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Marine Litter in the Northern Part of Gulf of Mannar, Southeast Coast of India

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ABSTRACT

Marine litter has become one of the problematic concerns in the Gulf of Mannar. This study was aimed to survey and evaluate the composition, abundance, distribution and quantification of the types, amount, sources and impact of marine litter on the beach of the Gulf of Mannar region. This is first of its kind in India especially in the Gulf of Mannar. Quantification, source and impact of marine litter in the Gulf of Mannar, India were surveyed from March 2006 to February 2008. Maximum shoreline marine litter was noticed in May and June 2007 and the minimum was noticed in Feb. 2008. Occurrence of Shoreline marine litter during the Southwest monsoon period was the maximum and the cool winter period was the minimum. The maximum shoreline marine litter was 94-95 items of 5,409-6,588 g and the minimum shoreline marine litter was 42 items of 2,088 g. Eight percent of the total litter included only three major items, viz., Plastic (48%), polystyrene (18%) and cloth (15%). Fishing represented the largest source, Tourism/recreation was the second and Sewage Related Debris (SRD) was the third common source of marine litter. Stranded marine animals and impact on the ecosystems of coral reef, seagrass were also observed. The findings revealed the factors such as proximity of a given beach to a population center, pilgrim and Southwest monsoon wind which most dominantly affect the litter distribution in the Northern Gulf of Mannar coastline.

Key words: Gulf of Mannar, marine litter, coral reef, seagrass ecosystems, Southwest monsoon

INTRODUCTION

The Gulf of Mannar (GoM) is referred as the Biologist's paradise because of the rich marine ecosystem with nearly 3600 species of living flora and fauna, apart from the seasonally migrating marine mammals like whales, dolphins, Dugongs and turtles. It is unique because of the presence of coral reefs, seagrass beds and mangroves, which act as spawning and feeding grounds and as shelter for many species of economically important finfish and shellfish. In recent years, this unique paradise is facing a lot of disturbance and threats due to anthropogenic and natural interference on the resources (Sacratees and Karthigarani, 2008). Both public and institutional awareness of importance of protecting the natural environments has increased in several countries during last few decades (Al-Kahem-Al-Balawi *et al*., 2008) Industrial activities, usually carried out in developing countries with weak legal framework and regulation infrastructure, led to pollution of water resources, destruction of fauna and flora, health hazards and deterioration of health quality (Eneh, 2011a, b). Marine litter has become one of the problematic concerns of marine environment

managers in many countries around the world. World-wide scientific studies on marine litter have indicated that litter is dangerous to animals like sea turtles, sea cows (Dugong), Dolphins, whales, sharks, sea birds, sponges and coral reef ecosystem, especially to the endangered animals (Bugoni *et al*., 2001; Barreiros and Barcelos, 2001; Sazima *et al*., 2002; Mascarenhas *et al*., 2004).

Marine debris is also often termed marine or beach litter. Marine debris has been defined as 'solid materials of human origin that are discarded at sea or reach the sea through waterways or domestic and industrial outfalls' (NAS, 1975); 'Dumping at sea of solid wastes originating from land-based sources' (Lentz, 1987); any manufactured or processed solid waste material that enters the marine environment from any source' (Coe and Rogers, 1997); 'Item appearing on beaches or at sea as a result of human activity' (Marine Conservation Society, 2004). Marine litter includes not only the debris formed on the shore but also that gets tossed around in the intertidal zone as well as that is found in the subtidal zone.

Marine litter is one of the offensive forms of pollution (Goldberg, 1997; Williams and Tudor, 2001) in the coastal areas not only because this is aesthetically displeasing but also because it can interfere with activities and health conditions of a number of beach biota. Abundance of marine litter is influenced by location and proximity of the beach to the litter source, beach usage, direction of wind, surface waves and currents, storm events, tourism, fishing, sewage disposal, river entry, shipping and frequency and timing of beach cleanings. Marine litter can travel long distances (Benton, 1995) and has the potential to resurface (Ye and Andrady, 1991). The majority of workers world-wide have examined spatial variations in litter accumulation on beaches adjacent to metropolitan areas and major tourist centres (Golik and Gertner, 1992; Corbin and Singh, 1993). As marine debris is increasing in the world's oceans (Ryan and Maloney, 1993) more research is required to monitor, evaluate and identify methods to reduce ocean dumping of waste materials. According to Palaz (2005), pollution as a result of human activity in the inner Gulf region is much less in the waters of the outer Gulf. Fundamental monitoring programme should provide a powerful tool for coastal resource managers (Manikandan *et al*., 2011). In order to save the life of endangered marine animals and to improve the socio-economic status of fisherfolk in the Gulf of Mannar region in India and also to provide a basis for marine litter monitoring, this study was aimed to survey and evaluate the composition, abundance, distribution and quantification of the types, amount, sources and impact of marine litter on the beach of the Gulf of Mannar region. This is first of its kind in India especially in the Gulf of Mannar.

