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The distribution and composition of litter on the Aoshan Beach Qingdao, China

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Abstract

Human health and marine life are being compromised consequent to the accumulation of municipal solid waste on many beaches and the scientific community is seriously concerned about this situation. The present study is the pioneer to determine the abundance and the composition of beach litter along the Aoshan Beach in Qingdao, China. The quantitative survey of the Aoshan Beach was conducted for approximately 3 months (May to July 2019) to evaluate the number of different types of litter. The average litter composition and its weight for 3 months were estimated to be 4441 ± 364.16 items/km with the corresponding weight was 260.52 ± 28.53 kg/km, respectively. The findings demonstrated that plastic litter was the most abundant by count (32.21% of the total account) followed by ropes and cotton (24.92%) and wood (14.20%). The weight of ropes and cotton was the maximum (22.52% of the total account), followed by plastics (20.47%), wood, and glass 14.59 and 14.94%. Moreover, floating litter from the Yellow sea deposited along the coast by high and low tidal waves. It was concluded that mitigation measures must be adopted to decrease littering its source, waste management, recycling, developing efficient tolls, and pursuing a long-term public awareness.

Keywords Beach · Abundance · Composition · Plastic · Items · Litter

Introduction

Beaches are one of the dynamic features on planet Earth. The global population will reach approximately 9.5 billion in 2050 with maximum population growth in developing countries (DeSA 2013). The presence of litter on coastal regions or beaches results in beach pollution (Commission 2009). Marine litter has been considered a pressing challenge of recent times and noted in many marine habitats. Marine litter is solid waste material which is directly or indirectly discarded and dumped into marine or coastal environment (Buhl-Mortensen and Buhl-Mortensen 2017). These materials could be medical waste, fragmented glass pieces, discarded syringes, fishing lines which can harm beachgoers and have an injurious effect on marine life due to the leaching of poisonous chemicals (Sheavly and Register 2007). Plastics were found the most abundant litter including wood on many beaches worldwide (Kusui and Noda 2003). The proportion of plastic litter has many temporal variations. For example, plastic was approximately 90% on Motupore Islands in Papua New Guinea beaches (Smith 2012), and 56.69% at Shilaoren Beach, Qingdao, China (Pervez et al. 2020a). Marine litter imparts negative impacts on ecological,

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aesthetic, and ecological sectors (Rochman et al. 2016). The presence of litter on the beaches and oceans may threaten the survival of marine and terrestrial organisms via entrapment, suffocation, and poisoning with cascading effects on food webs (Bergmann et al. 2015). These litter have the potential to deteriorate coastal economic activities (Gall and Thompson 2015), and anthropogenic beach litter pose threat to sea birds, sea turtles, and marine mammals through entanglement and ingestion (Provencher et al. 2014), resulting in torrential problem globally (Santos et al. 2009). They have an indirect effect on coastal tourism, social impacts, and on the local economy.

The major terrestrial litter sources are population density, tourism, recreational activities, illegal dumping, input from river and waste disposal sites (Lozano and Mouat 2009; Pervez et al. 2020a), with industrialization, population growth, and urbanization (Gregory 2009). Neumann et al. (2015) linked coastal litter with rapid urbanization and population growth along coastline. Marine litter sources might be commercial shipping, fisheries, offshore installation, and pleasure craft (Commission 2009; Pervez et al. 2020a). Beach litter can also be transported by river, wind, and ocean currents (Silva-Iñiguez and Fischer 2003). Numerous litter items such as paper, glass, metal, bottles, cans, jars, organic waste, etc. produced through recreational activities (Atik 2010; Pervez et al. 2020b). Developing countries are subjected to rapid urbanization with an annual growth of ~ 24%, and high consumption of plastic-related products by those people who possess middle monthly income status. Additionally, many countries have no adequate infrastructure to handle beach litter issues (UNEP-WCMC and IUCN 2018).

