Bachelor of Education (Honours) (Geography)

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HPI 4016E Honours Project

Final Report

Project Title: Marine debris from the foreshore to backshore in Hong Kong:

The abundance, seasonal variations, type of debris

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Abstract

The coastal environmental issues had been raised the attention from the society in these two decades. People care about the scenery and hygiene level on the beach, therefore more and more beach cleaning-up events had been launched around the world. While Hong Kong is a coastal city almost surrounded by marine, beaches are easily found as well as marine debris. By knowing the final sink of the marine debris helps people to decide and plan the waste management in long term. There were a lot of researches showing the different possible sink for the marine debris, including the wildlife animal, oceanic current, and beach. However, there is a gap between the predicted amount and the current number of marine debris. Hardesty et al., (2017) suggested that the backshore area of the beach is the final sink of the debris, which was ignored by the public. There was recent research conducted in Australia, Korea, and Taiwan, but not in Hong Kong. Therefore, this study is focusing on the marine debris found from the foreshore and backshore in order to figure out the Hong Kong marine debris distribution. There are three aims in this study: 1) The abundance, 2) Seasonal variations, 3) Different types of sources, of the marine debris found from the foreshore and backshore areas. As the result showed that the backshore accumulated more debris, and the dry season had collected more debris than the wet season. A different source of debris also has significant differences mutually.

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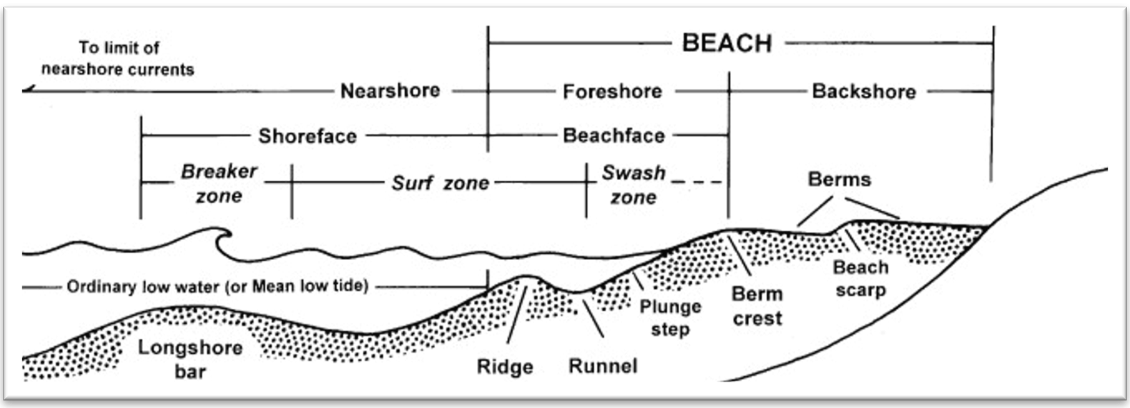
1. Introduction

Marine debris is a major environmental pollution problem. During industrialization and urbanization, people produce and consume different items for catering to their daily needs and routine. At the same time, the marine debris also increased sharply due to the misstatement of the city waste. Therefore, marine had become one of the major sinks of plastic accumulation. It is well-recognized that marine debris pollution threatens marine organisms, wildlife species, and the coastal scenery globally through a lot of researches. In Hong Kong, most of the research focused on debris such as the microplastic from the marine, river, beach, and marine organisms. Relatively little focused on the large marine debris which located in the coastal area of the beach. The ignorance of marine debris in the coastal area may miscount the accumulation of the debris in Hong Kong. Therefore, it is essential to investigate a new focus on marine debris accumulation in the terrestrial environment on the beach and understand the determinants of the abundance, seasonal variations, and type of debris, to provide comprehensive data of the debris accumulation in coastal which can be used to improve coastal waste management effectiveness and strategies.

According to Otvos (2000), the backshore is the area between the foreshore and the landward zone, which means affected by the storm overwash and sand dunes. And the foreshore is the area between the foreshore and the swash zone (Chrzastowski, 2005).

Figure 1: The zoning of foreshore and backshore area (Chrzastowski, 2005)



Marine debris (marine litter) is well-recognized pollution in the world. It defines as manufactured or processed solid waste material that enters the ocean environment from any source (Coe and Rogers, 1997; Galgani et al. 2010). Plastic is one of the major materials of the debris among glass, metal, and paper (Derraik, 2002; OSPAR Commission, 2007). The feature of plastic led to widespread over 70 years old which is durable, cheap, flexible, and lightweight (Derraik, 2002; Barnes et al., 2009). Because of urbanization and industrialization since the 1950s, people strived for faster and sanitary material in daily life, therefore plastic quickly replaced organic material (Sheavly et al., 2007; Kershaw et al., 2015). Plastic had been widely applied in a different part of our living, for instance, single-use packing, building, and construction, medical equipment, automotive, agriculture activity, as a result, plastic production had been increased steadily from 230 million tonnes in 2005 to 359 million tonnes of in 2018, even though the plastic pollution raised the concern over these decades (PlasticEurope, 2019).

