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# Marine debris surveys on four beaches in Rizhao City of China

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**ABSTRACT:** Compared with USA, UK, Brazil, Indonesia, Australia, etc., marine debris research in China has received less attention and few studies have attempted to quantify the abundance and mass of marine debris. In this paper, the abundance, composition and source of beached marine debris, and debris collection system and frequency as well as dustbins' conditionwere investigated in Duodaohai, Wanpingkou, Shanhaitian and National Forest Park beaches of Rizhao City from June 1 to 10, 2013. Based on these surveys, following conclusions were obtained: In four coastal beaches surveyed, the mean number and weight densities were 25.91 items/100m$^2$ and 341.39 g/100m$^2$, respectively. Most of the beached marine debris in the aforementioned beaches originated directly from land sources. There were two kinds of debris collection systems in these beaches at present; dustbins sometimes were not enough to be used in the swimming period.We hope that our study will be helpful to raise the level of environmental consciousness among people and to expand their anti-debris activities.

**Keywords:** *Abundance; Beached marine debris (BMD); Composition; Source; Rizhao City.*

## INTRODUCTION

Marine debris is defined as solid materials of human origin discarded at sea or reaching the sea through waterways (Zhou *et al.*,2011). It includes various man-made wastes which can be found in all beaches, ocean surfaces and seafloors or even isolated islands and unpopulated coastlines. (Benton, 1995; Gregory and Ryan, 1997; Haynes, 1997; Ribic *et al.*, 1997; Convey *et al.*, 2002; Otley and Ingham 2003; Rafee, *et al.*, 2008). Besides having significant immediate and accumulative effects on seabirds and marine mammals owing to entanglement and ingestion, marine debris can cause serious environmental and economic problems, particularly in areas dependent on fishing and/or tourism (Huin and Croxall, 1996; Croxall, 1997; Haynes, 1997; Laist *et al.*, 1999; Balance *et al.*, 2000; Sheavly, 2005). "Marine litter currently poses a dire, vast and growing threat to the marine and coastal environment", according to the United Nations Environment Program (UNEP, 2011).

At present, research on marine debris is primarily concentrated on the five following aspects: (1) Investigations of marine debris, which include surveys of Beached marine debris (BMD) (Bravo *et al.*, 2009; McDermid and McMullen, 2004; Martins *et al.*, 2011; Eriksson *et al.*, 2013; Rosevelt *et al.*, 2013), Floating marine debris (FMD) (Aliani *et al.*, 2003; Thiel *et al.*, 2003; Hinojosa and Thiel, 2009) and Seafloor marine debris (SMD) (Dameron *et al.*, 2007; Bauer *et al.*, 2008; Keller *et al.*, 2010).(2) Impacts of marine debris on marine wildlife and biodiversity (Raum-Suryan *et al.*, 2009; Votier *et al.*, 2011; Hong *et al.*, 2013). Marine debris has been a major threat to marine life (Derraik, 2002), and seabirds, turtles and marine mammals ingest plastic

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marine debris has been well acknowledged (Bond *et al.*, 2010; Lazarand Gracan, 2011; Williams *et al.*, 2011; Jantz *et al.*, 2013). (3) Methods of solving marine debris problems. These methods include investigations on sources of marine debris (Carson *et al.*, 2013) and uses of new technologies on detection of marine debris, such as webcam images and CIELUV (Kataoka *et al.*, 2012), GIS-based model (Martens *et al.*, 2012), numerical models (Lebreton *et al.*, 2012; Potemra, 2012). (4) Theories and experiments related with marine debris. For example, pathways of marine debris derived from trajectories of Lagrangian drifters (Maximenko *et al.*, 2012), small plastic debris changes water movement and heat transfer through beach sediments (Carson *et al.*, 2011), early microbial biofilm formation on marine plastic debris (Lobelle and Cunliffe, 2011), etc. (5) Reviews. For instance, marine debris review for Latin America and the Wider Caribbean Region (Ivar do sul *et al.*, 2007), Monitoring the abundance of plastic debris in the marine environment (Ryan *et al.*, 2009), a review of biodegradation of plastics waste (Gnanavel *et al.*, 2012) and a review of plastic waste biodegradation (Zheng *et al.*, 2005). Other aspects include the incentive program for fishermen to collect marine debris (Cho, 2009), and on North Pacific circulation and associated marine debris concentration (Howell *et al.*, 2012), and so on.

