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Preliminary study on marine debris pollution along Marina beach, Chennai, India

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HIGHLIGHTS

- A total of 6,872 pieces of debris falling in 46 categories (as per NOAA method) were collected in four surveys conducted in Marina beach between March 2015 and April 2015.
- The average number and weight of the debris per 100m is found to be 171.8 and 3.24 kg respectively.
- Plastic debris formed the majority of all the debris items (44.89 %) collected on the beaches during the survey period.
- The main sources of beach debris were shoreline/recreational activities (74.46 %) based on ICC method.

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ABSTRACT

Marine debris is a global issue with adverse impacts on marine organisms, ecological processes, aesthetics and economies. Numerous studies have been conducted to quantify debris on the beach, few of these have been conducted in the Chennai coast and are carried out by volunteers and NGOs. This preliminary study involves collecting and quantifying of various debris along the Marina beach in Chennai, India by conducting survey along the waterline as prescribed by the NOAA Marine Debris Program. Debris was collected on four occasions between March 2015 and April 2015 from 10 transects, each 5 m wide and 100 m long, sorted and categorized by type, quantity and concentration rate along the coastline. The results indicate that the plastic, paper and wood debris occur in the greatest number followed by food waste and metal. The major contributing factor for the debris abundance in Marina beach is the local recreational activity which suggests that the land-based sources provide major inputs to plastic pollution at the beach. These results reinforce that similar large scale projects, monitoring larger areas for considerably longer durations are to be undertaken for accurate quantification of available debris and their impacts on coastal habitats.

1. Introduction

The National Oceanic and Atmospheric Administration (NOAA 2011) defines marine debris as any persistent solid material that is manufactured or processed and directly or indirectly, intentionally or unintentionally, disposed of or abandoned into the marine environment or the Great Lakes. Marine debris causes problems beyond creating an eyesore for tourists. It is a source of serious damage to marine lives, ecosystems, fisheries, and navigational safety (Barnes, 2002; Derraik, 2002; Donohue et al., 2001; Hall, 2000; Hong et al., 2013; Rochman et al., 2013). Research efforts indicate that the amount and variety of marine debris present in the global oceans are considerable, increasing, and constitute a threat to the marine environment (Edyvane et al., 2004; Lidia and Fischer, 2003). Thus the marine debris is clearly a global issue, affecting all major water bodies above and below the surface. The marine debris can adversely impact humans, wildlife and the economic health of coastal communities (Sheavly and Register, 2007).

Marine debris load is often measured by land-based surveys along shorelines (Frost and Cullen, 1997; Cunningham and Wilson, 2003; Storrier et al., 2007; Hong et al., 2014). Beach surveys can identify the distribution and variation in litter quantity and type, through aggregate spatial and temporal beach monitoring (Rees and Pond, 1995; Kusui and Noda, 2003; Edyvane et al.,

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2004; Oigman-Pszczol and Creed, 2007). Beach litter surveys have been conducted around the globe for the purposes of better understanding the types and distribution of marine debris (Golik and Gertner, 1992; Velander and Mocogni, 1998; Kusui and Noda, 2003; Martinez-Ribes et al., 2007; Santos et al., 2009; Moore et al., 2011; Hong et al., 2014).

The marine debris research is comparatively poor in India and most of the published data are in the form of reports from NGOs and other voluntary groups as a part of the coastal clean-up event. Nigam (1982) was the first to study the origin of plastic pellets along the Caranzalem beach of Goa. Dharani et al. (2003) reported unusual quantities of marine debris along the Great Nicobar Island and concluded a prospective improper handling of the solid waste in adjacent foreign countries. The impact of ship breaking and marine debris accumulation along the Gulf of Cambay was studied and categorized into different polymer groups by Reddy et al. (2006). Sridhar et al. (2007) quantified the plastic litter along five sandy beaches of Karnataka, India. Ganesapandian et al. (2011) have reported the highest debris type to be plastic from the Northern Gulf of Mannar region on the Southeast coast of India. The impact of various anthropogenic activities along the Indian coastline was studied by Kaladharan et al. (2012) by monitoring the parameters such as CO_2, BOD, TSS, NH_3, NO_3, primary productivity, quantity of plastics and other non-biodegradable materials. Jayasiri et al. (2013) assessed the quantity of plastic debris on recreational beaches in Mumbai, India and studied the seasonal changes in the debris load.