While the garbage entered the environment, the advantage of its durability and insoluble became a pollution problem (Olivelli et al., 2020). The mismanagement of waste led to the marine debris crisis. There was an estimation that 4.8 to 12.7 million metric tonnes of land-based waster entered the ocean due to mismanagement worldwide in 2010 (Jambeck et al., 2015). Around 80% of the debris that can be found in the coastal area was plastic such as fishing equipment and packing (Barnes et al., 2009). There are more than 5 trillion pieces of wastes on the ocean had been estimated by different models (Eriksen et al., 2014) There are a lot of research focused on the sink of marine debris in order to locate the debris and amount, including sea surface (Eriksen et al., 2014), oceanic gyres (Law et al., 2010; Eriksen et al., 2013), river (Gasperi et al., 2014; Lebreton et al., 2017), seabed (Pasquini et al., 2016), wildlife (Bugoni et al., 2001; Gregory, 2009). However, there is a gap between the predicted amount and the current amount of marine debris (Thompson et al., 2004; Brennan et al., 2018). In the last two decades, the amount of debris on the foreshore had been increased whereas the amount of debris in the ocean was stable (Barnes et al., 2009). It is suggested that coastal areas had been ignored to be the possible sink of debris (Brennan et al., 2018; Olivelli et al., 2020). In Asia, there were researchers had been investigated that the backshore of beaches is a significant accumulation (Lee et al., 2017; Bancin et al., 2019). Only a few of the research focus on accumulation variation on the shore (Lo et al., 2018), even the study which conducted by the Hong Kong government to investigate the sources and fates of marine refuse only collects the data from the foreshore and ends before backshore (Environmental Protection Department, 2015).

Most of the marine debris regraded to human activities included land-based and ocean-based sources. The eco-tourism development had been supported by the government of the Hong Kong Special Administrative Region (HKSAR) since 2005, which encouraged local and overseas visitors to the countryside and coastal area (Cheung and Jim, 2013). From 2016 to 2017, there were around 13 million visitors had been to the country park (Agriculture, Fisheries and Conservation Department, 2017). The increasing number of visitors in the natural environment significantly related to the growing negative impact (Zacarias et al., 2011). Human activities are one of the major factors to affect the accumulation of marine debris (Hardesty et al., 2017; Olivelli et al., 2020; Willis et al., 2017). There is a positive relationship between the number of the visitor and the amount of the debris load (Jayasiri et al., 2013). Olivelli et al., (2020) indicated that the more accessible the beach, the more amount of debris can be found. It is also believed that the higher accessibility of the coastal area will attract more visitors, who increase the potential to have more debris accumulate on the beach (Willis et al., 2017).

Besides human activities, natural conditions are one of the important factors. The prevailing wind and wave action carried the marine debris to deposit on the coastal and even to the backshore area (Gregory et al., 2009; Hardesty et al., 2017). Wind and wave action are significantly affected the debris distribution on site, especially for the redistribution of debris. While the beach is affected by the prevailing wind and strong wave action, it is possible to relocate the debris on the beach until the debris enters the terrestrial area and is trapped by the vegetation (Olivelli et al., 2020). There was research conducted in Taiwan where has a similar weather condition as Hong Kong, indicted that the wave and wind are the possible factors. During storm events will pick up the plastic debris even further and enter the backshore. Therefore, the backshore of the coastal is a final sink for the marine debris instead of the intertidal and supralittoral zone (Bancin et al., 2019).

The accumulation of marine debris in the coastal area leads to a potential economic loss including the loss of tourism attractiveness and the expenditures of beach cleaning service (Balance et al., 2000). To reduce the negative impact of marine debris, the range of expenditure 10million to 33 million USD to minimize the destruction and improve the environmental condition for the coastal area (Hardesty et al., 2017). Beach clean-up is the most familiar strategy to deal with marine debris. Many non-governmental organizations held the beach clean-up globally such as International Coastal Clean-up (ICC) and Plastic Free Seas. The beach clean-up event usually focuses on the total amount of debris and the types of marine debris but lacks the spatial distribution analysis of the debris (Hardesty et al., 2017).

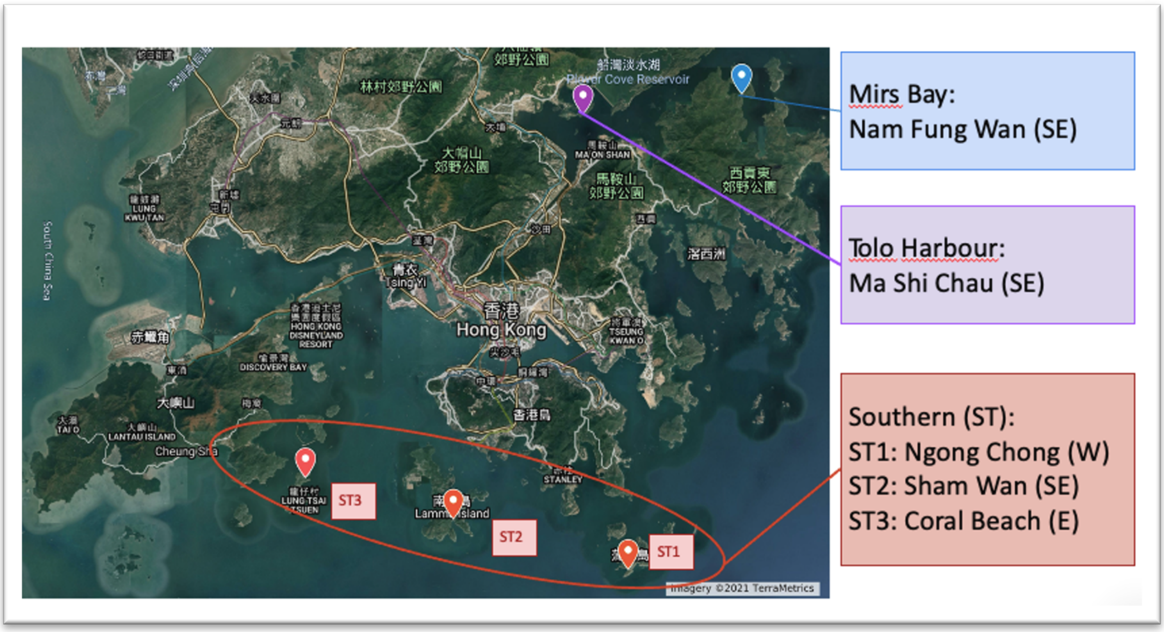
The study aims to investigate the marine debris from the foreshore to backshore in Hong Kong. The marine debris in 5 beaches will be counted during the wet and dry seasons. This study aimed (1) to quantify marine debris in Hong Kong coastal area; (2) to figure out the seasonal differences among the debris; (3) to classify the marine debris with possible activities.

