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Mangrove Forests in Navi Mumbai: Traps for Marine Debris

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Abstract: *Marine debris from mangrove forests in Navi Mumbai was studied for material type, % composition, overall shape, sizes and sources to understand the impact of human activities. The results show that more than 90% of the marine debris came from the land-based and human activities. Of the total marine debris, more than 70% items are plastics followed by styrofoam, fabrics and glass. Composition of marine debris revels materials such as plastics, styrofoam, wood, paper, metal, rubber, fabrics, glass and other material. More than 75% of the marine debris is of large-size (>10 cm & ≤1 m) and oversize (>1 m) followed by medium-size (≥2.5 cm & ≤10 cm). The results suggest that mangrove forests of Navi Mumbai are barriers for the medium-/big-size marine debris and acting as traps for marine debris. Mangrove forests in Navi Mumbai are filled with marine debris and plastic litter is a serious concern for the mangrove ecosystem.*

Keywords: Creek, Mangrove, Marine debris, Navi Mumbai, Plastics, Pollution

I. Introduction

Mangroves are unique ecosystems occurring along the sheltered inter-tidal coastlines, mudflats, riverbanks in association with the brackish water margin between land and sea in tropical and subtropical areas (IUCN, 2006; UNEP, 2014). Mangroves are salt tolerant species and can take up water despite of high osmotic potential of soil water and even if the salt is absorbed, it is excreted through the salt glands in the leaves (Maiti & Chowdhury, 2013). Mangrove develop a partially emerged root system, pneumatophores and prop roots, forming an effective filter that trap objects transported by currents, like floating plastic objects (Norris et al., 2017).

Zimmer (2021) recorded that total mangrove forest area of the world as of 2010 at 137,600 Km^2 (53,100 sq mi) spanning 118 countries and territories. Hamilton and Casey (2016) stated that mangrove forests cover area of about 132,000 Km^2 along subtropical and tropical shores and occupy the intertidal fringe. Global mangrove area currently equals about 15.2 million hectares with the largest area found in Asia and Africa, followed by North and Central America (Friess et al., 2019). Sahu et al (2015) reported that mangrove cover in India is 4,975 sq km (1.2 million acres), which is 0.15% of the country's geographical area. West Bengal has 42.45% of India's mangrove cover, followed by Gujarat 23.66% and Andaman & Nicobar Islands 12.39%.

According to Barbier et al (2011), mangrove forests provide multiple provisioning, regulating and recreational ecosystem services, but they are most valued for their role in coastal protection. Mangrove provide goods and services to humanity such as absorbing the waves/tides, protecting the shore, maintaining the biodiversity, accelerating the water purification and pollutants degradation, reducing the eutrophication, developing ecological tourism and popular science education (Li et al., 2021). Other important ecosystem services provided by mangrove include carbon sequestration (Almahasheer et al., 2017) and coastal protection and habitat for marine life (Duarte et al., 2013).

Mangrove forests are extremely important coastal resources, which are vital to our socio-economic development. Many investigators such as IUCN (2006), Kathiresan (2012), UNEP (2014), Martin et al (2019), John et al (2021) and van Bijsterveldt et al (2021) have documented about ecological services provided by mangroves such as economic benefits, ecological services, biomass and litter production etc.

Mangroves are also one of the most threatened ecosystems and continue to be cleared at an alarming rate. In spite of their importance to people, mangroves are consistently undervalued and continue to be lost at a rate that is 3-5 times greater than global deforestation rates (UNEP, 2014). Mangrove loss continues due to human activity, with a global annual deforestation rate estimated at 0.16%, and per-country rates as high as 0.70%. Degradation in quantity of remaining mangroves is also an important concern. An alarming 20%, or 3.6 million hectares of mangroves have been lost since 1980 (Friess et al., 2019). Human activity persisted as the dominant agent of mangrove loss and overall, 3,363 km^2 (2.1%) of global mangrove area was lost between 2000 and 2016, at an average annual rate of 0.13% (Goldberg et al., 2020).

The destruction of mangroves is usually proportional to human population density. Major reasons for destruction are urban development, mining, agriculture, overexploitation for timber, aquaculture and overfishing (Satheeshkumar et al., 2012). Adyel and Macreadie (2021) pointed that the world's largest single mangrove forest, the UNESCO Marine World Heritage-listed Sundarbans between Bangladesh and India, is under immense threat of plastic pollution. Bangladesh and India are ranked among the top twelve mismanaged plastic waste generating nations and are discharging plastic waste downstream through rivers and coasts (Jambeck et al., 2015). Maiti & Chowdhury (2013) recorded that mangrove ecosystem is under threat due to habitat loss, aquaculture expansion, overharvesting and increase of pollution load.

Smith (2012) reported that the most notable anthropogenic pollution that might stress mangroves is plastic waste. Syakti et al (2017) stated that data on the extent of the plastic problem in mangroves is scanty as most of the marine debris studies have focused on beaches. Rapid exponential population explosion enhanced human activities, such as industrial, agricultural, medical requirements and municipalities, and are being responsible for the increase in marine and terrestrial pollution across the world (Alimba & Faggio, 2019). Mangrove ecosystems are vulnerable and threatened by various pollutants such as marine debris containing plastics, textiles, glass, wood, etc (John et al, 2021). Not et al (2020) concluded that mangroves are highly susceptible to marine debris (litter) exposure due to their coastal habitats.