MATERIALS AND METHODS

The study sites were located along a 50 km stretch of shoreline in the northern GoM region of southeast coast of India (Fig. 1) (Latitudes between 09° 13' to 09° 16' N and Longitudes between 079° 19' to 079° 47' E). Surveys were conducted according to the well-established new protocols named as 'Gulf of Mannar pictorial marine litter survey sheet' prepared using a combination of methods developed by the Marine Conservation Society (Marine Conservation Society, 2004)/Beach-Watch survey protocol, the Environmental agency/National aquatic Litter group (EA/NALG, 2000) survey protocol, the Ocean-Watch method, WWF marine debris Beach survey protocol and the Ocean Conservancy's National Marine Debris Monitoring Program protocol. All anthropogenic debris items were categorized according to the material type as cloth, glass/ceramic, metal, leather, plastic, polystyrene, paper, rubber and wood in order to possibly determine the source and country of origin of the marine litter present.

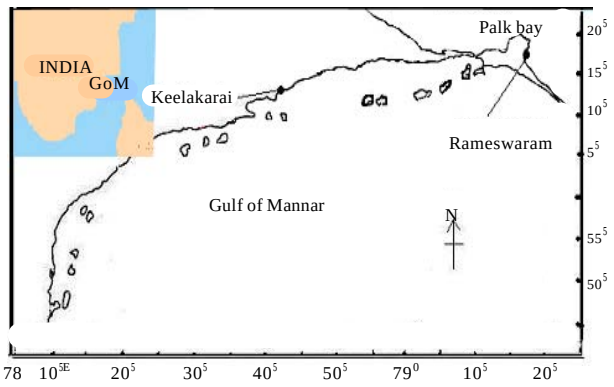

Fig. 1: Study sites in the Northern part of Gulf of Mannar, Southeast coast of India

Surveys were conducted at monthly intervals from March 2006 to February 2008. At each site, four 100 m^2 transects along the top wet strandline parallel to the beach were chosen at random, recording GPS location and permanent structures to allow the same stretch of beach to be surveyed over subsequent months. All litter items within each of the 100 m^2 transect were collected and natural debris were not removed. Marine litter items were categorized according to likely litter sources, in the GoM marine litter pictorial survey sheet. The percentage of source contributed to the total debris was then estimated using the matrix scoring method described by Whiting (1998). Weight and the number of litter items collected within each transact were recorded on the established form as to its composition and/or specific identification. Observations of dead, entangled or stranded animals were noted and relevant authorities informed. Statistical Analysis was done using Two-way ANOVA.

RESULTS

The maximum shoreline marine litter was 94-95 items of 5,409-6,588 g noticed in May-June 2007 and the minimum shoreline marine litter was 42 items of 2,088 g noticed in Feb 2008. Out of this, the most abundant items in number was plastic (47); the most abundant in quantity was also plastic (2,288 g) and the next was cloth (1,864 g); the moderate in number were polystyrene (20) and cloth (16); the moderate in quantity were polystyrene (967 g) and rubber (408 g) and less in number were wood (1) and leather (<1) and in quantity it was the metal (61 g) (Fig. 2, 3).

Test of Two-way ANOVA on the fluctuations in monthly occurrence of shoreline marine litter items at all stations in the Northern GoM in terms of number ($F = 183.67$; Dfn = 8; Dfd = 184) and quantity ($F = 96.97$; Dfn = 8; Dfd = 184) indicated significant differences ($p<0.05$). Seasonal assessment showed 210 items of 15,596 g of shoreline marine litter during the Southwest monsoon period as the maximum and 147 items of 8,261 g of shoreline marine litter during the Cool winter period as the minimum.

