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The preliminary assessment of abundance and composition of marine beach debris in the northern Persian Gulf, Bandar Abbas City, Iran

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Marine debris is a major challenge threatening ocean and coastal environment with no easy solution in coming years. The problem is totally manmade and extendeds to coastal areas around the world. The accumulation of marine debris is largely due to lack of awareness and environmental education among the public reinforced with mismanagement of municipal litter in coastal cities. Iran has about 2415 km of coastlines in the north and south of the country that suffer severely from a marine debris problem. Despite the great scale of the problem that leads to the shutdown of some beaches to beachgoers, there are no documented data on the abundance, composition and sources of marine debris dispersed on beaches. With the cooperation of marine biology student volunteers, we surveyed beaches at two scales, 100 m and 1 km searching for litter in varying ranges. The results revealed that the most common items are made of plastic/polystyrene. Tourism and recreational activities are responsible for more than 90% of litter production on the study beach. Fisheries and aquaculture are the second source of most abundant marine litter found on the beach with considerable distance from tourism activities. We conclude that lack of education about the consequences of marine litter is the main reason for marine debris at the study beach. Another reason is related to rapid construction of coastal areas and development of coastal cities with no proper infrastructure to manage municipal littering.

Keywords: marine beach debris, assessment, the Persian Gulf, Bandar Abbas city

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INTRODUCTION

One of the most ubiquitous and major problems threatening our marine environment is accumulation and fragmentation of solid debris particularly plastics (Barnes *et al.*, 2009; Thompson *et al.*, 2009). This versatile, inexpensive, light weight, durable and transparent material has many applications in our daily life with the annual global production at 245 million tonnes (Andrady, 2011). Since the mass production of plastics commencing around the 1950s, plastic items have accumulated around the world from pole to pole and are even reported from remote islands (Moore *et al.*, 2001a, b; Edyvane *et al.*, 2004; Barnes, 2005; Thompson *et al.*, 2009; Eriksson *et al.*, 2013; Thiel *et al.*, 2013). Despite the widespread recognition of the problem, evidence suggests that plastic debris accumulation is still increasing (Moore, 2008; Barnes *et al.*, 2009; Ryan *et al.*, 2009). The sources of the marine debris are from both land-based and marine-based activities, although it is estimated that half of the marine debris is produced from land-based activities (Sheavly & Register, 2007). On shorelines, accumulation of marine debris, especially plastics, is greater in the northern than in the southern hemisphere and there is evidence that plastic fragments are buried in the sediment (Barnes *et al.*, 2009; Ryan *et al.*, 2009). Marine debris is not only an eyesore but the potential hazard to marine biodiversity from tiny filter feeders to giant mammals in all oceans (Laist, 1997; Thompson *et al.*, 2009; Van Franeker *et al.*, 2011). Entanglement in plastic items, particularly discarded fishing gear is a serious threat to marine animals (see Laist, 1997; Moore *et al.*, 2009). Ingestion of stranded and fragmented plastic items can have fatal consequences for marine species (Browne *et al.*, 2008; Van Franeker *et al.*, 2011, Ramos *et al.*, 2012, Cole *et al.*, 2014). Many comprehensive studies have been done to quantify and monitor coastal debris around the world (OSPAR, 2007b; Cheshire *et al.*, 2009; information is also available at marinedebris.noaa.gov) but no such data have been reported for the coastline of the Northern Persian Gulf. The data collected in this research have been derived from volunteer beach debris monitoring efforts conducted during May 2014. Here we present the first quantitative assessment of marine debris found along Bandar Abbas beach. We aimed to understand the amount and composition of marine debris along the coastline of Bandar Abbas to determine their origins. The data

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are valuable for decision makers in the initiation of national projects to deal with the marine debris problem.