Compared with USA, UK, Brazil, Indonesia, Australia, etc, less attention is paid to marine debris research in China. Only a few studies have been reported in the domestic literature and these studies primarily focus on the following three aspects: (1) Treatment problems of domestic waste in a small island (Chen and Chen, 2010); (2) Monitoring methods, pollution investigations and potential risks of FMD on marine ecological system (Fan, 1997; Li, 2009; Su *et al.*, 2011); (3) surveys of BMD (Han *et al.*, 2010; Guo *et al.*, 2014). Few studies have attempted to quantify the abundance and mass of marine debris in China. Thus, only limited information is available on the marine debris condition in beaches or seawaters around China's coastal provinces (Zhou *et al.*, 2011).

The goals of this study are to identify the type, quantity and possible source of BMD, and debris collection system and frequency as well as dustbins' condition in Rizhao, China and contribute to the understanding, control and mitigation of such contaminant in the context of China's current conditions of high-speed socio-economic development and severe environmental deterioration. The objectives of this article are: (1) to identify the abundance and composition of BMD in the four beaches in Rizhao, China; (2) to identify the possible sources of BMD in the four beaches; (3) to assess debris collection system and frequency in the four beaches; (4) to analyze the condition of dustbins in the four beaches and identify whether they were enough to be used by beach goers, campers and cleaners in the swimming period.

This study has been performed in four beaches in Rizhao City of China during summer 2013.

## MATERIALS AND METHODS

### *Sites description*

Rizhao City lies in between 118°252 - 119°392 E and 35°42 -36°42 N. It's in the middle of China Mainland Coast and the southeast of Shandong Peninsula. It is adjacent to the Yellow Sea in the east and bordered by Linyi in the west, and Qingdao and Weifang in the north. It also shares a boundary with Lianyungang of Jiansu Province. Across the Yellow sea, it faces Korea and Japan to the east. Rizhao belongs to warm humid monsoon climatic area and the weather is moderate without summer heat and winter chilliness. The annual average temperature is about 12.5 °C. In 2009, Rizhao was recognized by the United Nations as one of the most habitable cities in the world.

The name Rizhao originated from an old saying 'It was the first to get the sunshine'. As the saying goes, the city is renowned for receiving nature's blessings with plenty of sun, sand and blue skies available all year round. Since 2003, the city has perfected the custom of receiving praise from State Tourism Administration as China' top tourist city. Duodaohai, Wanpingkou, Shanhaitian and National Forest Park beaches are the biggest ones in RizhaoCity (sometimes they are also called the first, second, third and fourth beaches, Fig. 1). The Duodaohai in Lanshan District and others are in Donggan District. The survey time was from June 1 to 10, 2013. Investigators are majority of students of year 2012 and some students of year 2011 in our college. They major in Geographic Science and are familiar with the conditions of these beaches, and have been trained before the surveys.

### *Methods*

All the BMD were basically classified into nine major categories (plastic, Styrofoam, wood, paper, metal, rubber, fabric/fiber, glass/ceramic, others materials including cigarette butts, food wrappers, construction waste and some shoes) according to the nature of the