The survey along the coastline is a prime approach to monitor litter load and is applied in numerous regions to characterize and quantify the litter load (Ribic et al. 2010). This approach is beneficent to determine efficient measurement, mitigation, litter origin, rate of incidence, and likely to underline possible endanger to the coastal and marine environment (Commission 2009). The abundance, origin, and distribution of beach litter have been investigated on different beaches across the world (Mokos et al. 2019; Williams et al. 2014). They followed a beach survey approach to quantify and characterize different types of litter. Beach surveys can be used to classify the distribution and variation of different litter types through temporal and spatial monitoring (Edyvane et al. 2004; Oigman-Pszczol and Creed 2007). Compared with other countries like the USA, Brazil, Australia, and Chile; China is paying less attention to marine litter (Zhou et al. 2011). China along with Europe and the USA is the world's biggest producer of plastic litter (Rochman et al. 2013). Cleaning on several beaches of Qingdao is carried out around 4:00 am on regular basis in the summer season by appointed workers and different types of litter are dumped into placed garbage tanks without proper segregation (Pervez et al. 2020a). In view of the absence of any cleaning activities practiced in the coastal areas of China or placement of garbage tanks on Aoshan Beach during the summer season, the current study focused on the status of solid waste types. The aim of the present study was to characterize and quantify different types of litter along Aoshan Beach Qingdao, China. It was the first ever survey carried out on Aoshan Beach to estimate the different types of litter generation. The significance of present study was to emphasize poor beach management. Moreover, beach management must emphasize beach litter and improve awareness through education and scientific outreach to beach visitors.

Materials and methods

Study area

Qingdao is a coastal city of China; located on the southern part of the Shandong peninsula. This region comprises widespread bays, coastlines, and beaches; it is a famous tourist spot in China. Qingdao is the leading city in terms of investment on environment and effective government policies (Bank 2007). The Gross Domestic Product (GDP) of Qingdao was 124.98 billion US dollar ($), and 9.046 million population in 2014. The excellently developed infrastructure and important strategic location assisted Qingdao to be ranked as 3rd most valuable seaport of China (Song 2010). This city is famous due to its national historical culture and coastal tourism. Qingdao receives ~ 30 million tourists every year. In 2017, Qingdao received 88.160000 million foreign and domestics tourists which are rapidly increasing from year to year.[1] The huge flux of beach visitors has been observed on multiple beaches of the Shandong during summer. For example, ~ 200,000 beach visitors were observed in the summer season on the Golden bathing beach, Qingdao.[2] However, various beaches of Qingdao have been suffering from several environmental issues in recent years. Likewise, algal blooms during summer and sea ice winter (Dong et al. 2010), heavy metal, and microplastic contamination were figured out at Shilaoren beach, Qingdao (Pervez et al. 2019; Wang et al. 2017). Aoshan Beach is famous for tourism, shipping, and recreational activities. It is located about 2 km (km) from the east of Aoshan Wei town and 20 km away from Jimo city. The length of Aoshan Beach is approximately 4 km and the width varies. The geographic location of the study area is shown in Fig. 1.

[1] http://qd.ifeng.com/a/20180912/6877126_0.shtml (Chinese translation).

[2] http://news.qingdaonews.com/qingdao/2015-08/17/content_11209692.htm (Chinese translation).