MATERIALS AND METHODS

This study was conducted as a pilot project to assess marine litter on the Bandar Abbas coastline with a quantitative approach. Marine beach litter was distinguished in the field following the definition of marine debris of UNEP (2009): 'Marine debris is any manufactured or processed solid waste material that has been accidentally or deliberately released to the sea', available at http://www.unep.org/regionalseas/marinelitter/about/default.asp. Beach debris was collected based on the standard method introduced by OSPAR commission entitled 'OSPAR Pilot Project on Monitoring Marine Beach Litter, Monitoring of Marine Litter in the OSPAR region' (OSPAR, 2007b). This survey was completed by student volunteers from Bandar Abbas University. The survey site is a stretch of 6 km upper limit of a beach located in Bandar Abbas coastal park (27°11′10.22″N 56°20′10.89″E).

The selection of sites was made according to OSPAR (2007b) guidelines. The criteria include sediments of sand or gravel, exposed to open water, according to visual observation frequently littered, good accessibility to the surveyors, over 1 km in length, and not located near input sources of wastewater (OSPAR, 2007b).

The selected area is used heavily as an intertidal fishing ground and known as a recreational site for youth and families. Beach litter was collected and sorted at two different scales (100 and 1000 m). Materials used for this survey were simple and inexpensive. We used gloves, pencils, printed paper forms and rubbish bags prepared by Bandar Abbas University. Ten

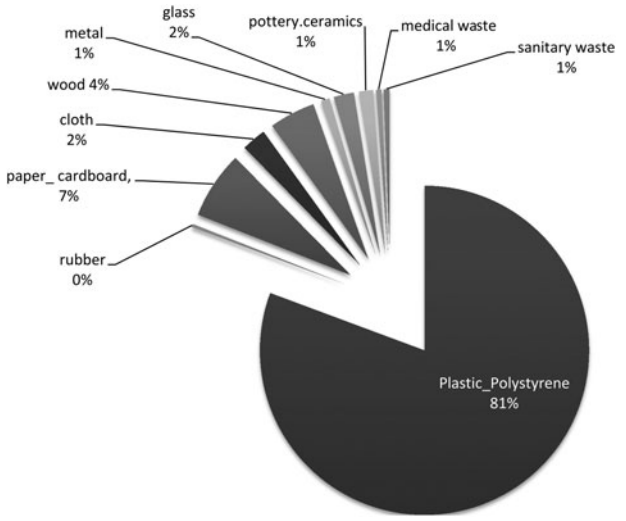

Fig. 1. Proportion of different debris categories found in 100 m stretches of beach during the project on May 2014 on the coastline of Bandar Abbas, northern part of the Persian Gulf, Iran.

categories of debris were determined based on OSPAR monitoring beach litter guidelines (2007b). Each debris item was identified, photographed and documented in the printed survey forms. Data analysis was done using Excel.

RESULTS

An average of 456 items of varying sizes were found per 100 m stretch of Bandar Abbas beach. Following the global tendency

