A National Marine Debris Management Strategy to conserve marine ecosystems

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Introduction

Marine debris which is defined as any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment is one of the most pervasive, yet potentially solvable, pollution affecting the world's oceans, coastal ecosystems and rivers. Whereas impacts of most anthropogenic activities are usually found near the point source, marine debris has been found to impact even distant locations, often affecting uninhabited areas also. According to United Nations Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP), 60 to 80%, of the global litter found in the coastal and marine ecosystems has originated from land and only the rest from sea based activities. The slow degradable nature of marine litter and the potential to pollute all spheres of oceans irrespective of point source has raised the alarm bells. The UNEP has recently initiated a special program 'Global Initiative on Marine Litter'. Three main industries which are affected by marine debris are fisheries, shipping and tourism and the estimated damage to these sectors in Asia-Pacific Economic Co-operation (APEC) region is US$1.265 million annually. In India, occurrence of marine debris along the Indian coast has been studied by the ICAR-Central Marine Fisheries Research Institute, since 2007. The study indicates that marine debris has affected the ecosystem and livelihood of fishers. In this article, the impacts of marine debris on the ecosystem are explained briefly followed by the possible solutions for controlling and reducing marine debris in the country and the need for a Nation at Marine Debris Management Strategy.

Types of marine debris

Since the major source of marine debris is land, an evaluation of the solid waste generated on land and the effectiveness of waste management can indicate the threat to the coastal ecosystem of the specific area. In most cities, there is no complete waste management system in place and the threat to coastal and riverine ecosystem from marine debris is evident. Indiscriminate dumping of solid waste on land reaches the drains, rivers and estuaries and finally ends up in the sea. During this process, these may sink and spread on the river bed or estuaries, can clog small canals and ultimately affect the aquatic habitats and its functioning which supports the local fauna. From the coastal waters, they are also transported to distant places by wind and water currents. They may either remain floating, trapped in gyres or eddies or sink and settle or become washed ashore as beach litter. For wastes originating at sea, usually from ships, the fate of the litter is the same. Studies have shown that debris can also lead to water stagnation thereby creating a breeding ground for mosquitoes and flies that spread diseases to humans. Discarded litter has thus become a concern for human life and health.

In India, estimates of Municipal Sewage Waste (MSW) in 2008 was about 48134 ton per day from 299 cities across the country with the per capita production being 0.376 kg per day. In a report on Municipal Solid Wastes in India based on the data from CPCB, it is stated that the major MSW is compostable waste (43 %) followed by ash and fine sand (41%). Paper which is degradable forms 5.7%. The other items which are non-degradable and semi-degradable were plastics, leather, glass, metal and

Solid wastes dumped in the Cochin Backwater

Clogged canals impacting local biodiversity

textile. Of these, plastics consisted of 32% followed by textile (28.7%) glass (17.2%), metal (15.6%) and leather (6.6%). The dominance of semi-degradable material which can be recycled clearly indicates the potential we have to move towards a zero-waste situation with proper waste management. Also, in the marine and coastal areas there are large biomass of floating weeds and sea grasses which are degradable and can be readily composted, but very little effort is currently made to effectively manage these.

The UNEP guidelines for assessing litter, list seven types of materials such as plastics, foamed plastics, cloth, glass and ceramics, metal, rubber, wood and others (electronic items, paraffin wax, etc) with a total of 77 individual codes for items coming under these categories (*UNEP Regional Seas Reports and Studies, No. 186; IOC Technical Series No. 83*:). This is mainly meant for uniformity in data collection and comparison of data under the Regional Sea Programme. The non- degradable and semi-degradable items commonly found in India are varieties of plastics (hard / foamed), rubber, metal, thermocol, textile and glass. In India, the quantity of litter on the beaches has been found to vary (*CMFRI Annual Reports in Eprints.cmfri.org.in*) with plastics being the major pollutants.