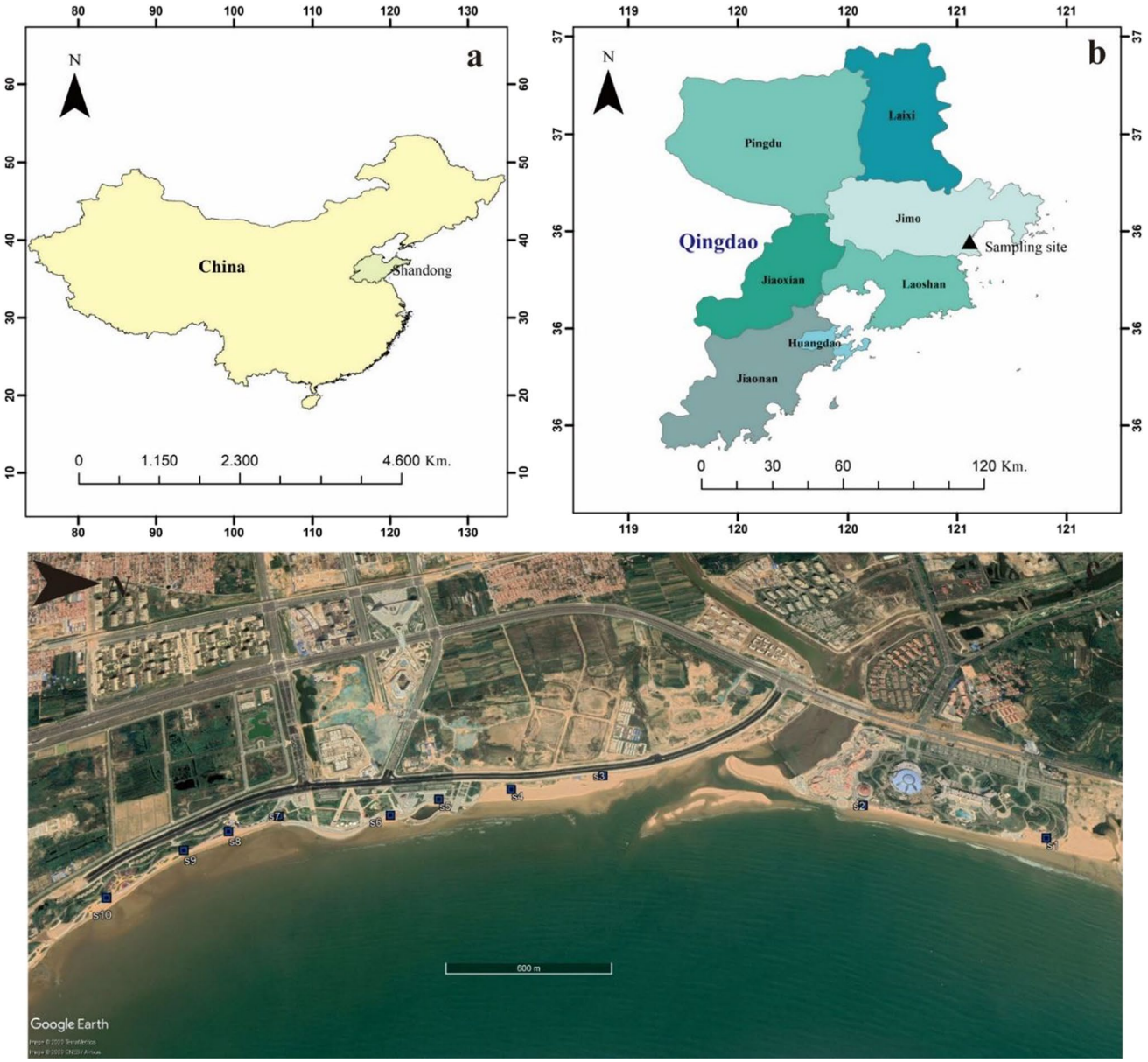

Fig. 1 Map of study area showing the different locations (**a**), China and Shandong province, (**b**) different district of Qingdao and sampling site. (**c**) sampling transects s1, s2,…… s10 on Aoshan Beach

Sampling method

The tri-monthly survey of the beach was carried out along the beachfront of Aoshan Beach in May, June, and July 2019. The sampling was undertaken in the summer season due to the high flux of beach visitors, while in winter it seems uninhabited on account of cold winter. A transects survey approach was employed due to its cost-effectiveness, efficient, low energy requirements, and time efficiency than other methods. This kind of survey has been previously applied in many studies (Ali and Shams 2015; Oigman-Pszczol and Creed 2007; Sheavly and Register 2007; Storrier et al. 2007; Williams et al. 2003) for the quantification and characterization of beach litter. Here, a total of 10 designated transects with equal width of 25 m were opted to count anthropogenic litter on Aoshan Beach. The sampling was performed in May which was repeated in June and then July 2019 for the selected transects. The transects were apart from each other with a distance of ~ 300 to 500 m (Fig. 1). GPS coordinates were recorded during a survey for replication and validation of outcomes. Transect lengths were considered as the distance between the first vegetation or concrete wall and the low tide shoreline (Santos et al. 2009). Anthropogenic litter larger than 3 cm was measured,

characterized, and weighed from each designated transect. Natural litter such as leaves, twigs, seaweeds were not enumerated during the beach survey. The collected items were distributed into 7 different predetermined litter types. These items were plastics, wood, rubber, glass, ropes, and cotton including t-shirts, pieces of clothing, metals, others containing cigarette packets, cigarette butts, electronic materials, etc., for each transect. Each item was counted and then distinctly weighed for 10 transects on Aoshan Beach. Moreover, 5 to 10 volunteers deliberately participated during the beach survey every time. A two-way analysis of variance (ANOVA) was performed to determine the significant difference between surveyed months, litter categories pertaining to the quantity and weight of litter. The number of litter items were expressed in items per kilometer (km), and corresponding weight in kilogram (kg) per km. Arc GIS and Google Earth software's produced a map of the study area. While IBM SPSS Statistics 20 performed the statistical analysis. Standard deviation (SD) was calculated in the Microsoft excel program for each transect concerning quantity and weight of litter items.

Results

Abundance of litter

A total of 442 ± 32.0 items of 7 predetermined litter with a corresponding weight of 23.74 ± 2.56 kg was recorded from selected transects of Aoshan Beach during May 2019. Similarly, approximately 500 ± 43.85, and 565 ± 49.62 items of the same types of litter were counted with the weight of 28.7 ± 3.63, and 35.01 ± 3.98 kg were weighed from the same designated transects during June and July 2019. The different types of litter on Aoshan Beach were shown in Fig. 2.