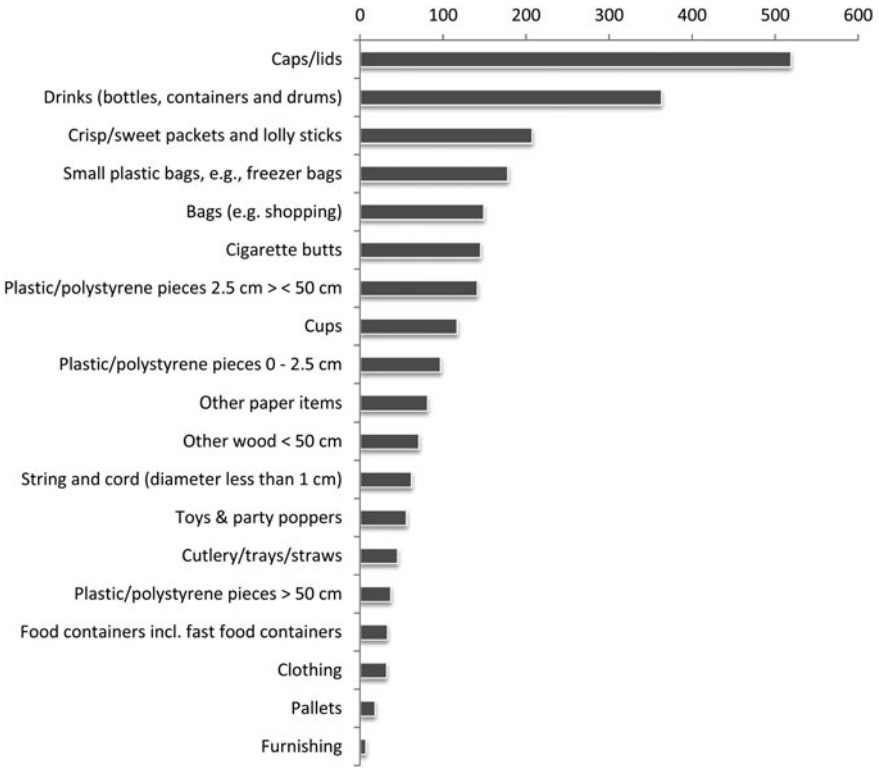

Fig. 2. The most common marine litter items found in the highest number on 100 m stretches of beach in Bandar Abbas, northern part of the Persian Gulf, Iran.

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Table 1. Sources and indicators selected for data analysis in the survey area on Bandar Abbas beach.

Sources	Indicators
Fisheries including aquaculture	Jerry cans, fish boxes, fishing line, fishing weights, rubber gloves, floats/buoys, ropes/cords/nets <50 cm, and >50 cm, tangled nets/cords, crab/lobster pot, oyster nets and mussel bags, oyster trays, plastic sheeting from mussel culture ('Tahitians')
Galley waste from shipping, fisheries and offshore activities (non-operational waste)	Cartons/tetrapaks, cleaner bottles, spray cans, metal food cans, plastic gloves, plastic crates
Sanitary and sewage-related waste	Condoms, cotton bud sticks, sanitary towels/panty liners/ backing strips, tampons/tampon applicators, other items
Shipping, including offshore activities (operational waste)	Strapping bands, Industrial packaging, Hard hats, Wooden pallets, oil drums (new and old), light bulbs/tubes, injection gun, containers
Tourism and recreational activities	4–6-pack yokes, plastic shopping bags, plastic bottles/containers for drinks, metal bottles/ containers for drinks, plastic food containers, glass bottles, crisp/ sweets packets and lolly sticks, caps/lids, cutleries/trays/straws, cigarette butts, cups, small plastic bags; freezer bags, cloth

(Derraik, 2002) the largest proportion of marine litter found in coastlines was made of plastics. In this survey at the scale of 100 m, more than 80% of total items were plastic debris. Paper and wooden materials ranked second and third (Figure 1).

The most common items found in the highest number were made of plastic/polystyrene including caps/lids, drinks (bottles, containers, drums) and crisp/sweet packets and lolly sticks (Figure 2). Our results indicate an average density of 4.5 items per metre in this 6 km beach survey.

To estimate the sources of marine litter in this area, we defined some marine litter items as indicators for five categories of potential origins of marine debris (Table 1). The possible sources of marine coastal litter includes fisheries and aquaculture, shipping activities, sanitary and sewage-related waste, shipping including offshore activities, tourism and recreational based waste.

Analysis shows that the marine debris left on the beach is mainly produced by beach users and recreational activities (Figure 3). About 94% of all marine items originated from beach users. Fisheries and aquaculture in the area is responsible for about 2% of observed marine litter on the beach.

For the 1000 m scale of the survey, the 4 km of the beach were investigated to determine the quantity and composition of all marine litter >50 cm in size. An average total number of 106 items was found in the study area. The highest proportion of marine litter were plastics which represented about 74% of total debris (Figure 4).

