



Marine pollution in India: Status and future perspectives

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Abstract

India is one of the largest contributors to marine pollution in the world. Pollution in marine habitat can occur through various ways like dumping of waste, sewage and industrial pollutants, and the use of fishing nets and plastics. In this review the status of marine pollution is assessed based on the case studies from the coastal states. It summarises the mitigation measures to marine pollution and effects on biota, and human health. Measures taken by Indian government to minimise pollution are discussed. However, marine pollution control is far from complete, the effective implementation of strategies would help in sustainability of the marine ecosystems contributing to country's economy.

Keywords: Marine biota, Plastics, Government, Mitigation, Strategies

Introduction

One of the major threats to oceans and aquatic organisms is marine pollution which involves the release of debris into the seas and oceans. The debris that are released into the sea contaminate the marine environment. They include materials that were deliberately dumped, lost at sea, or washed into the ocean from land, and can range in size from small plastic particles to abandoned boats and fishing nets. Major proportion of plastics such as PET (polyethylene terephthalate), HDPE (high-density polyethylene), PVC (polyvinyl chloride), LDPE (low-density polyethylene), PP (polypropylene), PS (polystyrene) that are found in marine debris (Devi and Biju Kumar 2024) ^[5].

The Indian coasts determine the economy of the country and sustenance, providing fish and seafood, tourism, and shipping lanes. Similar to the global marine pollution, the beaches of east and west coasts of India are highly polluted (Devi and Biju Kumar, 2024) ^[5]. However, factors causing pollution are plastic waste, sewage, oil spills, and industrial effluents. Assessment of marine pollution in India has been

done by many studies (Duraishamy and Latha, 2011; Narra *et al.*, 2022; Lincoln *et al.*, 2023) ^[8, 17, 20]. In this article, we discuss the status of marine pollution in India and the steps to be taken for a cleaner marine ecosystem.

Case studies on release marine litter into the oceans

1. Every day around 26,000 tonnes of plastic waste get generated from India, among which 10,000 tonnes is improperly managed. The reports show that recently million tonnes of plastic materials being released into the environment, contributing to 20% of the global plastic waste resulting in persistent plastic pollution (Devi and Biju Kumar, 2024) ^[5]. About 19.4 million tonnes are macroplastics and remaining 82% entered the natural environment due to inadequate collection and disposal. Littering or fly-tipping (5%), and marine activities (1%) also lead to their leakage (Table 1). Microplastics are leaked into the marine habitat through wear to tyres, road markings, and accidental loss of plastic pellets and washing of synthetic textile fibres (Robin *et al.*, 2023).

Table 1: Plastic leakage in marine ecosystems.

Sl. No	Type	Quantity (%)
1	1. Microplastics	12
	a) Transport related microplastics	4
	b) Microplastic dust	3
	c) Wastewater sludge	3
	d) Others	2
2	Macroplastics	82
3	Marine activities	1
4	Litter	5

*Source: OECD Global Plastics Outlook Database

2. The Central Pollution Control Board (CPCB) identified 80 points along the Indian coast where plastic waste enters the ocean. The significant contribution to the pollution is by the cities such as Mumbai, Chennai, and Kolkata. Studies from Indian coast establishes that, micro plastic contamination can be mainly seen in Indian sea salts (Seth and Sriwasthav, 2018; Vidyasanker *et al.*, 2021) ^[24].

3. According to the published literature, Karnataka (1.4 items/m²) is the highest producer of marine litter and Goa being the least producer (0.1 items/m²) in the West sand.

Sridhar *et al* (2007) quantified the marine litter in beaches of southwest coast of India and found that the low-density polyethylene and polystyrene were common on beaches. Food-based plastic debris were highest (43%), followed by domestic (28%), fishing (18%) and others (11%) from the beaches of Karnataka. Similarly, more marine litter mixes the Indian Ocean from the Andaman and Nicobar Islands, and Puducherry, Odisha states contribute the marine pollution in comparatively less proportion (Figure 1). The Gulf of Mannar and Palk Bay regions have intense fishing

activity (Senthilnathan, 2018) ^[23]. Daniel *et al* (2020) ^[4] showed that maximum deposition of fishing-related plastic items in beaches with higher fishing intensity than the other

beaches of Kerala. They suggested that fishing activities play a major role in generating marine plastic debris.

