jakarta's landfill site at the outskirts of the capital strongly depends on the capacity of the ships and weather conditions.

Uncontrolled and unregulated development activities lead to an unbalanced social-ecological system, and thus to an environmental degradation (Kurniawan et al., 2016; Kurniawan et al., 2019). This has become a challenge for the tourism development on Tidung Islands because it is also vulnerable to any impact by an interaction with Jakarta Bay (Jasmin et al., 2019), which has been recognized for a long time as the most polluted marine environment in Indonesia (Lestari and Trihadiningrum, 2019) and has even been an area of environmental concern since 1986 (Willoughby, 1986). The number of studies on solid waste in the Seribu Islands group has continuously increased (Uneputty and Evans, 1997; Willoughby et al., 1997; Maharani et al., 2018). However, these studies have not analyzed Tidung Islands in the context of tourism. Therefore, the aim of this study was to assess the magnitude of MD on the islands and impact on tourist perception.

2. Materials and methods

This study included several stages, a survey on collection of data on waste, surveys on collection of social data, and data analysis, descriptive and statistical.

2.1. Data collection

2.1.1. Beach debris surveys

The beach debris surveys were carried out at seven stations in the beach area, particularly in the tourism spots (Table 1 and Fig. 1). The station selection was determined based on a preliminary survey by considering beach characteristics, tourist activities, coastal ecosystem type, land use, and land cover.

The survey was carried out during the tourist season, in July 2018 and during weekends. The sampling was carried out in the morning, from 5.30 to 7.30 a.m. at each station. The time of waste collection was chosen to obtain data on the accumulation of tourism waste at daytime and nighttime, while minimizing the influence of garbage originating from the sea, considering that the waste cleaners start the beach cleaning at 7:30 a.m.

The MD sampling was carried out using line-transects with a length adjusted to the width of the beach. The line-transects extended from the low tide line to the base of the coastal vegetation (backshore) (70–100 m) (Lippiatt et al., 2013), and fresh and accumulated litters were sampled (Velander and Mocogni, 1999). The transect width for the debris observation was 5 m. The sampling at each station was repeated five times; the intervals between samplings being 5, 10, 15, and 20 m. The start and end points of each transect were marked with wooden flags. A global positioning system point was recorded to enable repeated sampling over subsequent collection periods.

At each transect, surveyors collected, categorized, and counted the standing macrodebris, larger than 2.5 × 2.5 cm^2 (Ribic et al., 1992; Cheshire et al., 2013). Based on the National Oceanic and Atmospheric Administration (NOAA, 2013), the debris was identified as plastic, metal, glass, rubber, processed lumber, cloth/fabric, and others/unclassifiable.

2.1.2. Perception surveys

The perception survey was carried out on the same tourist beaches as those of the debris observation sites. Data on perception and acceptance rate of tourists toward debris or waste were collected using questionnaires by interviewing tourists. The questionnaires on the perception of anthropogenic and organic waste densities, concern to debris, and tourist satisfaction used the Likert scale, from 1 (very low) to 5 (very high). The tourist satisfaction was obtained using the composite value of each ecosystem quality, facilities, cleanliness of each beach tourism object, and activity. Tourist respondents were selected through convenience sampling or accidental sampling by interviewing tourists that met the criteria and were ready for interviews. Individuals resting at the beach area were prioritized.

The tourists' acceptance index of the number of debris items per beach area was evaluated using the image capture technology (ICT). The ICT included six photos with different numbers of debris items in

Table 1
MD beach survey station descriptions.