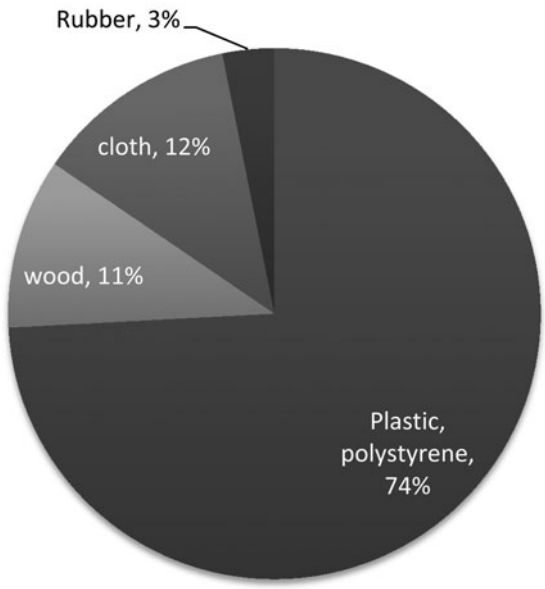

Fig. 4. Proportion of marine debris >50 cm recorded in 1000 m stretch of beaches during the project on May 2014 on the coastline of Bandar Abbas, northern part of the Persian Gulf, Iran.

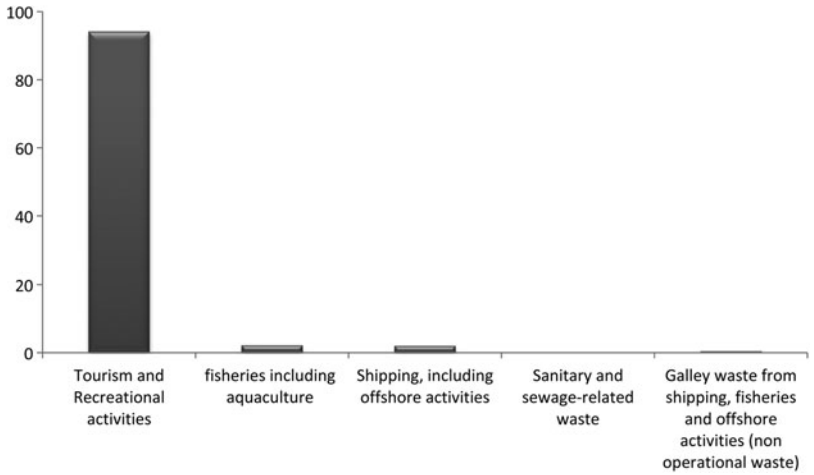

Fig. 3. Sources of all marine litter found on on 100 m stretches of beach in Bandar Abbas, northern part of the Persian Gulf, Iran.

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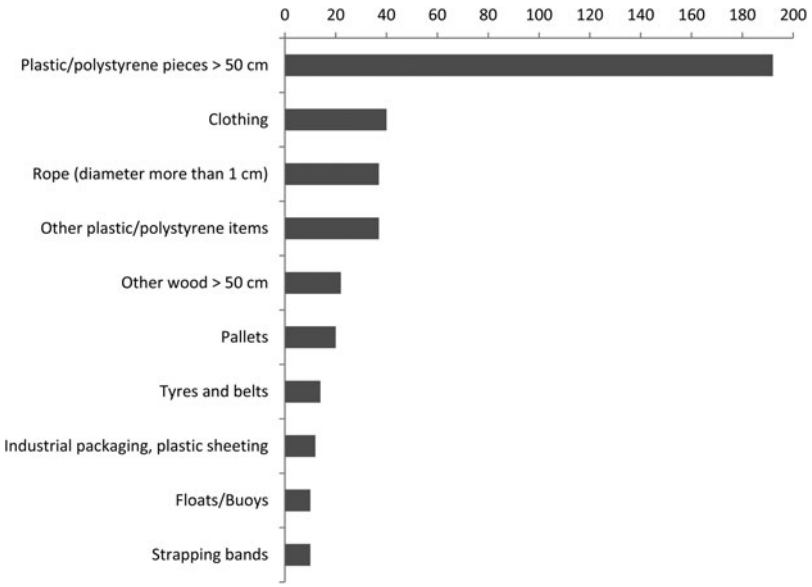

Fig. 5. The most common marine litter items >50 cm found in the highest number on 1000 m stretches of beach in Bandar Abbas, northern part of the Persian Gulf, Iran.