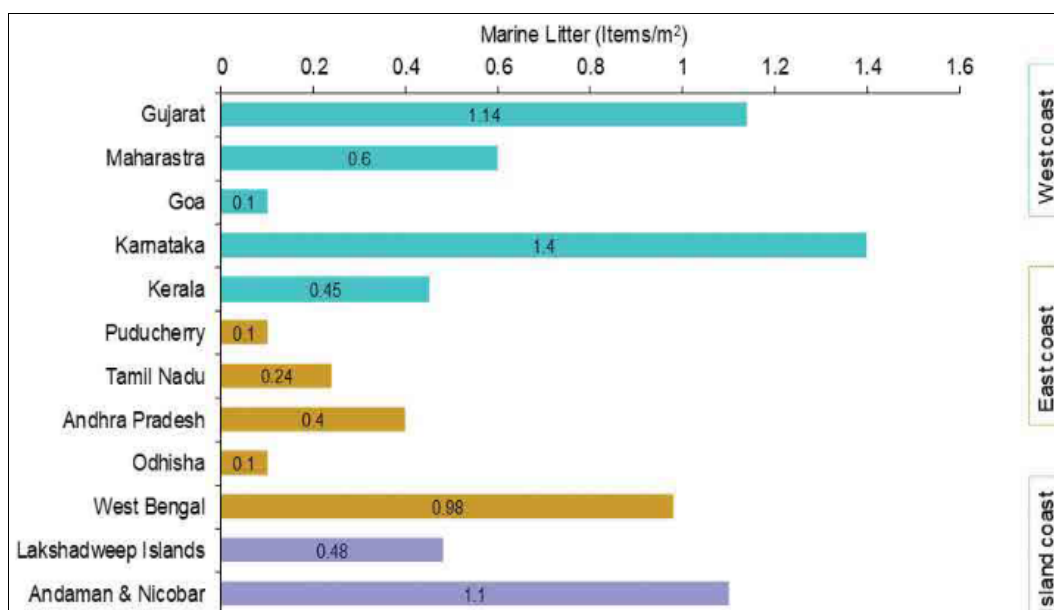


Fig 1: Marine litter data from the east and west coasts of India.

5. Indian coasts are threatened by pollution from domestic sewage and runoff from agricultural land (D'Souza *et al.*, 2022) ^[7]. Pollution affected the bivalves of the Mumbai coast, where shells such as *Paphia textile* were shells lost their colour. This is resultant of sewage and industrial waste that is released into the sea (Balasaheb *et al.*, 2017) ^[2]. The thermal power plant at Tuticorin discharges heated water and dumps fly ash into the sea. The fly ash gets deposited in the gills of marine organisms causing their death and leads to malformation in their eggs and larvae (D'Souza and Shenoy, 2023) ^[3].

Effect of plastic pollution

1. On marine biota

Various kinds of marine debris impact marine life, plastics constituting 75% of the litter and others such as rope, textiles/fabrics, lost fishing line and nets, wastes from cruise ships and oil rigs, etc (Figure 2). The marine debris impacts various types of marine taxa, with noticeable impacts on fish, sea birds and cetaceans⁵. Plastics debris also have tendency to absorb harmful chemicals like DDT and PCBs (Dharani *et al.*, 2003; Sindermann, 2005) ^[6, 25].