Station	Coordinates	Beach width (m)	Beach slope (°)	Land use/cover	Substrate and ecosystem type	Main activities	Intensity of activities
1	S 5° 47′ 51.24″ E 106° 29′ 35.71″	~12	6	Tourism area, tourist accommodation, settlements, public facilities	Sandy beach, seagrass	Tourism, service provision	Intensive
2	S 5° 47′ 46.14″ E 106°29′14.46″	~12	7	Shrubbery	Sandy beach	Fisheries	Less intensive
3	S 5° 48′ 1.97″ E 106° 30′ 16.24″	~10	7	Tourism area, tourist accommodation, settlements	Sandy beach	Settlements, homestay, shops	Intensive
4	S 5° 48′ 10.14″ E 106° 30′ 39.05″	~12	7	Tourism area	Sandy beach, seagrass	Tourism, mariculture	Very intensive
5	S 5° 47′ 36.03″ E 106° 28′ 57.87″	~12	7	Tourism area, plantation area	Sandy beach	Tourism	Intensive
6	S 5° 48′ 13,94″ E 106° 31′ 16.46″	~12	7	Plantation area, tourism area	Sandy beach, mangrove	Conservation, related to port, agriculture	Moderate
7	S 5° 48′ 9.30″ E 106° 31′ 15.45″	~12	5	Plantation area, tourism area	Sandy beach, seagrass	Conservation office, camping, aquaculture	Moderate

one beach area. The photos show scenarios of the state of waste, from 0 to 500 items of debris in one beach area (0, 50, 100, 200, 300, and 500 items of debris per beach area), modified from the approach reported by Needham et al. (2008) (Fig. 3).

The completed questionnaire was checked for validation and reliability. A total of 50 respondents completed the questionnaires. The interview for stakeholders was carried out through snowball sampling to collect information about the source and management of debris.

2.2. Data analysis

2.2.1. MD

The MD data were assessed using descriptive statistics. The values are reported as total, percent, density, min, max, and mean ± standard deviation (SD). The MD density (items/m^2) was calculated based on the total volume of MD (items) divided by the total transect area of the station (m^2).

To measure the magnitude of the MD for the whole beach tourism, the beach cleanliness index was determined using the clean coastal index (CCI), proposed by Alkalay et al. (2007), with all items of debris. The CCI was categorized into five classes, very clean or no MD is observed (0–2), clean or no MD is observed over a large area (2–5), moderate or items of MD can be detected (5–10), dirty or a large number of MD items are on the beach (10 − 20), and extremely dirty or most of the area is covered by MD (20 +).

2.2.2. Social perception analysis

The tourists' perception was assessed using descriptive statistics and regression analysis. The differences were considered significant when $p < 0.05$. The tourists' acceptance of debris items per beach area was analyzed based on the acceptability index of waste density on a scale of 0–1 (low to high). To obtain this scale, standardization of values was performed based on the formula reported by Kurniawan et al. (2019).

3. Results

3.1. Magnitudes on beach status

MD was observed at all surveyed beaches. The total collected and observed waste was 3743 items with a density of 1.83 items/m^2. The density was smaller than that reported by Willoughby et al. (1997).

The most commonly observed type of waste was plastic waste, 3139 items or 83.86% of the total waste, followed by glass and cloth/fabrics, 5.00% and 4.25%, respectively (Table 2). The content of plastic waste was very significant compared to those of other waste categories ($p = 0.0008$), with 448.43 items being encountered on an average, and density reaching 1.53 items/m^2. Several studies have also demonstrated plastic as the major debris at a beach area with tourism activities, e.g., in Cilacap in the southern coast of Central Java, Indonesia (Syakti et al., 2017), Hawaiian Islands, United States of America (Moy et al., 2018), Arraial do Cabo, Rio de Janeiro, Brazil (Silva et al., 2018), Santa Catarina State, Brazil (Marin et al. 2019), Las Salinas beach, Viña Del Mar, Chile (Rangel-Buitrago et al. 2019), and Seribu Islands group in Jakarta Bay, Indonesia (Willoughby et al. 1997).

Spatially, waste distribution was observed at almost all observation stations, including those in Tidung Kecil Island, that is reserved for conservation and is uninhabited. The volume of collected waste was 223 to 804 items, which implies that garbage was observed at each tourist beach area in the Tidung Islands group. Waste with the highest density was observed at station 3, 3.22 items/m^2, followed by stations 6 and 1, with 2.61 and 1.80 items/m^2, respectively, whereas the lowest density was observed at station 4, 0.74 items/m^2 (Table 3). Significant spatial differences in amount and density of waste existed ($p = 0.0305$). These differences indicate that the location characteristics spatially influence the presence of waste, and can be influenced by the pattern of the existing waste distribution and management (Table 1).