The total quantity of litter collected and weighed for three months was presented in Table 1. The analysis of variance showed a statistically significant difference ($p = <0.05$) among different types of litter with corresponding weights. The interactive effects of months and litter categories for the quantity of litter were given as,

$$F = (12, 42),\ p = 1.726,\ \text{partial } n^2 = 0.330,\ \text{observed power} = 0.773.$$

Similarly, the interactive effect of months and weight of different litter categories is as follow

$$F = (12, 4),\ p = 0.621,\ \text{partial } n^2 = 0.151,\ \text{observed power} = 0.294.$$

In term of area, the average quantity of litter was estimated to be 1688 ± 123.4 items/km in May 2000 ± 174.6, and 2260 ± 198.9 items/km in June and July with a corresponding weight of 94.2 ± 9,114 ± 14.2, and 139.6 ± 15.8 kg/km, respectively (Table 2). The overall average quantity of litter for three months was counted 4441 ± 364.16 items/km with an average weight of 260.52 ± 28.53 kg/km (Table 3).

Composition of litter

The finding of the present study showed that plastic litter was the most abundant item on Aoshan Beach, followed by (ropes and cotton), and wood. Plastic litter accounted approximately for 32.21% out of total litter items in May, 33% in June, and 32.75% in July for overall transects. As mentioned in Table 3, the average proportion of plastic litter for three months was estimated up to 32.21% followed by ropes and cotton, and wood accounted for 24.92% and 14.20%. In pairwise comparison, plastic was found to be significantly more common than all other types of litter (Fig. 3). However, the weight of ropes and cotton was the highest among others with weights of 5.4 ± 0.74 kg (22.92% of the total weight) in May, 6.17 ± 0.77 kg (22.11%) in June, and 8.0 ± 0.71 kg (22.73%) in July (see Table 1) for selected transects. The average weight of ropes and cotton for three months was estimated to be higher and comes out 58.67 ± 6.99 with the proportion of (22.52% of the total weight), followed by plastics 53.33 ± 4.71 (20.47%) and so on (Fig. 4). The average proportion of different litter types is listed in Table 3.

Discussion

Abundance of beach litter

The outcomes of the current study indicate that litter load along the Aoshan Beach, Qingdao, China was moderate than other studies elsewhere (Table 4). For example, the coastal region of the Gulf of Oman comprised 27.02 (± 14.48) litter items/km (Claereboudt 2004), and for the Australian beaches accounted 214 (± 68) litter per km (Taffs and Cullen 2005). The litter load on these beaches was lower than the present study (Table 4). Similarly, few other coastal regions such as Brazilian coasts (Santos et al. 2009), and few others (Table 4) had a greater amount of litter load than present findings. The variation of litter load among different coastal regions might be attributed to different anthropogenic activities and geographic features. These features could include population density or urbanization, wind direction, rate of beachgoers, recreational, fishing, maritime, and beach cleaning activities.

Fig. 2 Abundance of different types of litter on beachfront of Aoshan Beach

Table 1 Categories of litter with corresponding weights for three months of selected transects on Aoshan Beach

Litter type	May		June		July	
	Items	Weight/kg	Items	Weight/kg	Items	Weight/kg
Glass	35 ± 2.95	3.01 ± 0.29	40 ± 4.64	4.84 ± 0.66	50 ± 5.72	5.56 ± 0.80
Metal	25 ± 1.96	3.08 ± 0.21	35 ± 4.91	3.0 ± 0.43	30 ± 3.23	2.53 ± 0.31
Others	44 ± 3.06	1.99 ± 0.25	50 ± 6.77	3.39 ± 0.53	58 ± 5.94	4.0 ± 0.49
Plastic	131 ± 8.82	5.0 ± 0.45	165 ± 12.19	5.99 ± 0.53	185 ± 12.50	7.0 ± 0.68
Ropes & cotton	102 ± 7.02	5.4 ± 0.74	125 ± 6.45	6.17 ± 0.77	149 ± 11.57	8.0 ± 0.71
Rubber	20 ± 2.36	2.0 ± 0.21	15 ± 1.66	1.5 ± 0.17	25 ± 3.21	1.92 ± 0.27
Wood	65 ± 5.87	3.26 ± 0.41	70 ± 7.24	3.9 ± 0.56	68 ± 7.45	6.0 ± 0.71
Total	422 ± 32.0	23.74 ± 2.56	500 ± 43.85	28.7 ± 3.63	565 ± 49.62	35.01 ± 3.98

Table 2 Abundance of litter categories including weight (kg) per kilometer (km) for three months