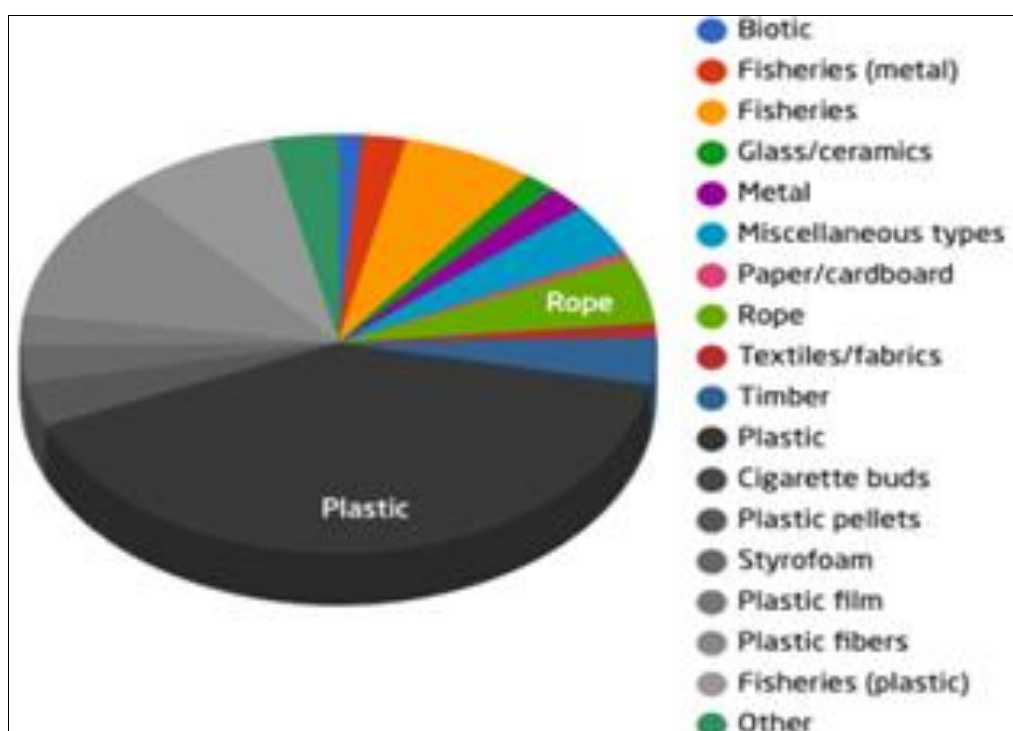


Fig 2: Litter types affecting marine life (Devi and Biju Kumar, 2024) ^[5].

Through ingestion, absorbed harmful chemicals such as PCBs and DDT enter into the system of the animal causing a number of health effects. These contaminants also pass through the food chain entering the body of tertiary consumers hampering their activities (Ajith *et al.*, 2020). Animals contaminated with PCBs and DDT have shown reduced reproductive successes, disruption in development and growth, disruption in endocrine system, pathological changes in cells and tissues, suppression of

immune system and genetic anomalies (Sindermann, 2005) [25].

When the global data on marine debris of 1997 and 2015 are compared, there has been a sharp rise in percentage of sea turtles, sea birds, marine mammals and fish affected by entanglement or plastic ingestion (Table 2). This is true for the Indian coasts. It was noticed that adult female Longman's beaked whale was found by ingesting plastics bags at Gujarath coast (Kaladharan *et al.*, 2014).

Table 2: Impact of marine debris on marine organisms.

Taxa	No. of known species	Increase in species entanglement from 1997-2015 (%)	Proportion of biota ingesting marine debris 1997-2015 (%)	Proportion of species with entanglement and ingestion record 1997-2015 (%)
Sea turtles	07	86-100	86-86	86-100
Sea birds	312	16-25	36-39	44-54
Marine mammals	115	28-33	23-26	43-54
Fish	16752	0.2-0.39	0.2-0.3	0.36-0.68

Source: Naidu *et al.*, (2017,2018) [19].

2. On mangroves and corals

Mangroves are source of food and shelter marine species, and their loss can case deteriorating effects on entire ecosystems (Sivadas *et al.*, 2021) [26]. The litter gets transported to the mangroves by the water currents, dumping of domestic solid waste, and deposition of debris covers the breathing roots of mangroves. Consequently, tidal flow gets obstructed to the mangroves and reduce several of mangrove dwelling organisms (Kripa, 2019) [14].

Marine litter destroys sensitive marine habitats such as coral reefs and seagrass beds. Plastic pollution decreases the availability of light, food and oxygen to corals, sponges and bottom dwelling by the process of smothering. The sediment oxygen becomes deficient and marine organisms cannot live in the anoxic conditions. As a result, survival of pathogens becomes difficult which lessens the population of marine biota (Devi and Biju Kumar, 2024) [5]. The coral reefs are affected by marine litter like nylon sacks, ropes, and monofilament fishing lines along the south east coast of India. Marine litter was found entangled in dugongs, turtles, branched corals, the sacks smothered the coral reefs preventing light penetration (Patterson Edward *et al.*, 2018).