The waste volume and density directly affect the conditions of the existing beach. Based on the CCI analysis results, the status of the tourist beaches on the Tidung Islands was classified as “dirty” to “extremely dirty”, with values of 14.87 to 64.32 (Table 3). The “dirty” beach category was observed at station 4, a tourist center, while others were categorized as “very dirty”.

3.2. Tourist perception

3.2.1. Visitor characteristics

The tourists visiting the Tidung Islands were mostly young, between 21 and 30 years (62%). The rest were visitors in the age range of 31–40 years (18%), teenagers (< 20 years) (14%), and people older than 40 years (6%). Generally, they were men (66%) and unmarried. Their occupation statuses were employed (36%), professional (26%), and university students (12%). Most of the visitors (60%) were not from Jakarta, from Jakarta (36%), from overseas (12%), and not from Java (8%). Most of the tourists (36%) visiting Tidung Islands were from the middle economic group with a majority income < IDR 3,000,000 per month (< US$ 214.29), followed by the group having an average income of IDR 3,000,000–4,000,000 per month (US$ 214.29–285.71) (24%). Very few (14%) had average incomes of IDR 5,000,000–10,000,000 per month (US$ 357.14–714.29). Only 10% of the respondents had an average income > IDR 10,000,000 per month (> US$ 714.29) (Table 4). In addition, 75% of the visitors had an average length of stay of 1 to 5 days, while 22% of them 6 to 10 days. The rest (4%) had an average length of stay of 11 to 15 days in a year (Table 4).

Fig. 3. Photographs showing the assumption scenarios of MD items used as visual supports to answer MD item questions. Each picture simulates a scenario with an increasing number of items in six different areas of the beach. a) 0, b) 50, c) 100, d) 200, e) 300, and f) 500 items of MD in one area of the beach.

Table 2
Total number and density of MD items on the beach by category on Tidung Islands.

Category	Total (items)	%	Density (items/m^2)	Min (items)	Max (items)	Mean ± SD (items)
Plastic	3139	83.86	1.53	199	691	448.43 ± 170.75
Metal	34	0.91	0.02	0	12	4.86 ± 4.81
Glass	187	5.00	0.09	7	48	26.71 ± 18.05
Rubber	118	3.15	0.06	6	37	16.86 ± 12.46
Cloth/fabric	159	4.25	0.08	5	33	22.71 ± 10.55
Processed lumber	102	2.73	0.05	0	62	14.57 ± 21.41
Other/unclassifiable	4	0.11	0.00	0	2	0.57 ± 0.79
Total	3743	100	0.26	223	804	534.71 ± 205.95

Table 3
Summary of MD distributions at seven stations on Tidung Islands.

Station	1	2	3	4	5	6	7	Total	Mean ± SD
Total (items)	539	535	804	223	452	783	407	3743	534.71 ± 208.95
Density (items/m^2)	1.80	1.78	3.22	0.74	1.51	2.61	1.36	1.83	1.86 ± 0.82
CCI	35.93	35.67	64.32	14.87	30.13	52.20	27.13	36.52	37.18 ± 16.40
Category of CCI	Extremely dirty	Extremely dirty	Extremely dirty	Dirty	Extremely dirty	Extremely dirty	Extremely dirty	Extremely dirty	Extremely dirty

Table 4
Visitor's characteristics on Tidung Islands.

Characteristic	Category	Number of respondents	Percentage (%)
Age (year)	< 20	7	14
	21–30	31	62
	31–40	9	18
	> 40	3	6
Gender	Man	33	66
	Woman	18	34
Education	Junior high school	2	4
	Senior high school	18	36
	University	30	60
Residence	Jakarta	18	36
	Outside of Jakarta (Java)	22	60
	Outside of Java	4	8
	Foreign	6	12
Occupation	Student	2	4
	College student	6	12
	General employee	18	36
	Entrepreneur	3	6
	Professional/technician	8	16
	Government employee/teacher/ retired/housewife	13	26
Marital status	Married	17	34
	Unmarried	26	52
	Other	7	14
Mean income (in US$)[a]	IDR ≤ 3,000,000 (US$ 214.29)	18	36
	IDR > 3,000,000–4,000,000 (US$ > 214.29–285.71)	12	24
	IDR > 4,000,000–5,000,000 (US$ > 285.71–357.14)	8	16
	IDR > 5,000,000–10,000,000 (US$ > 357.14–714.29)	7	14
	IDR > 10,000,000 (US$ > 714.29)	5	10

[a] Note: The exchange rate is IDR 14,000 per US$ in 2018.