UNEP in 1995 defined the marine debris (litter) as 'any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment' (GESAMP, 2019). Marine debris is introduced into the marine environment by its improper disposal, accidental loss and natural disasters (Zhou et al, 2011). Martin et al (2019) observed that plastic trapped by mangrove pneumatophores and prop roots affects the tree and associated fauna by preventing gas exchange and releasing harmful chemicals absorbed by or industrially added to plastic materials. Kantharajan et al (2018) reported that in 66 Km^2 mangrove cover of Mumbai, accumulation of plastic wastes threatens the biodiversity associated with the mangrove patches, along the Gorai creek, Versova creek, Mahim bay, Sewri-Mahul mud flats and Thane creek.

In light of the literature survey, it is urgent to monitor marine debris and to assess the debris coverage and their impact on mangroves (UNEP, 2014; Li et al., 2021). Hence in present study, marine debris from mangrove forests in Navi Mumbai was studied to assess materials/composition, size and sources. This study is expected to provide baseline data for the future assessment of the marine debris pollution, strengthen the control of land-based marine pollution and promote mangrove conservation in Mumbai and Navi Mumbai.

II. Materials and Methods

2.1 Study Area

Navi Mumbai is basically a satellite township on the west shore of Maharashtra. It was made in 1971 to be another urban township of Mumbai by Government of Maharashtra. As per Census India 2011, it had a population of 1,119,477.

2.2 Study Location

For the present study, three creeks of Navi Mumbai were selected on the basis of their strategic locations and different anthropogenic activities along the entire coastal area (Fig. 1).

- Panvel creek: (Lat: 18° 59' 26.5668" N & Long: 73° 7' 0.6384" E)
- Belapur creek: (Lat: 19° 34' 29.5284" N & Long: 74° 38' 45.2292" E)
- Taloja creek (Lat: 19° 2' 48.1452" N & Long: 73° 4' 50.8080" E)

These creeks are tide-dominated and the tides are semi-diuranal. The flood period lasts for about 6-7 h and the ebb period lasts for about 5 h. The average annual precipitation is about 3267 mm of which about 80% is received during July to September. The temperature range is 12-36ºC, whereas the relative humidity remains between 61% and 86% and is highest in the month of August. All three creeks have extensive mud flats with marshy areas, thick mangrove vegetation and are resourceful with fin fish and shell fish fishery potential (Pawar et al., 2019).

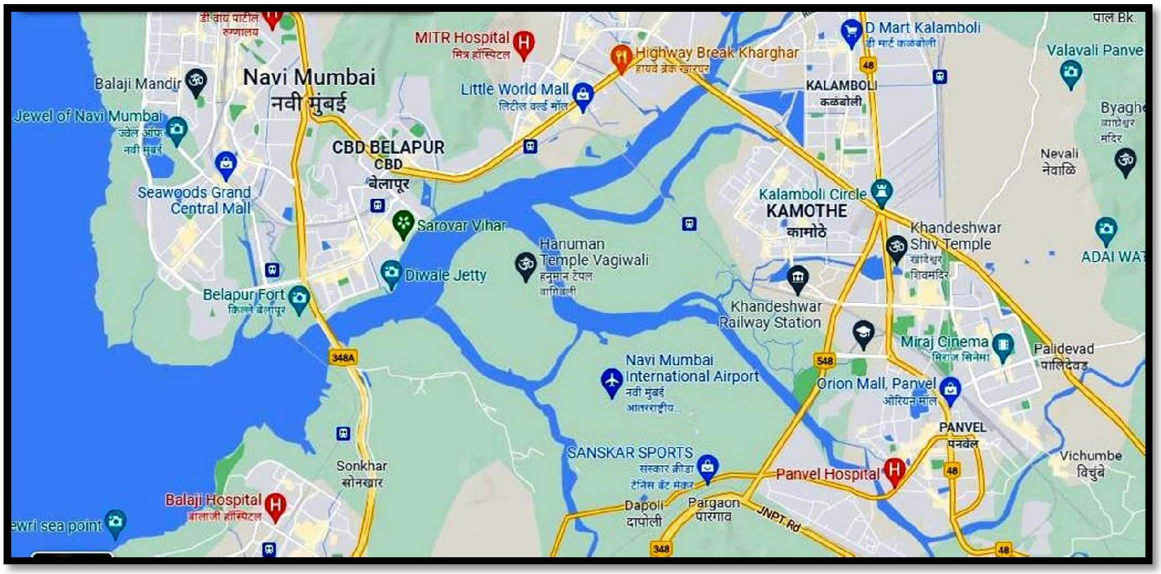

Figure 1: Geographic location of the study area (Navi Mumbai) (Source: Google Map).