The chemical pollutants in the sewage water released into the sea accumulate in reproductive tissues of the animals effecting the reproduction. Moreover, marine litter, comprising plastics and other debris, can alter the reproductive cycles of marine animals, declining their population and distribution.

3. Negative impacts on public health

Microplastics enter the body of humans through contaminated seafood, they lead to various health problems. Marine litter is a breeding ground for disease-carrying insects and increase the risk of waterborne diseases such as cholera and typhoid as they occur due to contaminated water sources. Lead and mercury enter humans through discarded electronic equipments. When these reach the water, contaminate seafood leading to health issues and neurological disorders. Discarded fishing hooks, glass, and metals can pose physical damage swimmers and beachgoers.

4. Impacts of marine litter on climate change.

Plastic production requires more of fossil fuels, such as oil and natural gas, which are major sources of greenhouse gas emissions. In addition, the transportation and processing of plastic also require lots of energy, contributing to carbon emissions. Their leakage contributes to climate change, the destruction of marine ecosystems, and the release of hazardous chemicals.

When the plastics are discarded they weather and erode into very small fragments. Devi and Kumar noted the presence of micro plastics in benthic polychaetes and bivalves for the first time from the surface sediments of the southwest coast of India. Microplastics abundance was relatively higher in surface water. Gurjar *et al.*, (2022) [10] working on marine pollution off Mumbai coast observed that the abundance of microplastics in pelagic carnivorous species. Microplastics (<250 µm) were higher in gastrointestinal tract of marine organisms.

The rising levels of CO₂ leads to global climate change, impacting the population of marine biota (Naidu *et al.*, 2018) [19]. Other factors like coastal tourism, port and harbour developments, damming of rivers, urban development and construction, mining, fisheries, aquaculture etc., are all sources of marine pollution threatening coastal and marine habitats, effects of ocean pollution (Devi *et al.*, 2024) [5].

Mitigation of pollution

a. The marine debris impacts various types of marine taxa, with noticeable impacts on fish, sea birds and cetaceans (Devi *et al.*, 2025).

b. If the amount of plastic waste moving the sea can be reduced, impact of plastics on marine ecosystem can be lessened. However, this can be achieved by reducing plastic consumption, proper disposal of plastic waste, and recycling.

b. **Creating awareness:** The awareness on growing marine pollution can be created by beach clean ups and outreach programmes. The use of fishing gear such as ghost net causes entangling and leading to suffocation and death. Efforts are being made to address the problem of ghost nets, including initiatives to remove them from the ocean and prevent their use in the first place. Some organizations are

involved in removing ghost nets from the ocean, either through manual removal efforts or through the use of specialized equipment or use of biodegradable nets that break down over time is recommended which prevents the entanglement (Devi *et al.*, 2024) ^[5].

Marine litter management

- Marine litter and microplastics distribution, characterisation study should be conducted across the Indian coast.
- A forum of coastal cities should be created for ensuring cross-learning ecosystem and to build a synergetic association of urban local bodies and local administration located on the coast.
- A long-term vision plan should be developed for promoting partnerships among coastal towns, cities and urban administration for the reduction of marine litter and the creation of sustainable waste management ecosystems. Initiatives like a multi-stakeholder approach that will recognise knowledge, expertise, technology, research, capacity building and advocacy as key drivers to safeguard life below water can be beneficial.

Regular beach clean-up and awareness programmes should be conducted instead of annual ones. The construction of sewage treatment plants, coupled with the promotion of proper sanitation infrastructure, can significantly reduce sewage discharge into the ocean. Stringent environmental regulations must be put in place to prevent industrial effluent discharge into the ocean. The development of effective oil spill response plans can mitigate the impact of oil spills on the environment.

The “5 R s viz. Reduce, refuse, reuse, recycle, repurpose” in plastic waste management can be followed. More research has to be done to address the levels, sources, distribution and fate of the different type of plastic polymers in the marine environment and their effect on aquatic organisms (Naidu *et al.*, 2018) ^[19]. The promotion of awareness and education campaigns can help in sensitizing the public about the importance of marine conservation and ways to reduce pollution (Ajith *et al.*, 2023) ^[1].

c. Awareness programmes are conducted in Maharashtra, Gujarat and Tamil Nadu to recycle or degrade the plastic material or the use cloth materials instead of plastics.

d. Government and businessman's need to bring about policies that minimise the pollution by replacing the plastics and sustainable development.

e. Use of biosensors to check pollutants and water quality is recommended.