3.2.2. Perception of MD

Based on the surveys, 80% of the visitors stated that it is very important to maintain the beach clean or without anthropogenic waste, while 62% of the respondents stated that it is very important to provide a beach without natural waste (Fig. 4). Generally, tourists visiting the Tidung Islands prefer a beach without rubbish. The visitors stated their serious concerns on the issue of MD on Tidung Islands. Notably, 64% of the total number of respondents were very concerned (Fig. 4). The majority of the tourists stated that they are very concerned regarding the MD issues. Statistically, a very significant factor of concern of the tourists on the beach is the anthropogenic waste ($p = 0.366$). It is not influenced by visitors' characteristics, including age, gender, education, occupation, and income. They feel uncomfortable, consider that the waste reduces the beauty of the beach and environmental health, and prefer a beach without waste.

The state of tourist awareness and concerns regarding waste issues was not on par with the attitude during the stay on the island. Based on the beach observation, some of them disposed garbage arbitrarily around the beach. According to the survey, the visitors assume that the waste originates from the tourists who dump or leave their trash on the beach (54%), from the land, carried by the wind and run-off (20%), is discarded or abandoned by residents (14%), and is carried from the sea (12%) (Fig. 5). The MD did not significantly influence the tourist satisfaction with the existing beach tourism. They were quite satisfied with the existing conditions with an average rating of 3.27 (moderate category).

3.2.3. Visitors' acceptance index

The majority of the respondents visiting the Tidung Islands desired a beach without waste (both anthropogenic and natural wastes). Regarding the visitors' acceptance index, a larger number of waste items per beach area led to a lower index score (Fig. 6). The number of waste items per beach area accepted by the visitors was 0 to 200. According to the results of field observations, only the beach around station 4 was close to the visitors' acceptance level (Table 3). The average total number of debris items per beach area was 534 (Table 3). The ratio between the visitor's acceptance level and average of total debris counts was 1:3.

4. Discussion

The volume and density of garbage on Tidung Islands were very

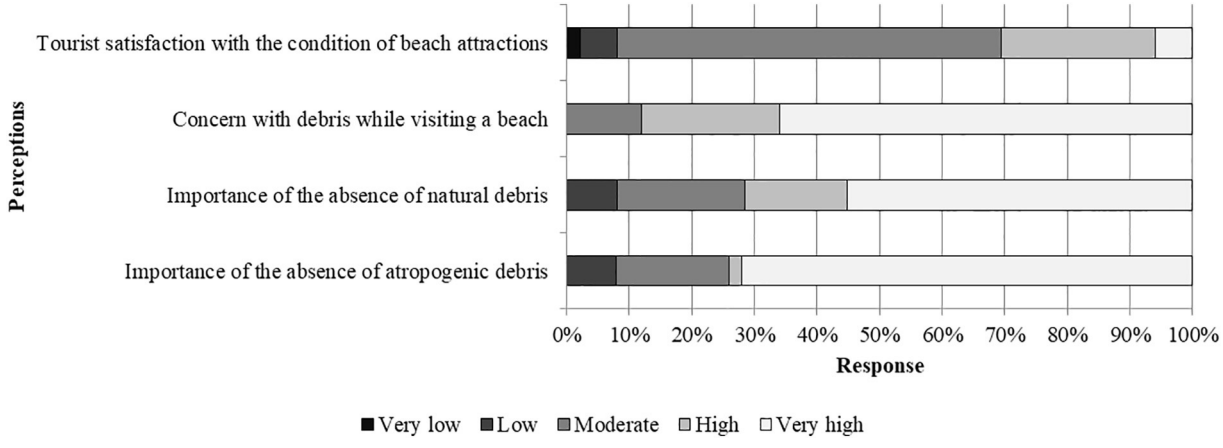

Fig. 4. Tourist perceptions on MD and beach.