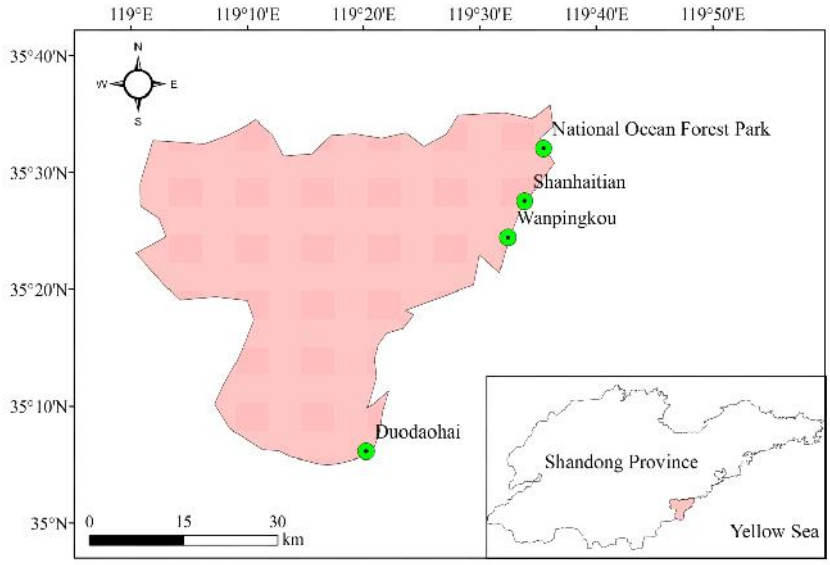


Fig.1: The location of investigated beached marine debris in the beaches of Rizhao City, Shandong province, China

material. The BMD surveys were conducted as near to low tide and whole beach as possible. Firstly, the investigation area was measured and calculated. Secondly, within the survey area, all the BMD was collected as long as they could be seen using eyes. Thirdly, gross number and weight of BMD were calculated and weighed. Fourthly, according to the survey area, mean number and weight densities (the units are items/100m$^2$ and g/100m$^2$, respectively) of every kind of category were calculated.

The investigation areas of the Duodaohai, Wanpingkou, Shanhaitian and National Forest Park beaches were 43767 m$^2$, 9900 m$^2$, 76755.5 m$^2$ and 5000 m$^2$, respectively. Within these regions, all the BMD was not accumulative, that is to say, all the BMD produced on that day was cleaned in the same day. Therefore, all the cleaners were told in advance that they would be replaced to collect all the BMD on that day when this beach was decided to clean. There are five major sources for BMD. They are coastal/recreational activity, related smoking activity, navigation/fishing activity, medical or sanitary activity, and other disposal source (e.g. wood, ceramics, plastic pieces, glass slices, bricks, etc). Moreover, the main BMD and source were also determined by interviewing some cleaners on these beaches.

At the same time, debris collection system and frequency, cleaners' incomes and the quantity of dustbins and distribution were also surveyed.

## RESULTS AND DISCUSSION

*Abundance and composition of beached marine debris*

In four coastal beaches surveyed, the mean total density of BMD was 25.91 items/100m$^2$and ranged from 8.48 to 44.98 items/100m$^2$. Wood was the most common, which accounted for more than 58.7%, followed by plastics (20%), Styrofoam (11.8%). Paper, metal, rubber, fabric/fiber, glass and other materials were scarce, which accounted for less than 5.0% of BMD. However, some sharp items, such as glass, plastic, construction waste had the potential to cause injuries.

The BMD mean number densities in Duodaohai, Wanpingkou, Shanhaitian and the Forest Park were 44.98, 33.47, 8.48 and 16.70 items/100m$^2$, respectively, with the maximum of Duodaohai and the minimum of Shanhaitian. The BMD mean weight density was 341.39 g/100m$^2$, with the maximum belonging to the category of plastics (127.68 g/100m$^2$), followed by wood (105.55 g/100m$^2$) and other materials (40.33 g/100m$^2$). As far as these beaches are concerned, the mean weight density in Wanpingkou was the highest (519.53 g/100m$^2$), while it was the lowest in Duodaohai (125.54 g/100m$^2$). In Shanhaitian and the Forest Park, the densities were 298.59 and 421.89 g/100m$^2$, respectively.