The Marina beach on the Southeast coast of India is extensively used as a recreational beach. The recreational uses such as swimming, surfing and picnicking generate debris such as food wrappers, plastic bags and cups, trash bags, product containers, toys and floats. Most of the debris data for beaches outside India have been collected systematically and scientifically, while most of the debris information in India has been collected mainly through beach clean-up activities. Although these activities give valuable insight to the debris problem they do not provide a quantitative estimate of each debris type. In this experimental study, we take the first step to assess the type and amount of debris for a small part of Marina beach. Further long term monitoring studies have to be carried out on different types of beaches to assess the impact of the debris on the ecology of the beach.

2. Materials and methods

2.1. Study area

Chennai Metropolitan City is located on the Southeast Coast of India with 56 km coastline and is the capital city of Tamil Nadu state. Chennai is the fourth most populous metropolitan area and the sixth most populous city in India with an estimated urban agglomeration of over 8.6 million people (http://www.chennai.tn.nic.in). Marina Beach is a natural urban beach in the city of Chennai, along the Bay of Bengal, part of the Indian Ocean. The Marina Beach runs for 12 km along the shoreline of the city. Two rivers meander through Chennai, the Cooum River through the centre and the Adyar River to the south. A third river, the Kortalaiyar, flows through the northern fringes of the city before draining into the Bay of Bengal at Ennore. The average width of the beach is 300 m with the maximum width of 437 m.

The Marina beach is the most crowded beach in the country and attracts about 30,000 visitors a day during weekdays and 50,000 visitors a day during the weekends and holidays. During summer months, about 15,000–20,000 people visit the beach daily (https://en.wikipedia.org/wiki/Marina_Beach#cite_note-12). For this study a portion of Marina beach was considered between 13° 3′36.568″ and 13° 3′38.261″ of the Northern Latitude and 80° 17′12.723″ and 80° 17′13.137″ of the Eastern Longitude and transects were carried out as prescribed by the NOAA Marine Debris Program (2011).

2.2. Survey method

Our study was conducted in a small area of the Marina beach, immediately south of Chennai Harbour and Cooum River. This beach experiences some of the lowest wave energy and is considered to be depositional (Kumar and Kunte, 2012). Fig. 1 shows the location of the study area. The beach survey was carried out bimonthly with a total of four surveys between March 2015 and April 2015. The access to the beach is open to the public and fishermen and there are no management regulations to clean up the beach at regular intervals. Also no permits were required for this study and field work. The samples were collected along ten transects each 5 m wide and 100 m long from the High Tide Line towards the vegetation line covering an area of 5000 m^2. All existing marine debris on the beach were removed at the end of February 2015 so as to remove possible effects of accumulation during the past months. For each survey, recorders walked back and forth along the 100 m transects and collected all visible anthropogenic litter in individually labelled plastic bags. Only surface debris was removed and no attempt was made to exhume buried items unless they protruded through the beach surface.

2.3. Classification and quantification

Survey results were recorded on data sheets of (Lippiatt et al., 2013) that listed 46 types of debris grouped into seven categories according to the type of materials naming plastics, metal, glass, rubber, wood/paper, cloth/fibre and others (food waste and corn stalk). Each debris type was separated, sorted, counted and placed in separate plastic bags. These 7 categories of debris were further characterized into five broad categories of origin namely, shoreline/recreational, ocean/waterway, smoking related, dumping, and medical/personal hygiene activities (ICC, 2009). The items that were too small or too degraded were categorized as 'others'.

Marine debris concentration was calculated per transect using the formula

$$C = \frac{n}{W * l}$$

where C = concentration of debris items (# of debris items/m^2); n = number of macro-debris items observed; w = width (m) of shoreline section recorded during sampling and l = length (m) of shoreline sampled.

3. Results

3.1. Quantities of beach debris

A total of 6872 pieces falling in 46 debris categories were collected in bimonthly survey conducted on the Marina beach between March 2015 and April 2015. The total weight of the debris was 129.67 kg (Table 1). The average number and weight of the debris on the beach were 171.8 counts/100 m and 3.24 kg/100 m respectively (Table 2). There is a clear and systematic difference in the seasonal pattern in abundance and weight of the debris observed during different sampling periods. The total number of items and weight were relatively higher in the April as compared to March (Fig. 2). The concentration of debris items was calculated from NOAA method and was found to be 1.37 items/m^2. This value is small when compared with other studies and could be attributed to the patchy occurrence of the debris (Rees and Pond, 1995; Kusui and Noda, 2003; Edyvane et al., 2004; Oigman-Pszczol and Creed, 2007).

The standard deviation when applied on the individual average of the quantities showed lumber to vary maximum with different