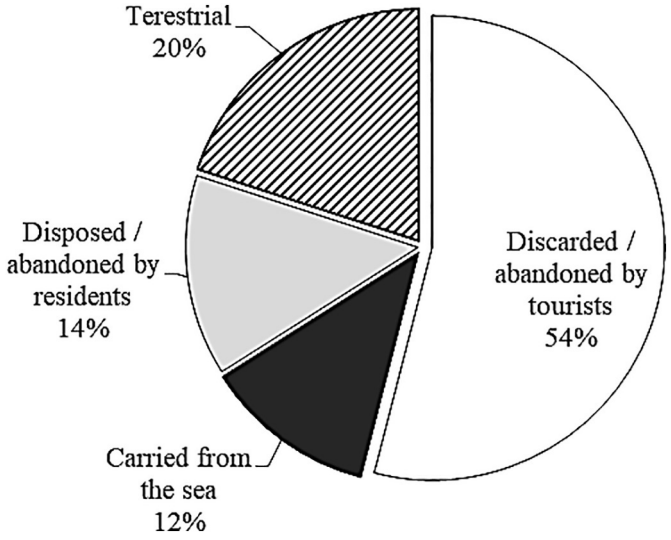

Fig. 5. Perception of MD sources.

high. The most common waste was plastic food and drink packaging and boxes (Fig. 7). Rubbish was observed even in the intertidal area. The types of waste in the intertidal area varied, from drinking glass bottles, tin cans, plastic packaging, rope, cosmetic packaging, cigarette butts, sanitary pads, to diapers (Fig. 7a and b). In addition, marine biota trapped inside drinking plastic packaging was observed (Fig. 7c). These findings show the accumulation of waste on the beaches of unmanaged islands during several periods. The wastes on Tidung Islands were estimated to originate from various sources, including the city of Jakarta (Uneputty and Evans 1997; Willoughby et al. 1997). However, the most significant sources of MD were the direct tourist activities and residents of the island. Similar observations have been reported by Marin et al. (2019). The tourist beaches close to the housing area and tourism accommodation are very dirty owing to multiple sources. This demonstrates that the main source of waste were the human activities on the island, not the sea. Thus, waste management on the island is crucial to overcome the waste problems on Tidung Islands. In particular, it is required to reduce the plastic waste (highest amount, most common type of garbage) by reducing the use of disposable plastic packaging and regulating the entry of supplies carried by tourists into the islands.

The waste management is still far from optimal. The volume of waste is largely influenced by the cleaning facilities and cleaning staff. However, the garbage removal is focused only on the island's iconic tourist beach. The favorite sites visited by a large number of visitors are cleaned every day by public cleaning services and tourism actors around tourist spots, such as the beaches around station 4, whereas the nonfavorite beaches are rarely cleaned. This management model is attributed to the Tidung Islands group not having a special janitor for tourism. The cleaning staff includes general cleaning workers for the islands. Thus, they are not available at any time to maintain the cleanliness of the island's beaches and existing attractions.

Specialized cleaning staff for tourism is needed on Tidung Islands. However, this requires additional costs. The cost of maintaining cleanliness is one component, quite large but required (de Araújo and Costa 2006), which includes the infrastructure and cleaning facilities. Additionally, the tourists and islanders still lack awareness on the need to dispose garbage in the trash bins. Thus, the awareness-increasing campaigns must be increased. The clean beach category must be an important target. These requirements are very important to increase the tourists' satisfaction, preserve the beauty of the islands, and increase the economic sustainability of the community from the tourism sector. Collaboration with tourism actors and residents is required to improve the efficiency of waste handling and processing as well as increase the public awareness (Rayon-Vina et al. 2019; Rayon-Vina et al. 2018). The waste management can be improved by linking the MD pressure and social aspect (Slavin et al., 2012). The islands should be appropriately designed to receive a large number of tourists, which can increase the island's vulnerability to environmental degradation.