Litter type	May		June		July	
	Items/km	Weight (kg)/km	Items/km	Weight (kg)/km	Items/km	Weight (kg)/km
Glass	140 ± 11.6	12 ± 11.60	160 ± 18.4	19.36 ± 2.4	200 ± 22.88	22 ± 3.2
Metal	100 ± 7.6	12 ± 7.60	140 ± 19.6	12.0 ± 1.72	120 ± 12.92	10 ± 1.24
Others	176 ± 12	7.6 ± 12.0	200 ± 26. 8	13.2 ± 2.12	232 ± 23.76	16 ± 1.96
Plastic	524 ± 35.2	20 ± 35.2	660 ± 48.4	23.6 ± 2.0	740 ± 50	28 ± 2.72
Ropes & cotton	408 ± 28	21.6 ± 28.08	500 ± 25.8	24.68 ± 3.08	596 ± 46.28	32 ± 2.84
Rubber	80 ± 9.4	8 ± 9.44	60 ± 6.64	6.0 ± 0.68	100 ± 12.84	7.6 ± 1.08
Wood	260 ± 19. 48	13.04 ± 19.48	280 ± 28.96	15.6 ± 2.24	272 ± 29.8	24 ± 2.84
Total	1688 ± 123.4	94.2 ± 9	2000 ± 174.6	114 ± 14.2	2260 ± 198.9	139.6 ± 15.8

Table 3 Average abundance of litter categories with corresponding weight percentage of each item per kilometer (km) for three months

Litter type	Items/km	Proportion	Weight (kg)/km	Proportion
Glass	366.67 ± 37.6	8.26	38.93 ± 4.63	14.94
Metal	280.0 ± 31.5	6.30	27.73 ± 2.97	10.65
Others	453.33 ± 46.7	10.21	27.33 ± 3.77	10.49
Plastic	1430.67 ± 100.2	32.21	53.33 ± 4.71	20.47
Ropes & cotton	1106.67 ± 69.3	24.92	58.67 ± 6.99	22.52
Rubber	173.33 ± 20.3	3.90	16.52 ± 1.88	6.34
Wood	630.67 ± 58.3	14.20	38.00 ± 3.99	14.59
Total	4441 ± 364.16		260.52 ± 28.53	

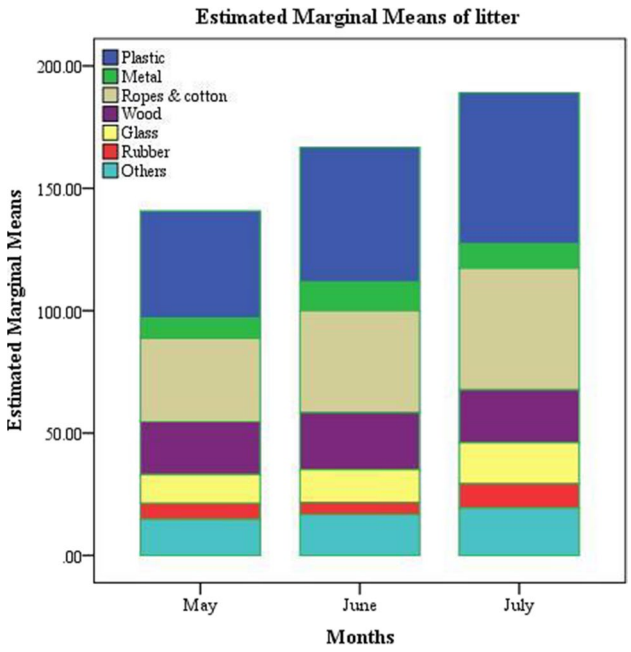

Fig. 3 Abundance of litter for three months. The plastic litter was significantly higher ($p = < 0.05$) than others in each studied month

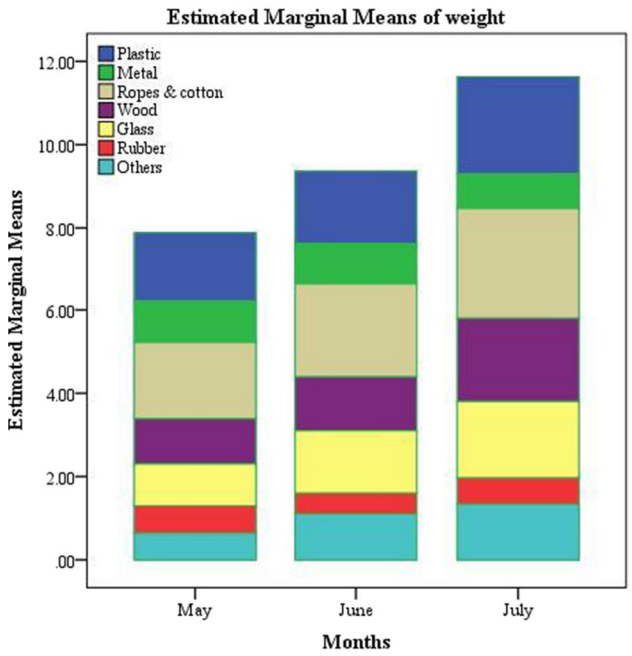

Fig. 4 The estimated weight of litter categories for three months. The weight of ropes and cotton was significantly greater ($p = < 0.05$) than other weights for each month