The most common items were plastic/polystyrene materials and clothing was the second-most common item observed on the reference beach (Figure 5). Of the other 10 categories found, plastic rope from the plastic/polystyrene category was third, which mostly indicates residuals of fisheries activities on the beach.

DISCUSSION

Marine debris is a multidimensional problem of global scale that particularly challenges coastal communities (Cheshire *et al.*, 2009). Despite the large-scale effort from different commissions and institutes (OSPAR, 2007b; Cheshire *et al.*, 2009; NOAA available at marinedebris.noaa.gov) the problem remains unsolved till today. Iran has an extended sea coast border which is estimated as about 644 km lying along the southern Caspian shore and about 1770 km on the northern part of the Gulf of Oman and Persian Gulf (Fisher, 1968). Globally, the main source of marine litter is from land-based and oceanic-based activities, with 50% originated from land (Sheavly & Register, 2007). The Persian Gulf is under tremendous pressure from many levels such as hydrocarbon pollution, heavy construction, offshore activities, severe drought caused by construction of dams, and changes associated with global warming (Sheppard *et al.*, 2010). The rapid pace of heavy construction in coastal areas and mismanagement of municipal litter results in beaches and intertidal zones being dumping places of litter. As our results revealed (Figure 3) the origin of marine debris found on these beaches is mainly due to beach users' behaviour, in that they accidentally or intentionally left their litter on the beach. A volunteer-based study conducted on Chilean beaches showed that the average of small plastic items per m^2 is 27 and that these originated from coastal urban centres and their economic activities (Hidalgo-Ruz & Thiel, 2013). Another similar study on a Caribbean coast in mangrove beach sites revealed that plastic and polystyrene items were the most abundant debris (Debrot *et al.*, 2013). The second source of marine litter is from fisheries activities (Figure 3) although it is not considerable compared with tourism and recreational activities. The traditional fishing method that is known as 'Moshta' is frequently observed at the intertidal zone. This efficient and environmentally friendly method of fishing is a cage of wooden bars that is embedded on the intertidal areas with a coverage of nets around it that simply traps fish and other marine animals. Fishermen collect animals at low tide by walking on the dry beach. It is estimated that some wood and nets are lost in storms or destroyed.

As well as the health and aesthetic problem, marine debris has fatal consequences for marine biota (Laist, 1997; Browne *et al.*, 2008; Cole *et al.*, 2014). Our great concern is about the amount of plastic items found on the beach (Figures 1 & 4). Following the global tendency (Ryan *et al.*, 2009; Thompson *et al.*, 2009) this non-degradable, long durable and inexpensive polymer makes up the highest percentage of total items recorded in the area. Recent studies show that fragmentation of plastic debris produces small fragments called 'microplastics' with harmful impacts on all trophic levels either through direct consumption or by release of chemicals (Rios *et al.*, 2007; Teuten *et al.*, 2009; Thompson *et al.*, 2009; Ivar do Sul & Costa, 2014).

We suggest expanding the environmental educational systems in coastal borders along with establishing anti-littering policies, to raise awareness about the consequences of litter on the marine environment. Littering behaviour is the one that needs to be changed. Due to the fatal consequences of marine debris on marine biota, immediate concern is vital in Iran. We recommend to marine biologists and policymakers to open up serious and immediate discussion in this field of research in Iran.

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