

dioxide and water. Many marine microorganisms like bacteria, fungi and yeast feed on the components that make up the oil. Though they are present in low numbers, their population size seems to increase in oil spilled areas. Twenty five marine bacterial genera are supposed to be active in oil degradation (Kimes et al., 2014). The biodegradations would be cheapest, convenient and environmental friendly technology. But, effect of this technique is practically to be proved in actual oil spill cases.

**References:**

Abha. S and Singh C. S, (2012). *Hydrocarbon Pollution: Effects on Living Organisms, Remediation of contaminated Environments, and Effects of Heavy Metals Co-Contamination on Bioremediation. Introduction to Enhanced Oil Recovery (EOR) Processes and Bioremediation of Oil Contaminated Sites*, Dr. Laura Romero-Zerón (Ed.), ISBN: 978-953-51-0629-6, InTech.

Bernabeu, A. M., S. Fernandez-Fernandez, F. Bouchetteb, D. Rey, A. Arcos, J. M. Bayona, J. Albaiges, (2013). Recurrent arrival of oil to Galician coast: The final step of the prestige deep oil spill. *Journal of Hazardous Material*, 250-251, 82-90

Anonymous, (1999). United Nation Environment Program, evaluation and oversight unit, annual report 1999.

Anonymous, (2010). International Agency for Research on Cancer, 2010.

Hayworth J. S, Clement T. P, Valentine J. F, (2011). Deepwater Horizon oil spill impacts on Alabama beaches. *Hydrology and Earth System Sciences* 15:3639-3649.

Kimes N. E, Callaghan A. V, Suflita J. M, Morris P. J, (2014). Microbial transformation of the Deepwater Horizon oil spill—past, present, and future perspectives. *Frontiers in Microbiology* 5:603. doi: 10.3389/fmicb.2014.00603

Mashroofeh Abdulreza, Alireza Riyahi Bakhtiari and Mohammad Pourkazemi, (2015). Distribution and composition pattern of polycyclic aromatic hydrocarbons in different tissues of sturgeons collected from Iranian coastline of the Caspian Sea. *Chemosphere*, 120, 575-583.

Suneel. V, P. Vethamony, K. Vinod Kumar, M. T. Babu., K. V. S. R. Prasad, (2013b). Simulation of trajectories of tar ball transport to the Goa coast. *Water Air and Soil Pollution*, 224:1538.

Suneel. V, P. Vethamony, B. G. Naik, K. Vinod Kumar., L. Sreenu, S. V. Samiksha, Yunus Tai and K. Sudheesh (2014). Source investigation of the tar balls deposited along the Gujarat coast, India using chemical fingerprinting and transport modelling techniques, *Environmental Science and Technology*, 48, 11343-11351

Suneel. V., A. Ciappa., P. Vethamony (2016). Backtrack modelling to locate the origin of tar balls depositing along the west coast of India. *Science of the Total Environment*, 569-570, 31-39.

Tao Z, Bullard. S, Arias. C, (2011). High Numbers of *Vibrio vulnificus* in Tar Balls Collected from Oiled areas of the North-Central Gulf of Mexico Following the 2010 BP Deepwater Horizon Oil Spill *Eco Health* 8:507-511.

Wang, P, and Roberts, T. M, (2013). Distribution of surficial and buried oil contaminants across sandy beaches along NW Florida and Alabama coasts following the Deepwater Horizon oil spill in 2010. *Journal of Coastal Research*, 29(6A), 144-155.

Warnock A. M, Hagen S. C, Passeri D. L, (2015) Marine Tar Residues: a Review. *Water Air Soil Pollution* 226:68

**Microplastic pollution: a serious threat to the marine ecosystem**

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**Introduction**



Fig 4. Classification of microplastics (Source: Veerasingam et al., 2016a ) Primary microplastics

Plastic pollution will be one of the most challenging ecological threats for the next generation. A recent research study estimated that 4.8–12.7 million metric tons (MMT) of plastic waste enter the world ocean (Jambeck et al., 2015). Of the top 20 countries releasing waste into the oceans, 10 have shores on the Indian Ocean, the third largest ocean in the world. Until now, all studies have focused on the environmental and the economic impact of macro-sized plastics. These plastics can be visualized, collected and studied. We do not have much information on the impact of microplastics in the marine environment.