*Possible source of beached marine debris*

Sources of the BMD in the four beaches were shown in Table 1. In the four beaches, the primary source of

Table 1: Source of beached marine debris in the four beaches of Rizhao City

| Beach | Other disposal | Medical/sanitary | Navigation, fishing | Smoking related | Coastal/recreational activities |
|---|---|---|---|---|---|
| Duodaohai | 12.0% | 2.0% | 16.0% | 7.0% | 63.0% |
| Wanpingkou | 15.0% | 1.0% | 18.0% | 6.0% | 60.0% |
| Shanhaitian | 30.0% | 1.0% | 8.0% | 7.0% | 54.0% |
| Forest Park | 10.0% | 1.0% | 12.0% | 9.0% | 68.0% |
| Averege | 16.8% | 1.3% | 13.5% | 7.3% | 61.3% |

BMD was coastal/recreational activity (61.3%), followed by other disposal sources (16.8%), navigation/fishing activity (13.5%) and the activity related smoking (7.3%). Only1.3% was associated with medical/sanitary activities. Plastics and wood were the main BMD, therefore, most of the BMD originated directly from land-based sources. At the same time, the possible source of BMD was also determined by interviewing cleaners and employees of management departments. The sources also included runoff, storm water drains, sewers and irresponsible disposal of rubbish by beach goers and campers.

*Debris collection system and frequency*

There were two kinds of debris collection systems in these beaches at present. One was that environmental health workers were employed all the year round in the Duodaohai beach. The other was that cleaners worked only in the swimming period (about from June 25 to October 7 in every year) in Wanpingkou, Shanhaitian and the Forest Park beaches. These workers mainly were women and old people because salaries were in the comparatively low level and about 1500-2000 RMB in each month. Furthermore, work load was heavy in the swimming season. They usually worked twice from 8 am to 12 am and 2 pm to 6 pm every day.

*Dustbins*

There were different number of dustbins according to the different lengths and areas of these beaches. There was a dustbin about each fifty meters. These dustbins were often used by beach goers, campers and cleaners. According to our surveys, dustbins sometimes were not enough to be used in the swimming period. It appeared that absent or inadequate solid wastes collection and disposal is a major contributor to the marine debris problem in these beaches.

*Abundance and composition of beached marine debris*

Based on the Bulletins of Marine Environmental Status of Shandong Province in 2013, the BMD surveys were carried out in the beaches of seven coastal cities: Yantai, Weihai, Dongying, Binzhou, Weifang, Qingdao and Rizhao. The results showed that the BMD primarily included plastics, glass, paper, metal, fabrics/fiber, rubber, Styrofoam, wood and other materials. The mean weight density was 140.233 g/100m$^2$, respectively. The mean weight density of BMD in Shandong Province was obviously lower than in Rizhao.

At the same time, Rizhao coast belongs to the North China Sea Area that consists of the following coastal seawaters of provinces and municipalities: Liaoning, Tianjin, Hebei, and Shandong. According to the Bulletin of Marine Environmental Status of the North China Sea in 2013, the BMD was primarily comprised of plastics and glass. The mean weight density was 26.25 g/100m$^2$. Plastics were the most common and accounted for 39%, followed by glass (32%). It can be seen that the weight density of BMD in Rizhao was more than that in other coastal regions of the North China Sea Area. On the basis of the bulletins of marine environmental status of Chinese coastal provinces (or autonomous regions) in 2012 and 2013, the BMD data of each province was in Table 2. It can be concluded from Table 2 that the mean number and weight densities of BMD in Rizhao were clearly higher than those in other coastal provinces. The possible reason was that small items of BMD were not collected by governmental agencies or cleaning services. In other words, the debris that no matter how small it was, as long as we could see with eyes, must be collected.