Though the percentage occurrences of glass, ceramics and metal debris are much lower compared to plastics, broken glass pieces and other sharp objects lying on the beach pose a threat to fishers and beach goers. In bivalve fishing areas of Vembanad Lake, especially where the clams are handpicked from intertidal/subtidal areas, fishers have indicated that broken glass pieces are a threat to their health and plastic covers and other debris have led to low catch per hour of fishing.

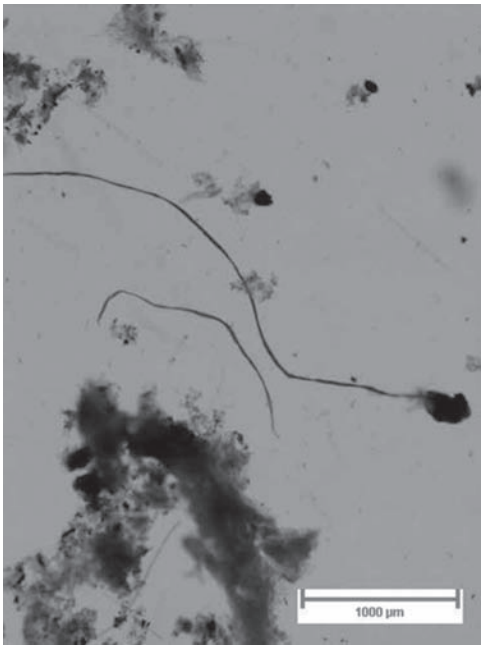
Foamed plastics that include thermocol are commonly used in packaging industry and as use-and- throw plates. Being light, the thermocol debris floats and is carried away by wind and currents and was one of the most common litter item in all surveys conducted by CMFRI in beaches and fishing areas. Tyres, footwear, bags and toys made of rubber, semi degradable textile material and mattresses are also common in the marine debris in almost all beaches and waterways. These actually degrade the habitats and reduce the functions of the ecosystems. Apart from this, these macro items soak and settle on the bottom affecting the benthic substrate and impacting the breeding and nursery grounds in critical habitats like mangroves, sea grasses and coral reefs. E-waste like used CDs, parts of computer and mobiles are also found in the marine debris but comparatively less.

Abandoned, lost, or otherwise discarded fishing gear (ALDFG) is one of the most dangerous types of marine debris. These nets called 'Ghost nets' can go on fishing, trapping, or entangling other fauna and act as a collecting entity of other debris thereby degrading habitats and reducing functional values of ecosystem services. Increased use of synthetic

material in fishing gear manufacture and range extension of fishing activities have led to presence of ghost nets in the oceanic and coastal ecosystems. In India, ghost nets sometimes get washed ashore. There is a need to create awareness among fishermen on the harmful effects of ghost nets on the marine fauna as well as navigators and other users of the marine ecosystem like divers and tourists. Countries like Australia which had severe problems due to ghost nets have devised several methods to tackle the problem. GhostNets Australia is an alliance of 22 indigenous communities from coastal northern Australia established in 2004. This program has trained and supported indigenous groups in removing ghost nets on shore and at sea. Such exercises are strenuous and these groups undertake cleanups of fishing gear and other debris at sea for periods extending to three weeks. Discarded lobster and other fishing traps are also a major concern in Australia and it is mandatory that traps are made with rot cord that decays in approximately six months.

Several reports on seabirds, turtles, seals, sea lions, whales and fishes that have suffered from entanglement or ingestion of marine debris are available. Plastic bags are mistaken by sea turtles for jellyfish, their prey and when they try to feed on it, the bag gets entangled and most often the turtle moves around with this. Recent studies show that plastics can act as a source of toxic substances which can affect the fauna when ingested, bio-accumulate and then be transported up the food web to humans. Studies suggest that 70% of marine litter sinks to the seabed, 15% continues to drift within the water column and 15% ends up on beaches. The benthic ecosystem is one of the most productive areas which support the demersal fishes, shrimps and several invertebrates like the octopuses, sea cucumbers, gastropods and bivalves. They depend on benthic substrate for all their major life cycle activities like foraging and breeding and hence are more vulnerable to impacts of marine litter. In Cochin backwaters and adjoining canals, spread of litter on the bottom has been found to affect breeding of shrimps and pearl spot (*Etroplus suratensis*) which are the major fishery resources there.