In addition, a couple of published reports about litter load on Qingdao and its surrounding beaches were presented in Table 5. The amount of litter load on those beaches was

Table 4 Comparison of Aoshan Beach with another coastal region worldwide

Beach	Items/km	Kg/km	Geographic proximity	References
Aoshan Beach	4441 ± 364.16	260.52 ± 28.53	Encompass Yellow sea, immense industrialized and populated, part of Southern Shandong peninsula	Present study
Bonaire, Caribbean	115,000 (± 58,000)	3408 (± 1704)	Southern Bonaire region include leeward and windward beaches, populated, volcanic islands, tropical hurricanes	(Debrot et al. 2013)
Belgium	64,290 (± 67,670)	92.7 (± 104.5)	Geographically lie near to central Europe, beaches along Southern North Sea, strong tidal current, dense population and urbanization	(Van Cauwenberghe et al. 2013)
Brazil	9100	–	Coastal region situated along Atlantic Ocean, highly urbanized, populated, and encompass many estuaries	(Santos et al. 2009)
Clifton Beach, Karachi, Pakistan	8665 (± 1483)	54.83 (± 8.58)	Populated coast of Arabian sea, encompass Lyari and Malir river, arid and hot desert environment	(Ali and Shams 2015)
Falkland Islands	77 (± 25)	17.3 (± 12)	Sparsely populated, military base is located inland, wind direction year-round is west/south west	(Otley and Ingham 2003)
Gulf of Oman	1790 (± 1040)	27.02 (± 14.48)	Omni coasts situated along the Gulf of Oman along the Arabian sea, less populated	(Claereboudt 2004)
Korean	4809 (± 2677)	865 (± 786)	Population density varies along different beaches, moderate and low slope, coasts lie along East sea. No major river to its surrounding	(Hong et al. 2014)
NS Whales, Australia	214 (± 68)	–	Coastal region of new south wales, near to village, tidal lagoon comprised of rock	(Taffs and Cullen 2005)
South African	37,400	100.5	Situated along Coffee Bay, no roads and industrial development by subsistence	(Madzena and Lasiak 1997)

Table 5 Prior investigations of litter load on beaches of Qingdao and its surroundings

Beach Name	Items	Weight	Reference
Aoshan Beach	4441 ± 364.16	260.52 ± 28.53	Present study
Duodaohai beach	44.98/100m^2	125.54 g/100m^2	(Zhou, 2015)
Forest Park beach	16.70/100m^2	421.89 g/100m^2	(Zhou et al. 2015)
No.1 Bathing beach	2,572/km	189 kg/km	(Pervez et al. 2020b)
Shilaoren beach	720/km	14 kg/km	(Pervez et al. 2020a)
Shanhaitian beach	8.48/100m^2	298.59 g/100m^2	(Zhou et al. 2015)
Wanpingkou beach	33.47/100m^2	519.53 g/100m^2	(Zhou et al. 2015)

estimated lesser than Aoshan Beach. This might be due to the lack of beach cleaning facilities on Aoshan Beach than other beaches. Likewise, beach cleaning activities carried out on regular basis at Shilaoren beach and No.1 Bathing beach, Qingdao (Pervez et al. 2020a, b) by appointed beach worker in the morning. Whereas, any placed garbage tank along the beachfront of Aoshan Beach by management authority for litter collection was not observed.

Beach litter composition

The finding of the present work depicted that plastic items counted were greater than all other types of litter on Aoshan Beach for three months. Moreover, many ropes made of plastic were not included in the plastic category here, because it was hard to distinguish plastic from the rope. The presence of the highest percentage of plastic items eases

Table 6 Abundance of different proportions of litter on several regions around the globe