2.3 Field Study/Sampling

Present study was conducted monthly from June 2021 to January 2022. Along each creek, three sampling sites were selected according to debris density, mangrove density, sludge hazard degree, tidal time, etc. and duration between the flood and ebb tides. Visual census surveys was used for monitoring of marine debris. The debris items are collected and categorized by material types and information of each debris item, such as % composition, overall shape, sizes and sources was recorded. Photographs of the debris were taken on site using Cannon 1100 D Zoom camera. For monitoring and assessment of marine debris, guidelines prescribed by SOA of China (2011) were followed.

III. Results and Discussion

The results show that more than 90% of the marine debris came from the land-based and human activities. Of the total marine debris, more than 70% items are plastics followed by styrofoam, fabrics and glass. Composition of marine debris revels materials such as plastics, styrofoam, wood, paper, metal, rubber, fabrics, glass and other material. More than 75% of the marine debris is of large-size (>10 cm & ≤1 m) and oversize (>1 m) followed by medium-size (≥2.5 cm & ≤10 cm). Land-based marine debris consists of items from coastal/recreational activity along with medical or sanitary activity. Sea-based marine debris are from navigation/fishing activity and represented by fishing nets, broken buoy, rope etc. The results suggest that mangrove forests of Navi Mumbai are barriers for the medium-/big-size marine debris and acting as traps for marine debris (Table 1, Fig. 2 & 3).

Table 1: Source & composition of marine debris in mangrove forest of Navi Mumbai

Sources	Activity	Types	Debris Items
		Fabrics	Clothing, jerkin, used clothes, shoes, pants, cotton gloves etc.
		Glasses	Beverage bottles, glass bulb, fluorescence tube light, beer bottle, glass bottle/cup etc.
		Metals	Beer tin, metal rods, lid of metal containers, fry pan, bangles,

Land-based	Coastal & Recreational activity		tin cover, umbrella, ring-pull can, metal food bottle etc.
		Plastics	Thick plastic bottle, real fruit juice container, small juice bottle, cigarette wrapper, lid of milk bottle, thermometer, packet of Chinese food, food containers, foot wares, bicycle tyre, gutkha & candy wrappers, lime tube, baby milk feeding bottle, whistle, measuring tape etc.
		Rubbers	Hand gloves, tyres (car, bicycle), sheets etc.
		Styrofoam	Thermocol, disposable tea cups & spoons, sketch pen, disposable glass, ball pen, ring, sponge sheet for bottle, particles, foam fast food box, etc.
		Fruits & vegetables	Lemon, coconut, onion, garlic, potato, sweet pea, brinjal, chilli, pineapple, banana peels, tomato etc.
	Medical or sanitary activity	Plastics	Medicine tablet strip, sanitizer plastic bottle, plastic drug board
Sea-based	Sea-based Navigation/ Fishing activity	Plastics	Fishing nets, floaters, broken buoy, rope

Li et al (2021) recorded that mangrove forests in the Beilun estuary, Fangchenggang are threatened by marine debris pollution including visual pollution and toxic substances carried by the debris. Naik et al (2021) recorded 8 types of non-plastic debris representing 38 items and 8 types of polymers representing 65 items in marine debris from Panvel creek.

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Fig. 2: Marine litter trapped in mangrove forests of the study area

Figure 3: Objects of various types trapped in mangrove forests of study area

Rahim et al (2020) stated that marine debris pollution in mangrove forests is actually affected by both natural factors and human activities such as mariculture, tourism and coastal dumping. van Bijsterveldt et al (2021) pointed that plastic debris is a major anthropogenic stressor to mangroves and the amount of plastic litter is largest in the region where mangroves are declining the fastest. Prolonged suffocation by plastic caused immediate pneumatophore growth and potential leaf loss. Plastics buried on the forest floor or inside the sediment in mangroves can create an anoxic environment and potentially induce tree suffocation and pneumatophore deformation (Sandilyan & Kathiresan, 2012).

Martin et al (2019) reported that in the Red Sea and the Arabian Gulf, marine litter was more abundant where the mangrove density was higher, and object distribution through the mangrove was depended on their shape and dimension. Goldberg et al (2020) suggested that rapid urban expansion into adjacent mangrove forests and the conversion of mangrove forests to human settlement are responsible for global declines in human-driven mangrove loss. The results of the study are in agreement with Adyel & Macreadie (2021) who stated that the world's largest single mangrove forest, the UNESCO Marine World Heritage-listed Sundarbans between Bangladesh and India, is under immense threat of plastic pollution.

This study shows that marine debris is a serious concern for the integrity of the fragile and diverse ecosystem of mangroves. Root and sediment within mangroves are efficient at trapping plastics, while root features i.e., density, thickness and height can influence the plastic accumulation and dispersion in the mangroves.

IV. Conclusion

The study recommends to eliminate plastic discharge to the environment, reduce plastic production, improve plastic waste collection and recycling infrastructure; and develop public awareness on plastic waste control. Substantial reduction in waste generation through prevention, reduction, recycling and reuse and periodic plastic clean-up programs, effective eco-tourism, plastic sorting and disposal program, are also critical to protect the future of the mangrove ecosystem. Strong monitoring and incentive scheme for the organisation involved with plastics recycling needs to be encouraged.

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