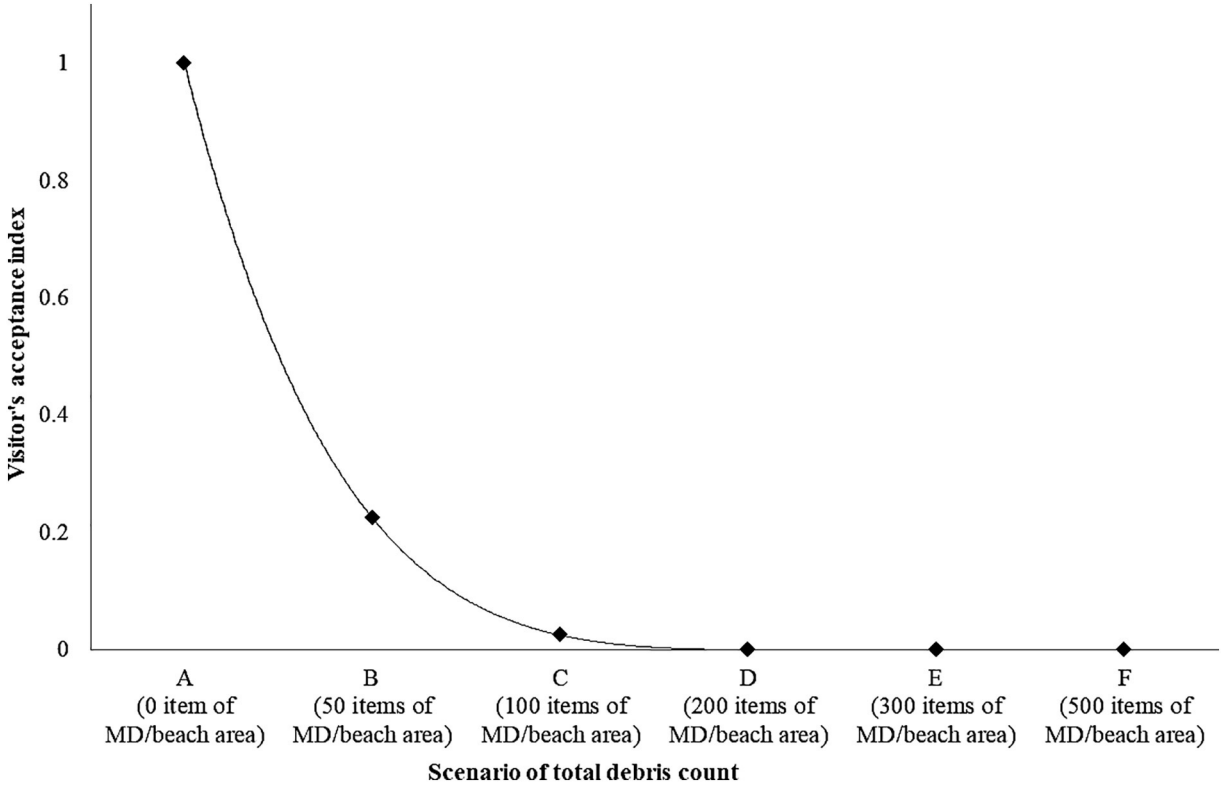

Fig. 6. Visitors' acceptance index of MD items in one area on Tidung Islands.