Location	Glass %	Metal %	Plastic %	Ropes & cotton %	Rubber %	Wood %	Paper %	Others %	References
This study	8.26	6.30	32.21	24.92	3.90	14.20	–	10.21	This study
Brazil	1.3	1.6	56.6	–	–	–	17.2	22.3	(Tourinho and Fillmann 2011)
Japan	2.2	1	92.9	–	–	–	1	2.4	(Kusui and Noda 2003)
Dutch coast	4	6	67	–	–	–	8	15	(Gorycka 2009)
Scotland	9.4	5.5	54.2	–	–	–	4.7	26.3	(Storrier et al. 2007)
Gulf of Oman	2.7	3.4	61.8	–	–	–	2.1	29.9	(Claereboudt 2004)
USA	1.6	5.2	66.2	–	–	–	24.9	2.1	(Moore et al. 2001)
Australia	6.4	3.2	89.7	–	–	–	0.5	0.2	(White 2005)
Brazil	3	18	64	–	–	–	6	-	(Oigman-Pszczol and Creed 2007)

to make comparison with other studies. Numerous studies reported a greater proportion of plastic among the different litter. For example, many investigators (Gregory and Ryan 1997; Derraik 2002; Ribic et al. 2012) estimated that the proportion of plastic items varies from 60 to 80%. Similarly, the coastal region of the Motupore Islands contained 89.7% plastic items (Smith 2012), and Shilaoren beach Qingdao, China contained 56.69% plastics items (Pervez et al. 2020a). Additionally, the weight of ropes and cotton was higher than other litter weights followed by wood, glass, and so on (Table 3). Wood was prominently observed on many beaches (Claereboudt 2004; Hong et al. 2014). The composition of litter varied from the beach to beach due to multiple factors or attributes such as the behavior of people, beach visitors activities, and geographic proximity etc. Variation of overall litter composition was noted in previous studies (Table 6). In all those studies (Table 6), plastic litter was dominant including the present study which poses threat and endangers the beach and marine environment. Moreover, the plastic may be disintegrated into microplastics that can enter into the food chain and thus become a threat to human health.

Sources of beach litter and management consideration

The presence of different types of litter on Aoshan Beach suggested both terrestrial and maritime origins. A comprehensive model was drawn (Fig. 5), modified from (Critchell and Lambrechts 2016) to explicit the phenomena of litter transport in the region. The ropes and cotton were the second most common litter category which was likely to stem from maritime activities though many plastic items washed by tides rather than deposition. These items enter the sea and pose risk for the maritime ecosystem. In contrast, Aoshan Beach is flanked by the Yellow sea, which carries floating litter (low buoyancy) via waves or tides and deposited along the beachfront. Moreover, Aoshan Beach and its surroundings consist of many restaurants, Shandong University, Qingdao campus, and few food outlets. Tourists usually prefer fast food, noodles, mineral water, beer, wine, and soft drinks including some other mild stimulants such as chocolates, candy wrappers, and chips packets, etc. that lead to litter pollution. These things might be coming from beach visitors and show their terrestrial origin.

There is a need for possible mitigation and management measures on Aoshan Beach to overcome the quantity of litter to delaminate the potential effect of litter on the beach and maritime environment. O'leary et al. (2002) suggested that product improvement and modification are practical methods to reduce different types of litter. Morishige (2010) recommended that nylon ropes, fishing gears, and nets can be converted into eco-friendly and non-polluted electricity. Plastic was noticed as the most abundant litter on many beaches worldwide including in China. So, it is essential to take instant management measures to mitigate plastic pollution and implement site-specific management plans to reduce beach pollution. The enforcement of laws, policies, appropriate management process for different litter categories, circular economy, awareness in citizens could overcome litter generation at national and international level (Löhr et al. 2017; Poeta et al. 2016; Williams et al. 2016).

Education and awareness have been recognized as an efficient approach for sustainable management (Visbeck 2018), and should focus on marine litter (Hartley et al. 2018; Löhr et al. 2017; Vlachogianni et al. 2017). The local public participation in marine-related litter research can boost their awareness, knowledge, and motivation towards sustainable management (Locritani et al. 2019; Rayon-Viña et al. 2019). Ocean education is an integral aspect that underline the awareness among citizens to get suitable and sensible decisions regarding the marine environment (Dupont and Fauville 2017; Guest et al. 2015; Locritani et al. 2019; Santos et al. 2009). It is highly recommended to establish sophisticated recycling and waste removal facilities along Aoshan Beach for long-term policy. Training programs and technology transfer workshops must be conducted to highlight