As it can be known from the above analyses, in Rizhao City, BMD pollution was very serious. This should deserve special attention. According to Bravo *et al.* (2009), densities of AMD (anthropogenic marine debris) reported from beaches throughout the world could be known (Table 3). As the BMD collected was mainly associated with land-based sources, the BMD and AMD could be compared each other. The majority of research results in Table 2 were close to our surveyed results. As for the composition of BMD, related literature at home and abroad was cited so as to validate our surveyed result. Based on Zhou *et al.* (2011) and Thiel *et al.* (2003), related references were in the Table 4.As can be seen from Table 4, plastics were the primary BMD on beaches worldwide. The main reason was that it was extensively used for

Table 2: BMD data of Chinese coastal provinces

| Province | Time | Mean number density (items/100m$^2$) | Mean weight density (g/100m$^2$) |
|---|---|---|---|
| Hainan | 2013 | 43 | - |
| Guangxi | 2013 | 1.53 | 13.72 |
| Guangdong | 2013 | - | - |
| Fujian | 2013 | 6.71 | 156.4 |
| Zhejiang | 2013 | 9.7 | - |
| Jiangsu | 2013 | - | - |
| Hebei | 2012 | 0.95 | - |
| Liaoning | 2013 | - | 6.07 |

- Means no data
The BMD data of Chinese coastal provinces was from the bulletins of marine environmental status of corresponding provinces in 2013.

Table 3: Densities of AMD reported from beaches throughout the world

| Country | Number of surveyed beaches | Average densities (items/100m$^2$) | Maximum densities (items/100m$^2$) | Reference |
|---|---|---|---|---|
| Scotland | 16 | 40 | 230 | Velander and Mocogni (1999) |
| Brazil | 2 | 70 | 210 | Araujo *et al.*, (2006) |
| Brazil | 10 | 14 | ~50 | Oigman-Pszczoland Creed (2007) |
| Japan | 34 | 4,500,000 | 28,000,000 | Fujieda and Sasaki (2005) |
| Japan | 18 | 340 | 220,000 | Kusui and Noda (2003) |
| Russia | 8 | 20 | 1670 | Kusui and Noda (2003) |
| Oman | 11 | ~40 | ~90 | Claereboudt (2004) |
| Jordan | 3 | 400 | 740 | Abu-hilal and Al-najjar (2004) |
| Panama | 19 | 360 | - | Garrity and Levings (1993) |
| Australia | 1 | 50 | 50 | Foster-Smith *et al.*,(2007) |
| Australia | 6 | 10 | 30 | Cunningham and Wilson (2003) |
| Israel | 6 | - | 90 | Bowman *et al.*, (1998) |
| Pitcairn islands | 2 | 20 | 40 | Benton (1995) |
| Ireland | 1 | 20 | - | Benton (1995) |
| Indonesia | 21 | 460 | - | Evans *et al.*, (1995) |
| Chile | 43 | 180 | 8270 | Bravo *et al.*, (2009) |

various purposes and its long persistence in the marine environment (Derraik, 2002). In some research, other items (such as Styrofoam, wood or glass) were more common, maybe owing to local customs, specific sources, consume and discard habits as well as different population densities on the coast. In the beaches of Rizhao, the chief BMD were wood, plastics and Styrofoam, which was consistent with results of majority of researchers.

*Possible source of beached marine debris*

Possible source of BMD could be obtained on the basis of the bulletins of marine environmental status of Chinese coastal provinces (or autonomous regions) from 2007 to 2013 in Table 5. In the article of Ivar do Sul *et al.*, (2007), the authors also discussed the possible sources of BMD which are shown in Table 6.

As it can be suggested from the above analyses, there was no doubt that land-based sources of BMD were most representative and beach users were responsible for some debris (irresponsible disposal of rubbish was a major contributor to the marine debris problem). Most plastics and wood were associated with land-based sources and tourism since many countries had a direct economic dependence with tourism.

*Debris collection system and frequency*

For the responsibility to beaches' cleaning, most of beach goers attributed it to the local administration. However, preventing land-based debris from polluting the coastal environment was an ongoing and complex management issue (Cheshire *et al.*, 2009). It was true that those cleaners should be more paid and respected. But, BMD could be prevented and controlled through an effective collaboration of education, legislation, and innovation (Sheavly and Register, 2007). Firstly, a long-term public education campaign is required to reduce BMD. Community participation in beach clean-up and survey activities has been valued by several authors who believed it as an important strategy of increasing public awareness (Rees and Pond, 1995; Jackson *et*

*al.,* 1997; Storrier and McGlashan, 2006). Secondly, more regulation and legislation related to reduce BMD should be implemented. Regular trash and debris collection and cleanup beaches in waterways and storm drains were necessary (Zhou *et al.,* 2011). Thirdly, more new techniques for detecting BMD on beaches were used, such as webcam images and CLELUV, GIS-based model, numerical modeling, etc. Moreover, beach clean-ups involving many volunteer participants were also conducted on beaches throughout the world (Bravo *et al.,* 2009). Volunteer participation facilitated extensive samplings and thereby helped to obtain more information from a wider range to sites (Rees and Pond, 1995).