2. Methodology

2.1. Sampling Site

In this study, 5 sampling sites were selected from 3 water control zones in Hong Kong including Nam Fung Wan in Mirs Bay; Ma Shi Chau in Tolo Harbour; and Ngong Chong, Sham Wan, and Coral Beach in Southern. All of the beaches have a backshore area without man-made development or structure. Also, all sampling sites are not under the management of the Leisure and Cultural Services Department, which means the beach would not have the official cleaning offered by the government. It helps to reduce the disturbance of the data collected from the regular cleaning.

Figure 2: The study area and sampling locations (Google, 2021)



2.2. Sample Collection

The first-hand data of marine debris will be collected from the foreshore to the backshore of the beaches to verify those aims mentioned above by referring to Hardesty et al (2017) sampling method (Figure 3). There were 3 transects had been conducted on each beach through random selection in the dry and wet season. Random sampling will be used to select the site of the transect. There will be a 2 m interval of each transect along the beach. For instance, if the total length of the beach is 100m, the potential transect will have 34 in total, then randomly select 3 of them. To minimize the bias, the transect will be conducted 2m from the entry of the beach in order not to select a point that has higher accessibility. When the selected point cannot access the backshore for at least 2m or within 2m from the beach entry, another transect will be randomly selected again. By using the sampling tool (Figure 4), each transect had divided into 2m2 per section. If any debris can be found from the first three transects, the survey will be finished at the third transects. If the debris cannot be found in the first three transects, there will be an extra three transects to be conducted. When vegetation covers half of the section, that will be identified as a backshore area. Also, the debris will be counted when half of it within the tool. The size of debris that larger than 5mm will be counted according to the different types of activities by using the modified version data collection sheet from International Coastal Clean-up Data Card (Table 1). The debris will be classified into different sources of activities including foreshore and recreation activities; ocean and waterway activities; smoking-related activities; dumping activities; medical hygiene; Fragments; Styrofoam, and others.

Also, there is some information of the site will be recorded during the sampling including 1) GPS of transect start and endpoints; 2) Date and Time (included the sampling duration) ; 3) Weather condition; 4) Wind direction and speed; 5) Length of each transect; 6) Gradient; 7) Type of vegetation in backshore. If there were any beach cleanup recorded can be found, the information of the event will be also recorded as the reference.