Test of Two-way ANOVA on the fluctuations in seasonal occurrence of shoreline marine litter items in terms of number ($F = 84.72$; Dfn = 8; Dfd = 56) and quantity ($F = 36.19$; Dfn = 8; Dfd = 56) indicated significant differences ($p<0.05$). The present study showed a total mean density of 61 items weighing 3655 g shoreline marine litter with the mean density of 10 cloth items of 1299 g, 2 glass/ceramic items of 175 g, 1 leather item of 79 g, 2 metal items of 61 g, 4 paper items of 87 g,

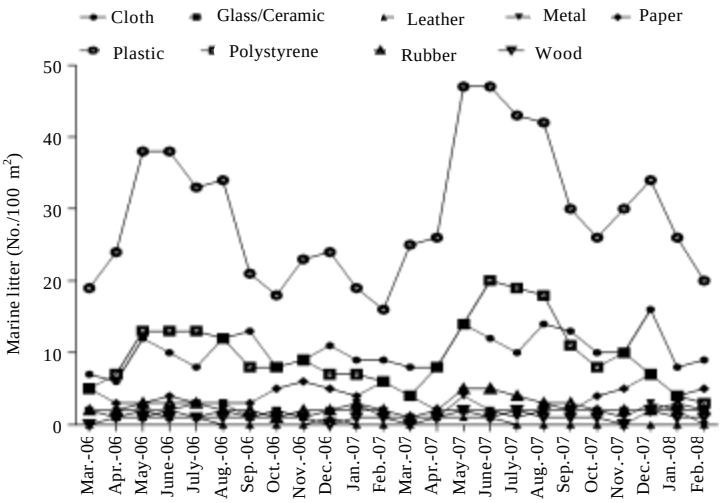

Fig. 2: Month-wise number of Shoreline marine litter in the Northern GoM

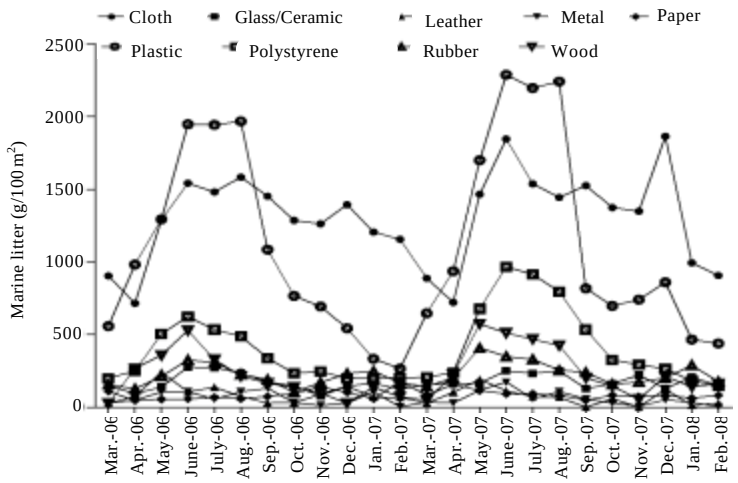

Fig. 3: Month-wise quantity of Shoreline marine litter in the Northern GoM

29 plastic items of 1100 g, 10 polystyrene items of 398 g, 2 rubber items of 225 g and 1 wood item of 230 g in every 100 m^2 area of the Northern GoM. Around 80% of the total litter included only three major items, viz., Plastic (48%), polystyrene (18%) and cloth (15%). Fishing represented the largest source (33.9%) in the majority of the beaches. Tourism/recreation (30.5%) was the second most common source of marine litter. Third common source of marine litter was Sewage Related Debris (SRD) (13%). Mostly, in all the beaches, litter from shipping (6.8) was relatively low compared to the litter from fishing, tourism/recreation and SRD. Litter from Land run off and medical sources were recorded infrequently although in low levels (3.8 and 0.4%, respectively, of total litter recorded) in all the months.

This study also evaluated the effect of marine litter on the ecosystem of coral reefs, seagrasses, seaweeds, sandy and muddy soft bottom communities in the Northern GoM. It has been observed that marine organisms like seaweeds, bryozoans, barnacles, polychaete worms, hydroids and

molluscs use marine litter as their mobile homes. Marine litter caused tissue abrasion and mortality of individuals or colonies of sessile invertebrates, such as sponges, scleractinian corals and the colonial zoanthid Palythoa. Seagrass and sponges were the most commonly affected, followed by scleractinian corals and colonial zoanthids in the GoM. This study noticed marine litter as the means for the invasion of many hard-substratum species to soft bottoms. This study also noticed the loss of tourism and recreation potential due to marine litter during the survey period. The present study indicated that marine litter in the GoM also presents a threat to a wide variety of marine animals (such as Dugong, Dolphin and Sea turtle) which may either ingest or become entangled in marine litter.