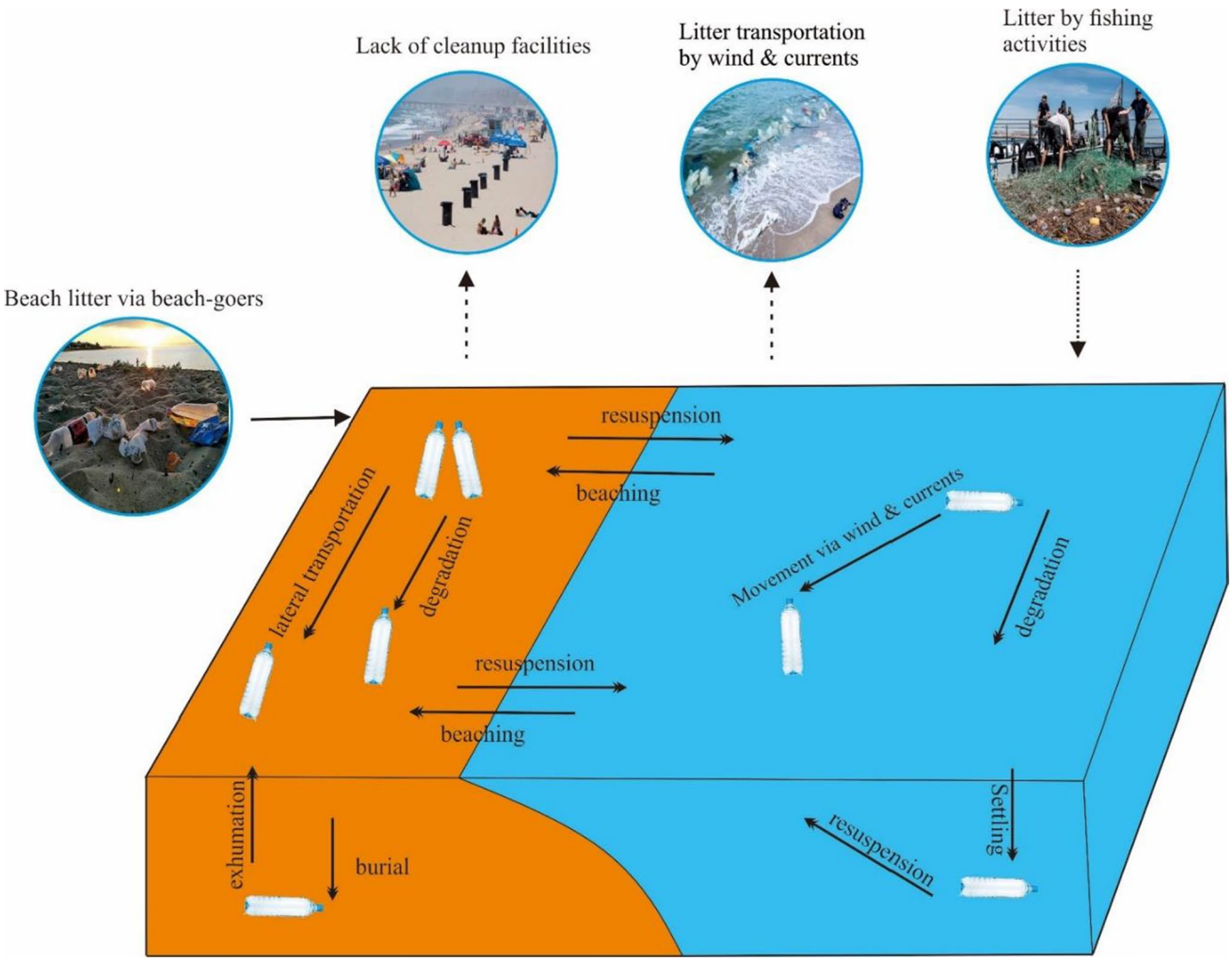

Fig. 5 Overall snapshot of litter processes in the region (Aoshan Beach). Modified from (Critchell and Lambrechts 2016)

the importance of recycling the materials. The promotion of community-based management policies is imperative to reduce inadequate litter. The polluter pay approach at community level might be an effective and efficient measure to prevent beach and marine environment from unwanted waste. Installation of separate garbage tanks for both biodegradable and non-biodegradable litter must be designated on the beachfront of Aoshan Beach.

Conclusion

This was the first-ever study conducted along the Aoshan Beach of Qingdao, China. The beach was mainly polluted by plastics, wood, rubber, glass, metal, (ropes and cotton), and others litter including cigarette packets, butts, electronic materials, etc. In terms of litter items, plastic was the most prominent litter followed by ropes & cotton, and wood. Ropes and cotton weighed greater than other litter followed by plastic, wood, and glass. The present study inferred that land-based origin and marine activities were the main sources of litter on Aoshan Beach. Beach cleaning facilities were lacking on the beachfront. The present study highly recommends instant measure which would be beneficent for possible management actions to mitigate litter pollution on Aoshan beach.

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problems along different beaches that has been created by rapid socio-economic growth of China.

Declarations

Conflict of interest There is no conflict of interest.

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