Figure 3: The example of doing the sampling on site

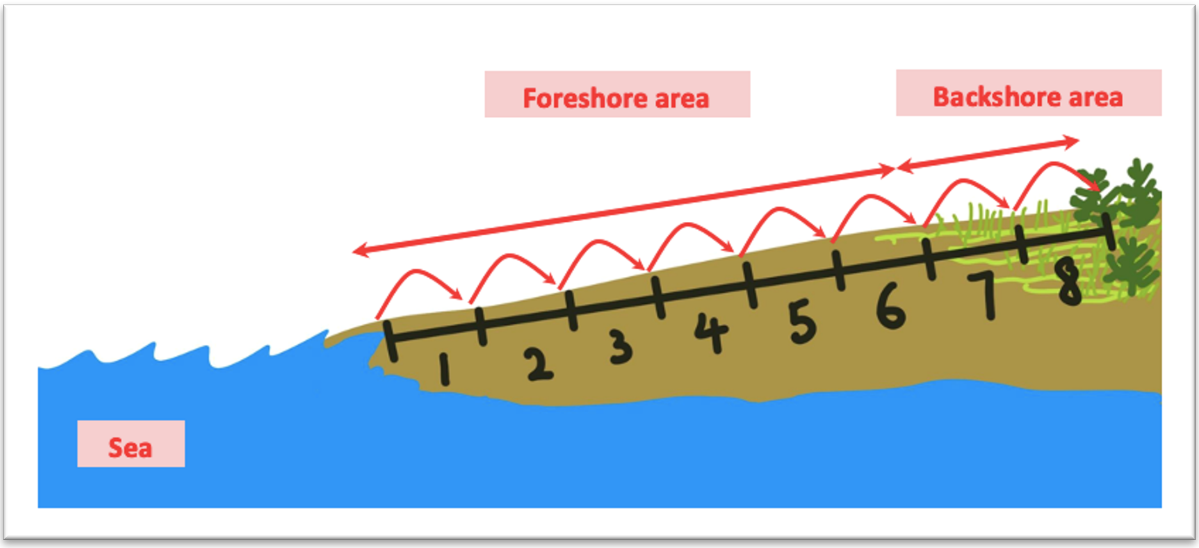


Figure 4: The sampling tool, Length:2meter, Width:1meter

Table 1. Classification of marine debris

Foreshore and Recreation activities (Debris from beach-goers, sports/games, festivals, litter from streets/storm drains, etc.)	
Bags	Food Wrappers/Containers
Balloons	6-Pack Holders
Beverage Bottles (plastic) 2 liters or less	Shotgun Shells/Wadding
Beverage Bottles (glass)	Cigarettes/Cigarette Filters
Beverage Cans	
Clothing, Shoes	
Cups, Plates, Forks, Knives, Spoon, Straws	
Ocean and Waterway activities (Debris from recreational/commercial fishing and boat/vessel operations)	
Bait Containers/Packaging	Oil/Lube Bottles
Bleach/Cleaner Bottles	Pallets/Crates
Buoys/Floats	Plastic Sheeting/Tarps
Fishing Line	Rope
Fishing Lures/Light Sticks	Strapping Bands
Fishing Nets	
Medical/ Personal Hygiene	Dumping activities
Condoms	Appliances (refrigerators, washers, etc.)
Tampons/Tampon Applicators	Batteries
Diapers	Building Materials
	Cars/Car Parts
Fragments	Tires
	Other items
Styrofoam	

2.3. Statistical Analysis

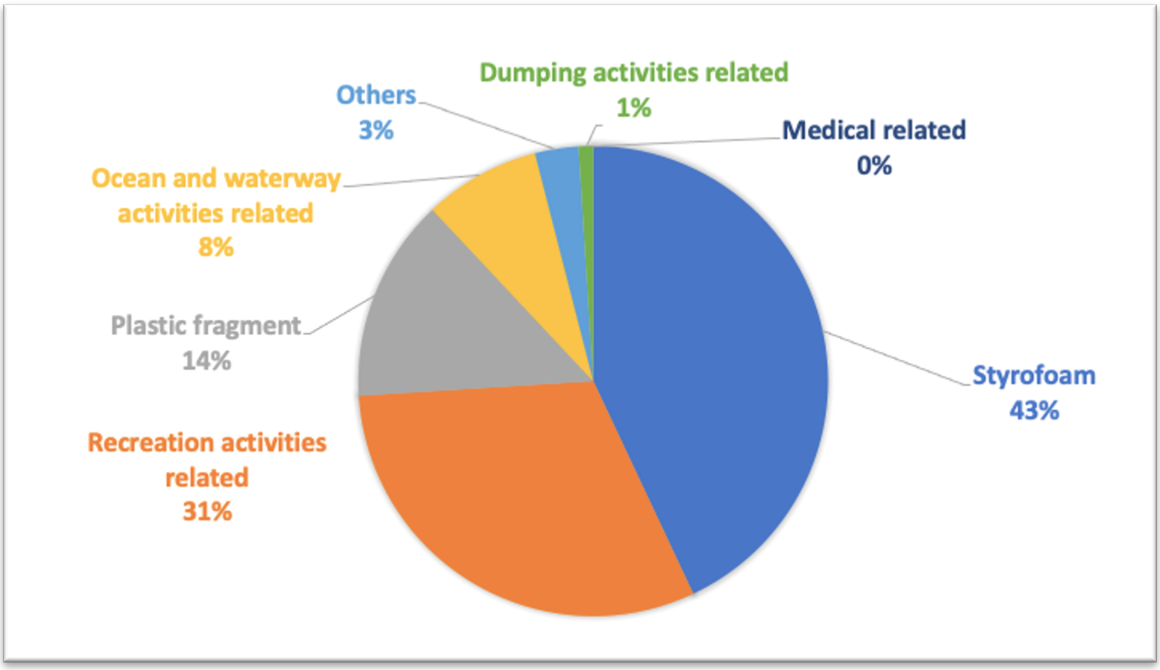
All statistical analyses were done via SPSS software, version 26.0. The number of the marine debris in front shore and backshore, classification, and seasonal variation through using the descriptive statistics. The Shapiro-Wilk test was applied to assess the normality of the data. The data set was a non-normal distribution ($p=0.000$). Also, the Mann-Whitney U test was applied to determine the abundance and seasonal among the foreshore and backshore areas. To elucidate the different types of debris in the foreshore and backshore area, Kruskal Wallis Test was used. The correlation between the abundance and slope of the transect was tested by the Nonparametric Correlation. In order to have a clear understanding of the distribution of the debris on the beach, the mean concentrations of debris in the form foreshore to backshore will be calculated and presented in the unit of items per m2. For all cases, were determined as statistically significant when the p values <0.05.

3. Results

3.1. The abundances of marine debris

The total number of collected marine debris was 10,360 items were counted of 48 transects across 5 beaches in the dry and wet season. The mean abundance of debris is 23.36 items per m2. Approximately, 43% of the total number of debris were Styrofoam, 31% were recreation activities related debris, 14% were plastic fragment, 8% were ocean and waterway activities related, 3% were others, 1% were dumping activities related, and <1% were medically related (Figure 5). While the average density of the debris among five beaches was 23.36 items per square meter. The Coral Beach in Cheung Chau has the greatest concentrations of debris with 87.52 item per m2, Ngong Chong in Po Toi was 19.04 item per m2, Nam Fung Wan in Wan Tsai South was 18.21 per m2, Sham Wan in Lamma Island was 9.82 per m2, and Ma Shi Chau was 7.51 per m^2.

Figure 5: The items of collected marine debris from all sampling sites



3.2. The spatial distribution of debris on the beach

In respect of the spatial distribution of debris on the beach, there was a significant difference between the foreshore and backshore areas (p=0.000) (Table 2). While the mean abundance of debris accumulated in the foreshore area (8.176 items ± SD 10.852 m2), the mean abundance of debris accumulated in the backshore area (38.540± SD 52.186 m2). The debris backshore area contained more than the foreshore area about 4.7 times. There are two main vegetation cover had found in the backshore of the sampling sites including grass and shrub. The Mann-Whitney test showed that is a significant difference in the debris between the grass and shrub in backshore ($p=0.047$). While the mean of debris accumulated in the grass (50.35± SD 88.003 m2) was significantly higher than the backshore which was covered by the shrub (23.953± SD 33.045m^2).