DISCUSSION

In the Northern GoM, Rameswaram beach directly faces the prevailing pilgrimage tourism and Sewage Related Disposal (SRD) and so litter tends to accumulate at a higher level. Mandapam beach is partially protected by Manouli and Hare Islands and therefore exposed to relatively low wave energy so litter accumulates at a lower level. Pudhumadam beach is unprotected by any reef flat and therefore exposed to relatively high wave energy compared to other beaches and directly faces the prevailing Southwest monsoon and west wind drift through the Agulhas and Mossambic currents. Hence, many litter items of foreign origin tend to accumulate at the highest level during Southwest monsoon wind compared to other study sites. Keelakarai is a thickly populated town and its beach is protected by a patch of reef flat and therefore exposed to relatively low wave energy compared to other beaches. The effects of Southwest monsoon, West wind drift through the Agulhas and Mossambic currents are only moderate. Litter tends to accumulate at the highest level on the intertidal zone arising from sewage disposal and illegal dumping which are back-washed into the sea. Occurrence of SRD is a relatively common feature on the GoM beaches especially at Keelakarai and Rameswaram. The above findings revealed the factors such as proximity of a given beach to a population center, pilgrim and Southwest monsoon wind which most dominantly affect the litter distribution in the Northern GoM coastline. During Southwest monsoon period the appearance of significant portion of litter items of foreign origin with future expiry dates and the high percentages of vessel-based litter items reported in this study suggest that the effectiveness of international, national and MARPOL legislation is still limited in this region. Continued and intensified public education campaigns aiming at reduction of litter at its source, as well as awareness of the MARPOL regulations among mariners and fishermen are required.

Surveys of shorelines around the world have recorded the quantity of marine litter either as number of items per km of shoreline or number of items per square meter of shoreline. In order to compare the density of shoreline litter found in the Gulf of Mannar, India, with other study sites, the numbers given here are their equivalent per 100 m^2. The results presented for the GoM are consistent with other worldwide surveys where plastics have been identified as the major category of marine debris reported (Moore *et al*., 2001; Nagelkerken *et al*., 2001; Williams and Tudor, 2001; Derraik, 2002; Kusui and Noda, 2003; Silva-Iniguez and Fischer, 2003) based on either weight/or number or both. A comparison of the results of the present study with those of some other tropical regions of the world For example, the study carried out in Mexico by Jones (1995) has shown 800 items which is 13 times more than that found in GoM in the present study. On the other hand, Jones (1995) has reported only 26 items in Hawai and 30 items in the coastline of Tasmania; Barnes and Milner (2005) have reported less than 36 items in various oceanic islands of the Southern ocean (generally uninhabited by man) which were less than half of that found in the

GoM now. This indicates that the status of shoreline e litter in the GoM is neither high nor too low to consider that it is clean.

Beaches differ in marine litter in number, quantity and types due to several factors. The results obtained from world-wide studies indicate that factors which affect the litter distribution on beaches include location and proximity of the beach to the litter source, type of beach, beach usage, slope, orientation and extent of exposure (Dixon and Dixon, 1981; Vauk and Schrey, 1987). Environmental factors affecting the distribution include the direction of wind, surface waves and currents (Cooke and Dixon, 1977; Vauk and Schrey, 1987; Golik and Gertner, 1992; Garrity and Levings, 1993), storm events, tourism, fishing, sewage disposal, river entry, shipping and frequency and timing of beach cleanings.

CONCLUSION

The present situation in the GoM is not that bleak. However, it may become a threat in due course. Although litter density found in the GoM appears to be very low compared to that of other regions of the world, these results should take into consideration the fact that litter is highly variable in time and space and differences among the sampling procedures employed can lead to different results. Most marine litter consists of non biodegradable materials especially plastic items which degrade slowly. So a continuous input of large quantities of these items can result in a gradual build-up in the marine and coastal environment. Monitoring marine litter is essential for the provision of reliable information about the effectiveness of action taken to reduce marine litter in the marine and coastal environments. Thus the information obtained from the present work provides a roadmap for addressing the source and impact of marine litter in the GoM.

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