*Dustbins*

Besides the above measures of controlling BMD, some people suggested to increase number of rubbish bins on the beach (Iver do Sul and Costa, 2007). Insufficient garbage bins was one of the causes for the high densities of BMD on the surveyed beaches (Bravo *et al.,* 2009). Leal (2002) thought seventy percent of debris was related with beach users and suggested to increase rubbish bins on the beach. Santos *et al.* (2003) believed that ninety percent of debris was related with beach users ignore and also advised to increase garbage bins on the beach. Evidently, it was important to have enough dustbins on the beaches for collecting BMD. Following these surveys, we will continue our study. At the same time, it is very important to encourage people not to dump debris by adopting various measures. The authors hope that our study will be helpful to raise the level of environmental consciousness among people and to expand their anti-debris activities.

Table 4: The composition of BMD in the various seawaters and beaches

| Study area | Composition | Referfence |
|---|---|---|
| South China Sea | Plastics (42.0%) and woods (33.7%) | Zhou *et al.,* (2011) |
| Fog bay, northern Australia | Synthetic (45%) mental (35%) glass(16%) | Whiting (1998) |
| Cliffwood Beach, New Jersey, USA | Plastics (42.5%) glass(29.3%) | Thornton and Jackson (1998) |
| The Gulf of Oman | Plastics(61%), followed by wood, other organic items and metal debris | Claereboudt (2004) |
| Kachelotplate, lower SaxonianWadden Sea | Plastics(60.4%) wood(24.5%) glass(0.9%) metal(1.6%) | Liebezeit (2008) |
| Falkland Islands | Plastics (74%) metal (3%) glass(11%) cotton (12%) | Otley and Ingham (2003) |
| Costa do Dende (Bahia, Brazil) | Plastics(76%) Styrofoam (14%) | Santos *et al.,* (2009) |
| Curacao, west Indies: Public beaches | Plastics(47%) glass(20%) metal(17%)synthetic (10%) | Nagelkerken*et al.,* (2001) |
| Goto Islands, Japan | Plastics(58.1%) others(14.5%) styrofoam(9.0%) | Nakashima *et al.,* (2011) |
| North Carolina, USA | Plastics(45.6%) Styrofoam (31.9%) wood (9.1%) | Viehman *et al.,* (2011) |
| Port Dickson, Malaysia | Plastics(55.7%) Styrofoam (16.1%) Paper (10.4%) others(14.6%) | Khairunnisa *et al.,* (2012) |
| Bootless Bay, Papua New Guinea | Plastics (89.7%) | Smith (2012) |
| Midway Atoll, USA | Plastics(91.1%) Styrofoam (7.3%) | Ribic *et al.,* (2012) |

Table 5: BMD sources of Chinese coastal provinces

| Province | BMD source |
|---|---|
| Hainan | BMD was primarily derived from human coastal/recreational activities and land-based sources. |
| Guangxi | BMD is mainly from tourists' discarded things, such as cigarette butts, metal tins, glass bottles, plastic bags. etc |
| Guangdong | The chief source of BMD was human coastal/recreational activities, followed by other disposal sources and navigation activities |
| Fujian | No related information |
| Zhejiang | The marine debris was primarily from land-based sources |
| Jiangsu | The primary sources of marine debris were human coastal and recreational activities, navigation, fishing and other disposal sources |
| Shandong | The BMD was mostly attributed to coastal/recreational activities, followed by navigation/fishing activities and other disposal sources |
| Hebei | The main source of BMD was human coastal/recreational activities, followed by navigation/fishing activities |
| Liaoning | The marine debris was mainly created through discharges of municipal work, industries, fishing boats and ships, and coastal/recreational activities |

The data of BMD sources of Chinese coastal provinces was from the bulletins of marine environmental status of corresponding provinces from 2007 to 2013.