Plastic products ranging from small ice cream spoons to large sheets and crates are dumped as litter on the beaches and obtained along with fish catch in gears like bag nets and trawls. In the estuaries, these occur in gill nets and drift nets. Even critical habitats like coral reefs of Lakshadweep have plastic litter. In a survey conducted the mean litter density was estimated as 7.71 g m^{-2} and in the 4 inhabited islands the litter density ranged from 2 to 11 g m^{-2}. Similar situation occurred in the ecologically sensitive, sea grass beds at Mandapam, Kilakkarai, Erwadi and Periyapattinam, which are habitats of dugong. Plastics are a transport vector of persistent organic pollutants (POP) and heavy metals as well as a source of chemical pollutants themselves such as phthalate plasticisers, polybrominated diphenyl ether flame retardants (PBDE; which are known to cause infertility in human beings) and bisphenols (endocrine disrupter). Depending on the size, plastics are classified into macro(>5mm) and micro plastics (<5mm) that includes particles as small as 10 nanometers. Micro-plastics are used as abrasive



Plastic strands in the gut of oil sardine

scrubbers in domestic cleaning products and industrial cleaning applications. Microplastics formed by the physical, chemical and biological fragmentation of larger items on exposure to UV light or due to abrasion are called 'secondary' microplastics. These have an increased risk due to their larger surface to volume ratio which results in higher adsorption capacities which, in combination with higher bioavailability makes them a potential carrier of pollutants into the food web. Plastic strands have been observed in the gut of sardine, anchovies and mackerel, while larger pieces were observed in higher trophic level fishes like dolphin fish and tunas besides sea birds. Analysis of zooplankton samples along Kerala has shown that nylon threads occur at densities of 3 to 4 per m^3 and this is comparatively very low (*CMFRI Annual Report 2015 -16*). This is a positive indicator that further deterioration of our coastal ecosystem can be prevented through proper management.

Estimates of litter in Vembanad Lake

Observation on seasonal occurrence of plastic wastes in beaches of Central Kerala indicate decline in plastic over the years (Fig. 1). One of the reasons for this decline is the frequent cleaning activities by various agencies as part of awareness programmes. Different types of surveys including transect / quadrant and participatory surveys were conducted in the marine and estuarine regions to assess the quantity of litter on the surface, column and bottom. The litter collected per unit area and time (for floating litter) were sorted and identified and their number and weight noted.

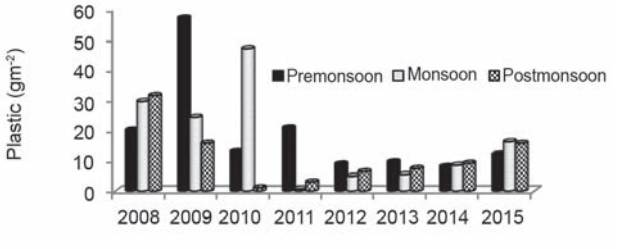


Fig. 1. Seasonal occurrence of plastic wastes in central Kerala beaches during 2008-2015

Bottom litter

All through the Vembanad Lake, litter is present on the substrate, but highest quantity is in Cochin backwaters and bar mouth region. Along the sides the spread of litter is to the height of 50 cm and more.

Column litter

It has been estimated that during low tide, about 135 tonnes of litter pass though the columns in a year towards the bar mouth. Some of these can also be flushed back during high tide. The survey has indicated that plastic flex, cloth, bottles, plastic coated sacks, thermocol pieces/ sheets, footwear etc are common.