Table 2: Summary statistics of marine debris in foreshore and backshore area among 5 sit

		Overall		Ngong Chong		Nam Fung Wan		Ma Shi Chau		Coral Beach		Sham Wan	
		foreshore	backshore	foreshore	backshore	foreshore	backshore	foreshore	backshore	foreshore	backshore	foreshore	backshore
	N	24	24	6	6	6	6	6	6	3	3	3	3
Number Items/ m^2	Mean	8.176	38.540	20.074	17.996	3.847	32.573	1.663	13.361	13.135	161.917	1.104	18.544
	Std. Deviation	10.852	52.186	15.266	10.765	1.992	16.962	1.369	9.086	5.947	58.050	1.296	5.192
	Minimum	0.167	1.500	5.944	7.625	1.000	9.562	0.375	1.500	9.571	111.750	0.167	14.300
	Maximum	39.889	225.500	39.889	32.25	6.600	57.25	4.125	26.000	20.000	225.500	2.583	24.333

3.3. The seasonal variation of foreshore and backshore

The foreshore and backshore areas data had split, to compare the seasonal difference among two areas (Table 3). In respect of seasonal variations, it was found out that the mean abundance of debris accumulated in the backshore area during the dry season (53.809± SD 61.059 m2) was significantly higher than that during the wet season (13.092 ± SD 11.821 m2, p = 0.002). However, no significant difference was found between the dry and wet seasons in terms of the mean abundance of debris accumulated in the foreshore shores (p= 0.571).

Table 3: Seasonal variation of marine debris in foreshore and backshore area

		Wet season		**Dry season**	
		foreshore	backshore	foreshore	backshore
	N	9	9	15	15
Number Items/ m^2	Mean	12.676	13.092	5.476	53.809
	Std. Deviation	15.946	11.821	5.230	61.059
	Minimum	0.750	1.500	0.167	10.000
	Maximum	39.139	42.375	20.000	225.500
	P value	0.571		0.002*	

3.4. The spatial distribution of debris on the beach according the types of debris

The amount of debris between the foreshore and backshore area according to different types of debris is different (P<0.05). The mean of recreation activities related to debris, ocean and waterway activities related, dumping activities, medical, Styrofoam, Plastic Fragments in the foreshore area were 4.108, 0.716, 0.099, 0.032, 0.676, and 1.012 items/ m^2, respectively. The mean of recreation activities related to debris, ocean and waterway activities related, dumping activities, medical, Styrofoam, Plastic Fragments in the backshore area were 10.544, 2.958, 0.539, 0.122, 9.377, 2.586, and 0.247 items/ m^2, respectively. All of the types of debris had been paired up to test whether they have significantly different from each other in foreshore and backshore areas by using the Mann-Whitney test (Table 4a & 4b). For the foreshore area, the recreation activities related debris dominated among others debris type (4.108±SD 7.953m^2), also the recreation activities (4.108± SD 7.953m^2, p=0.001) and Ocean and Waterway activities (0.716± SD 0.910m^2, p=0.018) related debris accumulated in the foreshore area were significantly higher than the Styrofoam (0.585± SD 1.790m^2). For the backshore area, the recreation activities related to debris and Styrofoam were the main debris found in backshore 10.5442± SD 8.309m2, p=0.000; 9.3769± SD 29.103m^2, p=0.004 respectively, also both of them accumulated in the backshore area significantly higher than that dumping activities debris (0.5394+_SD 1.0266m^2).

Table 4a: Summary statistics of marine debris in foreshore and backshore area among different types of debris

		Recreation activities		Ocean and Waterway activities		Dumping activities		Medical		Styrofoam		Plastic Fragments		Others	
Foreshore: Fore Backshore: Back		Fore	Back	Fore	Back	Fore	Back	Fore	Back	Fore	Back	Fore	Back	Fore	Back
Number Items/ m^2	Mean	4.108	10.544	0.716	2.916	0.099	0.539	0.032	0.123	0.585	9.377	0.676	2.586	1.012	0.247
	Std. Deviation	7.953	8.309	0.910	3.895	0.222	1.027	0.071	0.159	1.790	29.103	1.193	6.917	2.215	0.384
	Minimum	0.000	0.667	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Maximum	31.500	29.667	3.250	14.875	0.889	4.750	0.222	0.500	11.722	177.75	6.917	38.250	8.167	1.250

Table 4b: The result performed by Mann-Whitney test between different types of debris

Foreshore	Insignificant	Significant					
	Recreation activities	Ocean and Waterway activities	Dumping activities	Medical	Styrofoam	Plastic fragments	Others
Recreation activities	/	/	/	/	/	/	/
Ocean and Waterway activities	0.063	/	/	/	/	/	/
Dumping activities	0.000	0.000	/	/	/	/	/
Medical	0.000	0.000	0.286	/	/	/	/
Styrofoam	0.001	0.018	0.003	0.000	/	/	/
Fragments+Bottle Cap	0.003	0.221	0.013	0.001	0.729	/	/
Others	0.011	0.072	0.069	0.007	0.566	0.711	/