Table 6: The possible sources of the WCR (Wider Caribbean Region) and Latin America literature research

| Reference | Country | Main focus |
|---|---|---|
| Silva-Iniguez and Fischer (2003) | Mexico | Thirty-one percent had their sources recognized (18% land and 13% marine- based) |
| Lara-Domınguez *et al.* (1994) | Mexico | Debris was mainly from recognizable land-based sources |
| Chaparro and Velez (1997) | WCR | Marine debris sources at Puerto Rico. Recognized as mainly land-based sources |
| Singh and Xavier (1997) | WCR | Marine debris was recognized as mainly land-based sources |
| Wade *et al.* (1991) | Jamaica | Fifty-eight percent had their sources recognized (＞90% land and ＜10% marine-based sources). |
| Corbin and Singh (1993) | St. Lucia & Dominica | Most land-based sources |
| Costa *et al.* (2005) | Brazil | Land-based sources accounted for almost the totality of the items found on Pernambuco State beaches. |
| Leal (2002) | Brazil | Seventy percent related debris to beach users |
| Soares *et al.* (2007) | Brazil | Mostly plastics (73%-including cigarettes butts) attributed mainly to beach users |
| Widmer *et al*. (2004) | Brazil | Mainly land-based sources |
| Wetzel *et al.* (2004) | Brazil | Beach users appear as the main source |

## CONCLUSION

Marine debris causes various problems through its effect on local scenery, the ecosystem, tourism development and marine economies. It is not only a local problem but also a problem that escalates on a global scale. However, research on marine debris in China is still at an initial stage and there are many problems that need to be coped with. At present, the most important objective is to find out marine debris status in beaches or seawaters around coastal provinces, as well as the abundance, composition and sources of marine debris. However, because of limitations of fund, we only surveyed the conditions of BMD in the four beaches. In the following study, we hope to investigate the situation of FMD and SMD by the aid of more funds in the four bathing beaches.

In this article, based on the investigations in Duodaohai, Wanpingkou, Shanhaitian and the Forest Park beaches of Rizhao City, the abundance, composition and sources of BMD, debris collection system and frequency, dustbins' number and distribution were identified. The primary conclusions are as follows:

In four coastal beaches surveyed, the mean total density of BMD was 25.91 items/100m$^2$. Wood was the most common, which accounted for more than 58.7%, followed by plastics (20%), Styrofoam (11.8%). The BMD mean weight density was 341.39 g/100m$^2$, with the maximum of plastics (127.68 g/100m$^2$), followed by wood (105.55 g/100m$^2$) and other materials (40.33 g/100m$^2$). The BMD mean number and weight densities in Duodaohai, Wanpingkou, Shanhaitian and the Forest Park were 44.98, 33.47, 8.48 16.70 items/100m$^2$ and 125.54, 519.53, 298.59, 421.89 g/100m$^2$, respectively.

In the four beaches, the primary source of BMD was coastal/recreational activity (61.3%), followed by other disposal source (16.8%), navigation/fishing activity (13.5%) and the activity related smoking (7.3%). Only1.3% was associated with medical/sanitary activity. Plastics and wood were the main BMD, therefore, most of BMD originated directly from land sources. There were two kinds of debris collection systems in these beaches at present. One was that workers were employed all the year round. The other was that cleaners worked only in the swimming period (about from June 25 to October 7 in every year). In the swimming season, these cleaners' work load was heavy. There were different number of dustbins according to the different lengths and areas of these beaches. There was a dustbin about each fifty meters in average. These dustbins sometimes were not enough to be used in the swimming period.

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## CONFLICT OF INTEREST

The authors declare that there are no conflicts of interests regarding the publication of this manuscript.

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