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Plastics: A menace to the mangrove ecosystems of megacity Mumbai, India

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Background

The indiscriminate rapid development of megacities with no proper planning, formal settlement and waste disposal in the coastal areas, are the major causes of plastic pollution in the seas of the tropical developing countries (Tibbetts, 2015). Mumbai, a megacity in India, located at 18°53'–19°19' N and 72°47'–72°59' E, bordering the Arabian Sea along the west coast, is home to 18.41 million people having a diversified life style (Census of India, 2011). A general lack of awareness on environmental issues, and the inadequacy and inaccessibility to appropriate waste disposal systems led to the generation of 750 tonnes of plastics (Chatterjee, 2017a).

Mangroves are structurally complex iconic ecosystems, which cover an area of 66 km^2 in Mumbai. They occupy tidal-fed areas between human settlement of the city and the shoreline, acting as a reserve for rich flora and fauna (Forest Survey of India, 2017). But they also serve as the undesignated anthropogenic waste dumping areas. Diversity-rich mangroves on the seven islands of Mumbai have been mostly denuded and now the islands are interconnected in the name of urbanization to form the present day city (Kathiresan, 2008). In recent times, the 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 Mumbai.

Biodiversity and ecosystem services of the Mumbai Mangroves

The mangrove ecosystems of Mumbai are home to 10 true mangrove species, dominated by *Avicennia marina* and 403 species of associated flora and fauna (Table. 1) (Kantharajan *et al.*, 2018; unpublished data). The privately managed 708 ha of mangroves in Pirojsha Nagar, Mumbai, support 185 species of birds, 30 species of reptiles, 13 species of crabs, and 20 species of fish and 7 species of prawns (SPGF, 2000).

Table 1 Biodiversity assemblage of the mangrove ecosystem in Mumbai

Major group	No. of species
Flora	
Mangroves	10
Associates	7
Salt marshes	6
Seaweeds	5
Fungi	6
Others	22
Fauna	
Chordata	161
Arthropoda	68
Mollusca	115
Annelida	2
Platyhelminthes	1
Total	403

The mangroves offer notable services such as fish production, breeding and feeding grounds for fauna, rich biodiversity, shoreline protection from erosion and recreation to the public. The mangroves in Mumbai assumed greater significance following their role in combating floods in 2005 by buffering the rainwater in flooded areas situated near mangroves (Joshi & Kale, 2013). The major recognized threats to the mangroves of Mumbai are habitat destruction for urbanization and industrialization, poor freshwater inflow, sewage disposal, and illegal dumping of wastes including plastics (Vijay *et al.*, 2005; Kathiresan, 2008; Kantharajan *et al.*, 2018). A recent survey revealed the widespread occurrence of plastics and other waste materials such as bottles, tyres, thermocol (polystyrene), foot wears, abandoned fishing nets and glass pieces, in the mangrove areas, which is detrimental to the coastal environment. At Juhu, Gorai and Versova, the mangroves are littered with plastics and other trash (Figure 1).

Figure 1 Plastics and other trash in the Mumbai mangroves at Gorai creek (a) and near Juhu (b)

Effects of plastics on the mangroves

Plastics on the mudflats and in the mangroves impede the establishment of seeds and growth of seedlings (FAO, 2002). Physiological processes such as photosynthesis and respiration can no longer function due to suffocation. The occurrence of plastics also reduces the habitats available to faunal groups viz., molluscs, crabs, birds, mud skippers, etc. For instance, increased occurrence of plastics in the Panama mangroves is negatively correlated with the abundance of crab holes (Bulow & Ferdinand, 2013). Phthalates and bisphenol A are some of the toxic compounds released during the degradation process of plastics that can reduce offspring quantity, increase hatching failure, and disrupt larval development of key mangrove fauna (Hammer *et al*., 2012). Coastal and marine birds, sea turtles, fishes and other aquatic organisms are known to ingest plastic mistakenly as food.

It is worth mentioning that mangrove mudflats of Sewri-Mahul and Thane creek in Mumbai are recognized as Important Bird Areas (IBAs) in India, which support nearly 205 species of migratory and non-migratory birds, of which several are threatened, rare and near threatened species (e.g., Indian Skimmer, Red-headed Bunting, Eurasian Collared Dove, White Stork, Painted Stork, Lesser Flamingo and Black-headed Ibis) (Nitsure & Pejaver, 2002; Chaudhari-Pachpande & Pejaver, 2016). Micro-plastics of less than 5 mm in size have been reported around the urban beaches of Mumbai (Jayasiri *et al*., 2013). Their presence is probably caused by the degradation of marine plastic debris accumulating in the mangroves (Nor & Obbard, 2014). Micro-plastics ingested by birds, attributed to their feeding habits and foraging behaviour, pose a huge threat to the food chain as they are transferred to higher trophic levels (Hammer *et al*., 2012). Micro-plastics, with larger area of exposure, adsorb more contaminants such as polychlorinated biphenyls, polycyclic aromatic hydrocarbons and other pesticides than natural sediments. There is therefore a potential risk for the migratory flamingo birds which come to feed in the contaminated waters and sediments of Sewri-Mahul and Thane creek (Dhananjayan *et al*., 2012; Chaudhari-Pachpande & Pejaver, 2016). In addition, the movement and sound generated by plastic carry bags hanging on the trees frighten the birds and alter their foraging behaviour (Sandilyan & Kathiresan, 2012).

Plastics entering the mangrove creeks of Mumbai, caused by the dumping of trash by human settlements and/or tidal flow, get entangled among the network of root structures (Vennila *et al*., 2014; Kantharajan *et al*., 2017). For instance, 55-71% of the non-biodegradable wastes inside the Mahim creek mangroves are plastics and they obstruct tidal flow into and from the mangrove swamp (Singare, 2012). The accumulation of plastics, which hindered regular water flow, was considered one of the main causes of the Mumbai floods in 2005. The blocking of tidal flow can adversely affect the feeding sites of many animals (Sandilyan & Kathiresan, 2012; Joshi & Kale, 2013).

Management of plastics and other trash is necessary for maintaining the intactness of mangrove ecosystem in Mumbai. Recently, clean-up drives are often organized by municipalities, local residents, students, industries, NGOs and nature enthusiasts. For instance, a one-day clean up, organized by the Maharashtra Mangrove Cell, collected and removed 30 tonnes of plastic wastes from the Versova mangroves in April 2017 (Jesrani, 2017). Report on the occurrence of an estimated 500 tonnes of plastics near Bhandup (Chatterjee, 2017b), indicates that the present efforts are not sufficient to clean the mangroves and still, many mangrove areas remain littered. More innovative ways for litter management and effective implementation of pollution laws are essential to control the menace of plastics and to recover the health status of the Mumbai mangroves in the long run.

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