Backshore							
	Recreation activities	Ocean and Waterway activities	Dumping activities	Medical	Styrofoam	Plastic fragments	Others
Recreation activities	/	/	/	/	/	/	/
Ocean and Waterway activities	0.000	/	/	/	/	/	/
Dumping activities	0.000	0.000	/	/	/	/	/
Medical	0.000	0.000	0.125	/	/	/	/
Styrofoam	0.000	0.534	0.004	0.000	/	/	/
Plastic fragments	0.000	0.004	0.694	0.081	0.010	/	/
Others	0.000	0.000	0.414	0.415	0.000	0.361	/

4. Discussion

4.1. The marine debris along the foreshore and backshore area

According to the result, it proved that the backshore area deposit more debris than the foreshore area on the beach. As Brennan et al. (2018) findings suggested that the backshore vegetation increased the difficulty of the debris back to the sea, which led to the storage of the marine debris in the vegetation cover area. The result of the servery agreed that the mean of marine debris in the backshore area was nearly 5 times that of the foreshore area. Also, during the fieldwork time, the debris trapped by the vegetation cover was a common feature (Figure 6). In addition, the type of vegetation also affects the amount of debris found on the backshore. Hardesty et al., (2017) mentioned that a higher amount of debris tended to be found in the site which has grass and shrubs instead of the forest. Although there was no forest included in those 5 sampling sites, our result also showed that the amount of marine debris between grass and shrub cover has significantly different. The grass cover in the backshore able to trap a double number of the marine debris found from the cover of the shrubs. There was no significant correlation between the slope of the transect and the number of marine debris (p=0.565).

Figure 6: The marine debris trapped in the backshore area

4.2. The seasonal variation of the debris

In respect of the seasonal variation, it is suggested that the wind is the major factor of debris accumulation on the beach. It is predicted that the wet season will collect more marine debris. It is because the typhoon which has high energy with strong wind usually occur during the wet season in Hong Kong. However, according to the result, there was more marine debris can be found in the dry season, which is unexpected. Cheung et al., (2016) suggested that strong monsoon winds that come from the northeast may contribute to the movement of the marine debris, especially for the debris that has low density. According to the Hong Kong Observatory (2021), during the sampling period, there were 2 times Strong Monsoon signals announced in the wet season and 13 times of Strong Monsoon Signals announced in the dry season. The total hours of the strong monsoon signal in the dry season (~318 hours) is much more than the wet season (~31 hours) (Figure 7). While during the dry season, the marine debris comes with the sea wave and affected by the strong wind continuously may favor the marine debris go into the backshore and difficult to escape from it.

Figure 7: The strong monsoon signal launched during the sampling period

Strong Monsoon Signal

Searching period : [202006 - 202102]
Total number of records : [15]

Direction	Start Time		End Time		Duration hh mm
	hh mm	dd/mon/yyyy	hh mm	dd/mon/yyyy	
East	07:05	31/Jul/2020	20:40	31/Jul/2020	13 35
East	14:40	18/Sep/2020	08:45	19/Sep/2020	18 05
East	00:45	01/Oct/2020	13:40	02/Oct/2020	36 55
East	21:35	05/Oct/2020	07:40	06/Oct/2020	10 05
East	02:40	14/Oct/2020	10:15	15/Oct/2020	31 35
East	22:05	15/Oct/2020	05:10	16/Oct/2020	07 05
NorthEast	09:11	24/Oct/2020	13:00	25/Oct/2020	27 49
East	23:55	27/Oct/2020	13:30	29/Oct/2020	37 35
East	04:45	23/Nov/2020	05:15	24/Nov/2020	24 30
North	23:00	29/Dec/2020	12:25	31/Dec/2020	37 25
North	02:10	08/Jan/2021	12:00	08/Jan/2021	09 50
North	08:45	11/Jan/2021	11:30	12/Jan/2021	26 45
East	23:15	16/Jan/2021	07:45	17/Jan/2021	08 30
East	23:15	02/Feb/2021	09:45	03/Feb/2021	10 30
East	16:45	08/Feb/2021	11:45	10/Feb/2021	43 00

Strong Monsoon Signal as displayed in this database between 1 January 1950 and 14 April 1956 refers to the "Local Strong Wind Signal" adopted in Hong Kong which covered warning of strong winds due to monsoon or less intense tropical cyclones. With effect from 15 April 1956, the Strong Monsoon Signal and the Tropical Cyclone Strong Wind Signal No. 3 were introduced to delineate the warnings for monsoon systems and tropical cyclones.

4.3. The source of the marine debris

During the data collection, the marine debris had categorized by different sources and types including recreation activities; ocean and waterway activities; smoking-related activities; dumping activities; medical hygiene; Fragments; Styrofoam, and others. In the backshore, the main marine debris is recreation-related debris and Styrofoam. There are two main possible reasons to explain the result. First, the visitor nearby the beach may contribute the amount of the marine debris when they are having reaction activities. As the recreation-related debris is single-use plastic such as food wrappers, cups, plates, spoons, and straws, which light and widely used for containing food and drinks in Hong Kong as well as Styrofoam(Cheung et al., 2016). The annual report of international coastal clean-up mentioned the food wrappers are the top items collected from the coastal area around the world as well as Hong Kong (Ocean Conservancy, 2020). Also, Styrofoam is a common material used in the commercial fishing industry (Pruter, 1987). Therefore, it is not surprising that most of the marine debris found on those sampling sites is related to reaction activities and Styrofoam.

Second, density is another factor that affects the transportation of debris on the beach. The lower density may favor the Styrofoam which is the lowest density among other debris to flow with the wind and accumulate at the back of the beach. Browne et al., (2010) indicated that the wind can affect the movement of the debris on the beach, especially the debris with low density. While the Styrofoam is around 0.2g/cm^3 and the dumping-related debris such as construction wood is around 400g/cm^3. The result of the survey supported that the lower density of the debris, the higher sensitivity of the flowing wind onshore, therefore higher concentration will be found on the beach, especially on the backshore area.