Floating litter

About 75 to 100 kg of litter (wet weight) floats on the surface waters (less than half meter) and passes through the Cochin backwaters to the Arabian Sea during low tide per day. This can settle near the bar mouth region or float away from the coast.

Impacts of marine debris on three major sectors

Tourism : This is one of the largest business sectors of the world economy contributing significantly to the GDP and employment generation. The accumulation of marine litter on the beaches and in the coastal areas can affect natural aesthetic beauty thereby reducing their recreational value and affect the tourism based on these ecosystems. In India, the travel and tourism sector is a fast growing industry which provides significant socio economic benefits. If we don't act fast enough to reduce our litter outputs and have proper litter management plans it will adversely affect the sector.

Shipping industry : Marine debris are known to cause navigational hazard for the shipping industry as reflected in the increasing number of coast guard rescues to vessels with impacted propellers. Apart from this, accidents in the sea due to collision with marine debris have been cited as reason for human fatalities.

Fishermen and fisheries : The trapping of assorted type and size debris in fishing nets has been found to affect fishermen as removing these from the nets is time consuming. In small stake nets where shrimp is the major catch, fishermen have to engage extra labour to remove the debris from the catch. In a study conducted on stake nets in Vembanad Lake, shrimp catch in the net ranged from 0.525 to 1.36 kg while the average weight of litter in these nets ranged between 1.87 to 13.8 kg per day per net. Experimental fishing conducted along Central Kerala has clearly indicated the growing threat to fisheries with the material collected in the nets from near shore areas having huge quantities of trash especially plastics and pieces of nets. Entanglement of debris including fabrics and ghost nets on the propellers and blocking of intake pipes of the fishing vessels have considerable impacts on fishing time and maintenance costs.

Plastic collected from stake nets

Plastic waste collected during experimental trawl fishing operations

International agreements and initiatives

Initially, considering the importance of marine environment in global economy, the Inter governmental Oceanographic Commission (IOC) and the United Nations Development Programme (UNDP) initiated programs to conserve the resources and maintain the health of the marine environment. However these rules and guidelines did not directly target marine debris, though there were instructions that wastes should not be dumped and environment should be clean and healthy. The subsequent alarming rate of increase of marine debris in all regions and its ecological, social and economic impacts led to major global initiatives such as listed below.

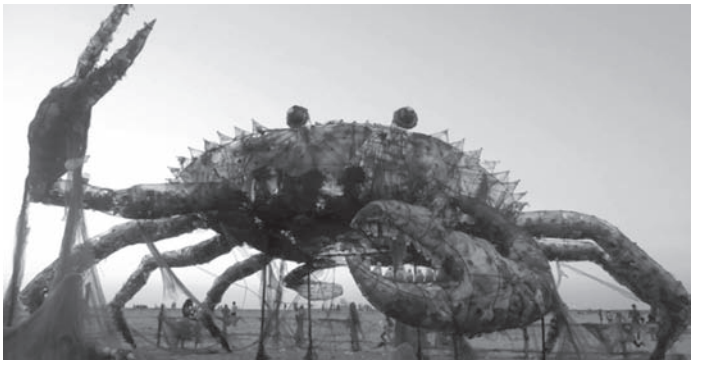
Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities (GPA) of UNEP was established in 1995 and is the only inter-governmental mechanism which addresses the impacts of land-based sources and activities on coastal and marine environments and human well-being. Its goal is to prevent, reduce, control or eliminate and/or recover from the impacts of the degradation of the marine environment from land-based activities by facilitating the duty of States to preserve and protect the marine environment. The 'Global Partnership on Marine Litter' (GPML) was launched in June 2012 at Rio + 20 in Brazil. It seeks to protect human health and the global environment by the reduction and management of marine litter as its main goal, through several specific objectives. 'The Future We Want' an outcome document of Rio+20 (2012) supports the sustainable management of wastes through waste minimisation activities by the 3 R's (Reduce, Reuse and Recycle) and also through energy recovery. It also calls for the development and enforcement of comprehensive national waste management policies, strategies, laws and regulations.The 'London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter' an international treaty limits the