Initiatives /Policies taken by Indian government to tackle marine litter

1. India-Norway cooperation project: The India-Norway cooperation project was created to reduce plastic and chemical pollution in India. This initiative works to explore various dimensions of plastic and chemical pollution India in general and Gujarat in particular to develop action plans for pollution control. The project is meant to implement the Stockholm Convention on persistent organic pollutants to mitigate the plastic and chemical pollution.

2. Circular economy solutions for preventing marine litter

Recently the German Federal Ministry for the Environment (GIZ), Nature Conservation, and Nuclear Safety (BMU)

implemented a circular economy project in collaboration with the Ministry of Environment, Forest, and Climate Change, Government of India, which is operational at NCSCM, Chennai, India. The project supports the Central Pollution Control Board (CPCB) and State Pollution Control Boards (SPCBs) in Kerala, Tamil Nadu, and Uttar Pradesh, to develop digital technologies for the quantification and tracking of marine litter, litter leakage monitoring in marine ecosystems ¹⁷.

3. Flagship programmes, Legislations and Policies in India

The Government of India has taken various initiatives to mitigate the production of marine litter. The existing legislation, policies, and flagship initiatives are listed below.

1. Plastics and recycled plastics manufacture, sale, and usage rules (1999)
2. Rules have laid down provisions for the manufacturing, usage, end-of-life (EoL) product management, and criteria for manufacturing plastic containers and carry bags.
3. Amendments (2002, 2003) signify that original and recycled plastic manufacturing, mandate registration and authorization for manufacturers who produce, sell, or trade plastic packaging.
4. Plastic Waste Management (Amendment) Rules (2011, 2016, 2018, 2022). The Government of India brought about the Plastic Waste (Management and Handling) Rules, 2011, which imposes conditions for the manufacture, storage, sale, and use of plastic carrier bags and sachets, which are regulated by the State Pollution Control Board and local authorities. Plastic Waste Management Rules (2016) emphasize the use of environmentally friendly packaging materials. Manufacturers and brand owners of plastic materials are required to submit an Extended Producer Responsibility (EPR) plan. The import of solid plastic waste, PET bottles are banned in the new (2016) rule (Ajith *et al.*, 2023) ^[1].
5. The amended rules of 2018 state that only those multi-layered non-recyclable plastics having no alternate use will be removed. The rule also relates to the trade of hazardous waste used for recycling, recovery, and reuse.
6. National Marine Litter Policy of India: The National Marine Litter Policy of India, announced in 2018. The National Marine Litter Policy aims at monitoring marine litter using remote sensing, Sustainable coastal tourism through the ecolabel certification of beaches to minimize beach litter etc. Several workshops are conducted for the management of marine litter.

To promote conservation of natural resources, the schemes and programs are launched such as National River Conservation Plan, the National Mission for Clean Ganga, and the National Biodiversity Act. Besides, Namami Gange Programme, Puneet Sagar Abhiyan, Suchitwa Sagaram (Government of Kerala) Swachh Sagar, Surakshit Sagar, Swachh-Nirmal Tat Abhiyan (Mumbai coast) were conducted to clean the marine environments. The control on single use plastics by the Indian Government is effective, plastics measuring <100 micron is banned.

Conclusion

Marine pollution has become severe environmental issue in India, requiring immediate attention and action. Several case

studies have shown that the coastal cities are the major releasers of marine debris of which the industries and thermal power plants contribute significantly to the pollution. The marine organisms are vulnerable to pollution because the plastic waste causes entanglement leading to their death. Use of plastic fishing gears for fish capture imposes threat to marine biota. The implementation of solutions, such as reducing plastic use entering the sea, improved sewage treatment, ban on Single Use Plastics and strengthening environmental regulations, creating awareness by beach clean-ups and outreach programmes can help in mitigating the impact of marine pollution. Nevertheless, many legislations and initiatives are taken by Government of India to tackle marine pollution. However, it is the responsibility of the citizen create pollution free environment for the sustainability of marine life to strengthen the economy of the country.

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