5. Limitation

There are some limitations among the studies. First, the sampling sites did not cover all 7 water control zone of Hong Kong, which may not able to represent the comprehensive data of marine debris accumulated in the foreshore and backshore areas. Second, the small sampling size of the studies also may affect the accuracy of the research. The sampling sites were facing the west, south, and southeast, it would be better to collect more data from the different facing beaches in order to project the variation in between. Third, the studies only covered the sandy beach, but not much others types of beach such as mud and pebble in Hong Kong. Forth, the beach cleaning up event organized by the citizens may also affect the result of the studies. Although those 5 sampling sites are not under the management of the Leisure and Cultural Services Department, the sense of treasuring the nature beauty had been enhanced, people may investigate the cleaning beach event on their own. If there were beach cleaning up event occurred during the sampling period, the data of the foreshore area may affect the most.

6. Suggestion and Implication

According to the research conducted by The Government of the Hong Kong Special Administrative Region which regarding the sources and fates of marine refuse (Mott MacDonald, 2015). The data collection area was ended by the vegetation cover. For the very first stage in short term, it is important to have another updated research to project the marine debris by counting the debris at the back of the beach to fill the gap of the missing debris in Hong Kong. The citizen can also get involved to get first-hand coastal and environmental data while they organized the cleaning up event by themselves. Therefore, the government should take the lead to collect back the data actively instead of leaving their effort for just a cleaning up event. In the middle stage, waste management should be involved after having the hotspot of the marine debris. Each hotspot should have its strategies to overcome the marine debris. To clarify the source of the debris is essential, if the source of the debris is from the land, more environmental education should be provided such as signage and educational events. If the debris comes from the marine, it is essential to understand the regional and global ocean current to find the related country to cooperate a marine debris management policy. In long term, reducing the debris from the source is one of the major solutions. While most of the debris collected from our local beach is recreation-related debris and Styrofoam, the producer responsivity scheme helps to increase the cost of production to avoid overproduction and consumption.

7. Conclusions

In conclusion, the backshore area is one of the possible final sinks for the marine debris which may be ignored by the people in the past. Therefore, the debris on the backshore should also be considered and counted in order to project a more comprehensive status of the distribution among marine debris on a beach in Hong Kong. It would be great to have more research regarding the “missing” debris to improve our waste management. Hoping this research can contribute a new angle of concern toward the coastal environment.

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References

Agriculture, Fisheries and Conservation Department. (2017). *Country and Marine Parks – AFCD Annual Report 2016-2017*. (Retrieved April 23, 2020, from https://www.afcd.gov.hk/misc/download/annualreport2017/en/country-parks.html

Ballance, A., Ryan, P. G., & Turpie, J. K. (2000). How much is a clean beach worth? The impact of litter on beach users in the Cape Peninsula, South Africa. *South African Journal of Science*, *96*(5), 210-230.

Bancin, L. J., Walther, B. A., Lee, Y. C., & Kunz, A. (2019). Two-dimensional distribution and abundance of micro-and mesoplastic pollution in the surface sediment of Xialiao Beach, New Taipei City, Taiwan. *Marine pollution bulletin*, *140*, 75-85.

Barnes, D. K., Galgani, F., Thompson, R. C., & Barlaz, M. (2009). Accumulation and fragmentation of plastic debris in global environments. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *364*(1526), 1985-1998.

Brennan, E., Wilcox, C., & Hardesty, B. D. (2018). Connecting flux, deposition and resuspension in coastal debris surveys. *Science of the total environment*, *644*, 1019-1026.

Browne, M. A., Galloway, T. S., & Thompson, R. C. (2010). Spatial patterns of plastic debris along estuarine foreshores. Environmental science & technology, 44(9), 3404-3409.

Bugoni, L., Krause, L., & Petry, M. V. (2001). Marine debris and human impacts on sea turtles in southern Brazil. *Marine pollution bulletin*, *42*(12), 1330-1334.

Cheung, L. T., & Jim, C. Y. (2013). Ecotourism service preference and management in Hong Kong. *International Journal of Sustainable Development & World Ecology*, *20*(2), 182-194.

Cheung, P. K., Cheung, L. T. O., & Fok, L. (2016). Seasonal variation in the abundance of marine plastic debris in the estuary of a subtropical macro-scale drainage basin in South China. Science of the Total Environment, 562, 658-665.

Chrzastowski M.J. (2005) Beach Features. In: Schwartz M.L. (eds) Encyclopedia of Coastal Science. Encyclopedia of Earth Science Series. Springer, Dordrecht. https://doi.org/10.1007/1-4020-3880-1_34

Coe, J. M., & Rogers, D. B. (1997). Marine debris: sources, impacts, and solutions. *Springer Series on Environmental Management*.

Derraik, J. G. (2002). The pollution of the marine environment by plastic debris: a review. *Marine pollution bulletin*, *44*(9), 842-852.

Edyvane, K. S., Dalgetty, A., Hone, P. W., Higham, J. S., & Wace, N. M. (2004). Long-term marine litter monitoring in the remote Great Australian Bight, South Australia. Marine Pollution Bulletin, 48(11-12), 1060-1075.

Mott MacDonald. (2015). *Investigation on the Sources and Fates of Marine Refuse in Hong Kong* (pp. 1–44). Hong Kong, China.