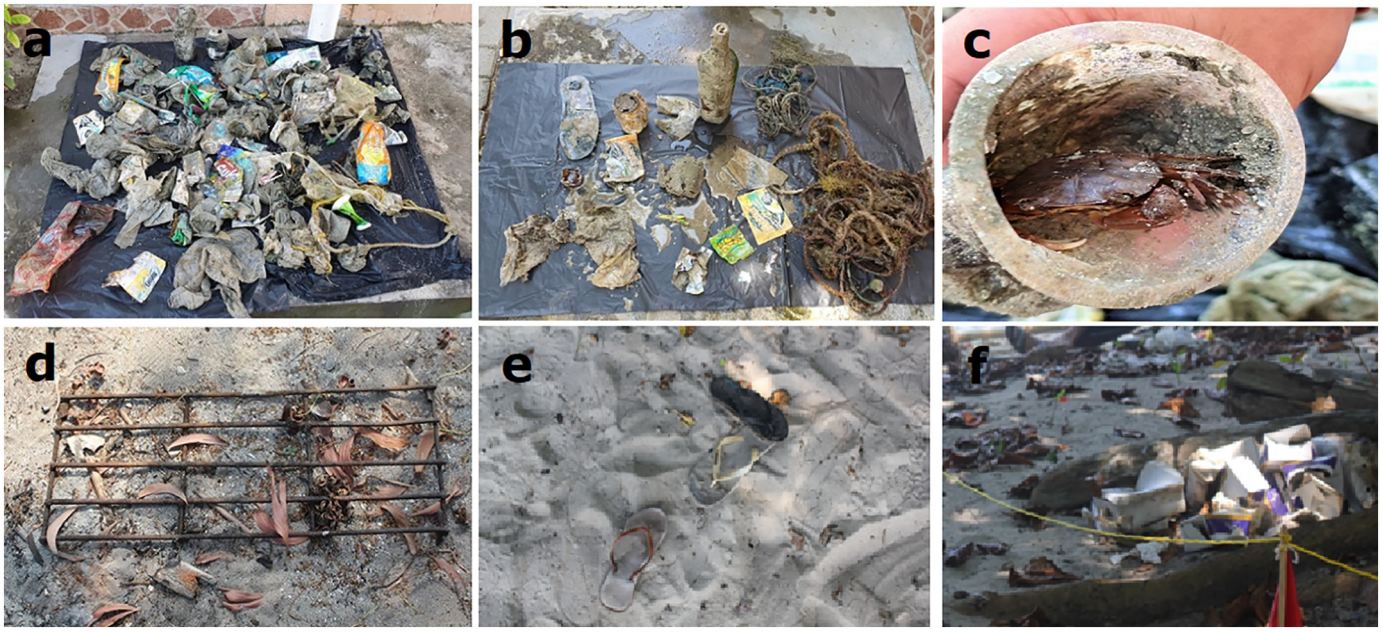

Fig. 7. MD at the beach area. (a, b) MD at the intertidal area, (c) marine biota trapped inside drinking plastic packaging, (d) used grill/barbeque utensils, and (e, f) discarded flip flops and food boxes at the beach.

5. Conclusion

The tourism development on the Tidung Islands has not been accompanied by a responsible integrated management. Thus, the tourist activities have led to the highest amounts of waste on the island and accumulated in the coastline and intertidal area, particularly plastic waste, such as food and drink packaging and boxes. On the small tourism island, the waste management should involve not only the beach areas favorite for tourist visits, but all island areas. Therefore, a specialized tourism cleaning officer is needed, not only as a janitor but also engaging in zero-waste tourism campaigns. Collaboration with tourism actors is required to reduce the waste from tourists because tourist satisfaction has not been achieved. The poor environmental conditions will reduce the number of tourist visits. These conditions will make the tourism unsustainable. Moreover, the island management should focus on prevention by educational activities and campaigns for the residents, tourist guides, and visitors. The frequency of garbage collection from the island needs to be increased to clean the tourist destination. The placement of an adequate number of trash bins along the access roads on the island is expected to decrease the volume and density of waste on the beach.

This study included limited data in terms of tourist perception. This limitation should be overcome in following studies by considering the categories and motivations of tourists. The physical-oceanographic factor also needs to be assessed to evaluate the movement pattern of MD sent to Tidung Islands beaches particularly in the monsoon season.

Author statement

All authors had equal contributions to this study.

CRediT authorship contribution statement

Yusra Hayati:Conceptualization, Methodology, Investigation, Data curation, Visualization, Writing - original draft.**Luky Adrianto**:Supervision, Writing - review & editing.**Majariana Krisanti**:Supervision, Writing - review & editing.**Widodo S. Pranowo**:Supervision, Writing - review & editing.**Fery Kurniawan**:Data curation, Writing - review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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