discharge of wastes generated on land and disposed of at sea, is one of the first global conventions to protect the marine environment from human activities. The FAO Code of Conduct for Responsible Fisheries was adopted in 1995, and its Principle 6.7 states that the management of fish harvesting processes should be carried out in a manner which reduces waste and Principle 6.8 promotes the protection of critical habitats from destruction, degradation and pollution from human activities. The 'UN Fish Stocks Agreement' (UNFSA) adopted in 1995 and enforced in 2001 is based on the general provisions of the UNCLOS which states that fishing should be conducted in a manner that will protect the marine environment and prevent loss of fishing gear. The 'Honolulu Strategy' created in 2011 is a framework for a comprehensive and global effort to reduce the amount and impact of land-based and ocean-based sources of marine debris introduced into the sea and accumulated marine debris on shorelines. The International Convention for the Prevention of Pollution from Ships MARPOL 73/78 - seeks to prevent and reduce the amount of debris being discharged into the sea from ships.

Awareness Campaigns

The program 'International Coastal Cleanup Day' held on 17th September every year where thousands of volunteers join together to clean the beaches and coastal areas completed 25 years in 2011. In India, the program is organised by the Indian Coast Guard. About 99 tonnes (t), 116 t and 71 t were collected by 22458, 19935 and 19600 number of participants with an average collection rate of 4.4, 5.8 and 3.7 kg per participant during 2012, 2013 and 2014 respectively. This indicates that about 70 to 116 tonnes of debris are spread along Indian coasts which can enter the coastal waters and then spread to the Indian Ocean.

ICAR- CMFRI has also initiated several programmes to create awareness on marine litter. In 2012, on World Environment Day, an installation Art of an 'Octopus' was created on Cherai beach. The impressive 3 m tall sculpture was created using 125 kg of plastic bottles and carry bags collected from the beach. Similarly a crab ('Mad Crab') installation which occupied a ground area of 400 sq.ft and was 17 feet in height and 19 feet in width was erected on Fort Kochi beach on 30th December, 2013 using discarded plastics on the beach by involving the local communities and visitors to beach in the campaign. A short movie titled 'Ocean or plocean?' with a message to reduce littering produced by ICAR-CMFRI won the Beaver Bronze award under the science documentary section in *Rashtriya Vigyan Chalachitra Mela* and Competition, 2014 (National Science Film Festival,) organised by Vigyan Prasar, National Institute of Science and Technology Communication, Noida and National Council of Science Museums, Kolkata, held at Bengaluru in February, 2014. Apart from this,



Mad crab installation Art using discarded plastic bottles

competitions for school children on impacts of litter on ecosystems and several lectures on Marine litter by staff involved in this project have helped to make public aware of the impacts of litter. However this alone cannot solve the problem unless there are facilities to deposit the litter and destroy it properly without causing additional problems. In Kozhikode, fishermen who used to take a share of the fish catch in plastic carry bags for domestic use have shifted to using small buckets for own use thereby reducing use and discard of plastic bags which are small welcome initiatives.