Eriksen, M., Maximenko, N., Thiel, M., Cummins, A., Lattin, G., Wilson, S., ... & Rifman, S. (2013). Plastic pollution in the South Pacific subtropical gyre. *Marine pollution bulletin*, *68*(1-2), 71-76.

Eriksen, M., Lebreton, L. C., Carson, H. S., Thiel, M., Moore, C. J., Borerro, J. C., ... & Reisser, J. (2014). Plastic pollution in the world's oceans: more than 5 trillion plastic pieces weighing over 250,000 tons afloat at sea. *PloS one*, *9*(12), e111913.

Galgani, F., Fleet, D., Van Franeker, J. A., Katsanevakis, S., Maes, T., Mouat, J., ... & Amato, E. (2010). *Marine Strategy Framework directive-Task Group 10 Report marine litter do not cause harm to the coastal and marine environment. Report on the identification of descriptors for the Good Environmental Status of European Seas regarding marine litter under the Marine Strategy Framework Directive*. Office for Official Publications of the European Communities.

Gasperi, J., Dris, R., Bonin, T., Rocher, V., & Tassin, B. (2014). Assessment of floating plastic debris in surface water along the Seine River. *Environmental pollution*, *195*, 163-166.

Gregory, M. R. (1990). Plastics: Accumulation, Distribution and Environmental Effects of Meso-, Macro-And Mega Litter In Surface Waters and on Shores of the Southwest Pacific. In *Proceedings of the second International Conference on marine debris. US Department of Commerce. NOAA-TMNMFS-SWFSC-154* (pp. 55-84).

Gregory, M. R. (2009). Environmental implications of plastic debris in marine settings—entanglement, ingestion, smothering, hangers-on, hitch-hiking and alien invasions. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *364*(1526), 2013-2025.

Hardesty, B. D., Lawson, T. J., van der Velde, T., Lansdell, M., & Wilcox, C. (2017). Estimating quantities and sources of marine debris at a continental scale. *Frontiers in Ecology and the Environment*, *15*(1), 18-25.

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.

Jayasiri, H. B., Purushothaman, C. S., & Vennila, A. (2013). Plastic litter accumulation on high-water strandline of urban beaches in Mumbai, India. *Environmental monitoring and assessment*, *185*(9), 7709-7719.

Kershaw, P. J., & Rochman, C. M. (2015). Sources, fate and effects of microplastics in the marine environment: part 2 of a global assessment. *Reports and studies-IMO/FAO/Unesco-IOC/WMO/IAEA/UN/UNEP Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) eng no. 93*.

Lebreton, L. C., Van Der Zwet, J., Damsteeg, J. W., Slat, B., Andrady, A., & Reisser, J. (2017). River plastic emissions to the world's oceans. *Nature communications*, *8*, 15611.

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(3), 288-298.

Lee, J., Lee, J., Hong, S., Hong, S. H., Shim, W. J., & Eo, S. (2017). Characteristics of meso-sized plastic marine debris on 20 beaches in Korea. *Marine pollution bulletin*, *123*(1-2), 92-96.

Lo, H. S., Xu, X., Wong, C. Y., & Cheung, S. G. (2018). Comparisons of microplastic pollution between mudflats and sandy beaches in Hong Kong. *Environmental Pollution*, *236*, 208-217.

Ocean conservancy. (2021). The 2020 Cleanup Reports. The International Coastal Cleanup. https://oceanconservancy.org/wp-content/uploads/2020/10/FINAL_2020ICC_Report.pdf.

Olivelli, A., Hardesty, D., & Wilcox, C. (2020). Coastal margins and backshores represent a major sink for marine debris: insights from a continental-scale analysis. *Environmental Research Letters*.

Otvos, E. G. (2000). Beach ridges—definitions and significance. Geomorphology, 32(1-2), 83-108.

Sheavly, S. B., & Register, K. M. (2007). Marine debris & plastics: environmental concerns, sources, impacts and solutions. *Journal of Polymers and the Environment*, *15*(4), 301-305.

Pasquini, G., Ronchi, F., Strafella, P., Scarcella, G., & Fortibuoni, T. (2016). Seabed litter composition, distribution and sources in the Northern and Central Adriatic Sea (Mediterranean). *Waste management*, *58*, 41-51.

PlasticsEurope. (2019). Plastics – the Facts 2019 An analysis of European plastics production, demand and waste data. Retrieved 14th April, 2020 from https://www.plasticseurope.org/application/files/9715/7129/9584/FINAL_web_version_Plastics_the_facts2019_14102019.pdf

Pruter, A. T. (1987). Sources, quantities and distribution of persistent plastics in the marine environment. Marine Pollution Bulletin, 18(6), 305-310.

OSPAR Commission. (2007). OSPAR Pilot Project on Monitoring Marine Beach Litter. Monitoring of marine litter in the OSPAR region. *OSPAR Publication*, (386).

Thompson, R. C., Olsen, Y., Mitchell, R. P., Davis, A., Rowland, S. J., John, A. W., ... & Russell, A. E. (2004). Lost at sea: where is all the plastic?. *Science*, *304*(5672), 838-838.

Willis, K., Hardesty, B. D., Kriwoken, L., & Wilcox, C. (2017). Differentiating littering, urban runoff and marine transport as sources of marine debris in coastal and estuarine environments. *Scientific reports*, *7*, 44479.

Zacarias, D. A., Williams, A. T., & Newton, A. (2011). Recreation carrying capacity estimations to support beach management at Praia de Faro, Portugal. *Applied Geography*, *31*(3), 1075-1081.

Zurcher, N. A. (2009). Small plastic debris on beaches in Hong Kong: an initial investigation. HKU Theses Online (HKUTO).