Remediation Operations

Fishermen are directly impacted by the increase in litter in the coastal areas and attempts have been made by fishermen themselves to remove litter in the past. In 2012, members of 12 Kayal Samraksha Samithy with technical support from Asoka Trust for Research in Ecology and Environment (ATREE) and Vembanad Nature Club collected about 40 bags of plastics and used this for levelling about 150 m of the Muhamma –Kalyanasseri Road in association with the local Panchayat (New Indian Express, May 16, 2012). Recently another local attempt to remove the solid waste accumulated in Cochin backwaters was initiated by the youth belonging to Dheevara Sabha. The litter accumulated in the shore line area is in layers and intermingled with silt, making it heavy and difficult to remove. Using a hired canoe they are using pumps to splash water over the substrate during low tide to loosen the settled litter, followed by manual removal of the litter with rakes. The program was inaugurated on 2nd October, 2016 and during the period from October 4th to 21st they have removed about 9.1 tonnes from the shore line area. The collected litter packed in bags was removed by Cochin Corporation. Analysis of the litter component in all the surveys conducted by ICAR-CMFRI has indicated the dominance of plastics, thermocol, cloth, rubber and other synthetic articles. Since most of these items can be recycled and reused, proper management measures to segregate and process the waste at the production /collection level will solve the problem to a large extent. A district level committee can be constituted to draft an action plan to solve the problem. Funds for this activity also should be provided.

Wastes collected during cleaning of Cochin Backwaters

Need for National Marine Debris Management Strategy

Though the UNEP was established in 1972, a targeted program for marine debris control was initiated only since 2003. The problem of marine litter was recognized by the UN General Assembly (UNGA), which in its Resolution A/60/L.22 (November 2005) calls for national, regional and global actions to address the problem of marine litter. Now apart from Regional Seas programs, each nation is implementing its own strategy for marine debris reduction and control. ICAR- CMFRI has been organising stakeholders meeting every year in all maritime states. Marine litter is one of the major problems identified by fishermen and they have demanded a solution for this. Considering the growing threat to resources sustainability and reduction in ecosystem functional services leading to loss of livelihood in fisheries sector, we strongly recommend that there should be a National Marine Debris Management Strategy with specific goals for Prevention and Control of debris accumulating, spreading and in coastal and marine ecosystems affecting the fish production. The Ministry of Environment and Forest (MoEF) has issued MSW

management and handling rules –but this has not targeted marine debris. Considering the global importance of plastics, we have to develop a responsible method of disposing used plastics instead of making it a "litter". The long term solution lies in proper development and utilization of waste management facilities in all villages, municipalities and corporations so that it does not become a regional and global issue. Few suggestions for reduction marine debris are given below.

1. Prevent/reduce generation of waste that contributes to the marine litter (First identification of major component in the litter then measures to reduce)
2. Prevent/reduce litter reaching the marine environment : Proper segregation of litter which can be recycled and reused (Eg: Korea, US)
3. Collect litter from the marine environment through incentives
4. Provide Incentives to fisher for marine litter collection (n the Republic of Korea, fishing boats are provided with large bags to collect litter and an economic incentive of US$10 per 100 litre bag is provided to fishermen)
5. Development of Environment-friendly design in packaging (Eg Japan)
6. Extended producer responsibility (EPR) makes a producer financially and/or logistically responsible for the post-consumer (i.e. waste) stage of a product's life cycle (Eg EU states)
7. Provision of adequate low-cost or free and easy-to-use collection facilities in ports
8. Incentive schemes to promote proper disposal of discarded gear
9. Improvements in waste management infrastructure in tourist areas (e.g. placing suitable bins on beaches, followed by regular clearing)
10. There is a need for greater producer responsibility and more widespread application of the polluter pays principle.
11. Marine litter clean-ups (costly but necessary downstream actions)
12. The development of new recycled plastic products

Integrated Approach

Marine debris management should be an integrated approach involving even the smallest unit like households and village governing bodies.

- **Funding** is required from central governments or international agency to develop waste management infrastructure and provide incentives.
- **Municipalities/local governments** upstream and downstream should invest further in waste and wastewater treatment infrastructure and in managing these effectively. This can help to prevent marine litter at source.
- **Private and public sectors** should try to develop new packaging design with improved durability, recyclability and green chemistry.
- **NGOs and voluntary organisations** should plan and organize programs to motivate changes in consumer habits and norms and encourage producer responsibility.
- **Local communities** without age and gender bars should engage in awareness and clean-up activities.
- **All categories of consumers** including tourists should make responsible choices regarding purchases and take responsible actions regarding waste disposal.