Microplastics are tiny plastic fragments in the environment with size of less than 5 mm in diameter. The following two types of microplastics are currently existing: (i) primary microplastics which are made to carry out certain functions (e.g. toothpaste, skin cleansers and cosmetics) and microplastic pellets used

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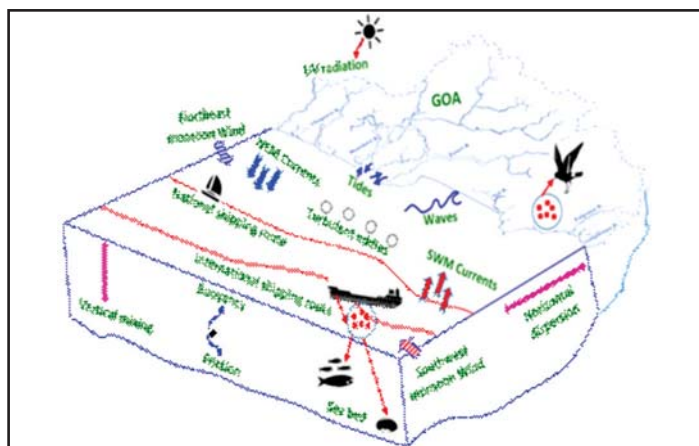


*Fig 5. Classification of microplastics (Source: Veerasingam et al., 2016a) Secondary microplastics*

for the manufacturing plastic material and (ii) secondary microplastics, which are generated when macro-sized plastics in the marine environment are physically (wind, wave and current), chemically (UV light radiation) and biologically (microbial activity) degraded and fragmented into micro-sized (<5 mm) particles (Fig 4 & 5).

**Sources and controlling factors**

The sources of microplastics in marine systems are both sea and land based sources. Sea based sources could be from accidental and/or unintentional spillages from ships during their voyages or handling of raw materials in harbours.



*Fig 6. Sources and factors influencing the transportation and distribution of microplastics in the marine environment (Source: Veerasingam et al., 2016b).*

Microplastics may also enter into the coastal waters through rivers, streams, storm water drains and sewerage systems following spills at inland processors or during transport (Fig 6). (Jambeck et al. 2015) estimated that 80% of plastics in the sea originates from land based sources and is transported by rivers to the oceans. The catastrophic events including tsunami and flood can also transport plastics into the marine environment (Veerasingam et al., 2016c). Winds, tides, waves and currents can carry the floating plastic debris over long distances from their original point.

Oceanographic modelling of floating debris has shown accumulation of floating plastics in five ocean gyres, and the distribution of microplastics within the water column appears to be dependent on the composition, density and shape of plastic polymers affecting their buoyancy (Eriksen et al., 2014). Modelling studies in the Indian Ocean shall help to identify and predict regions with ecological communities and fisheries, which are vulnerable to the potential consequences of plastic contamination.

In India, Polyethylene (PE) and Polypropylene (PP) are the most largely used plastic raw materials. As per the report of FICCI (2014), ~ 2.3 MTPA (million tonnes per annum) of PE was produced, while domestic consumption was ~ 3.4 MTPA. Therefore, PE is imported from Saudi Arabia, Qatar, UAE, Korea, USA, Singapore, Thailand, Germany, Spain and Malaysia. In India, the production of PP is 2.5 MTPA, while demand is 2.1 MPTA only. Therefore, the excess PP materials are exported to China, Egypt, UAE, Turkey, Vietnam and Indonesia (FICCI, 2014). These products are imported/exported through sea-routes (Fig 7). Recently, Duhec et al. (2015) found that the Southeast Asia is the main source of the plastic debris and Somalia is another potential primary source of marine debris in the Western Indian Ocean. Therefore, there is a possibility for an increase in the accidental/ unintentional spill of MPPs in the ocean. Recent studies found that the deposition of sea-based microplastics are more during the

northeast monsoon along the east coast of India, whereas those plastics are abundant during the southwest monsoon along the west coast of India (Veerasingam et al., 2016 a,b,c).

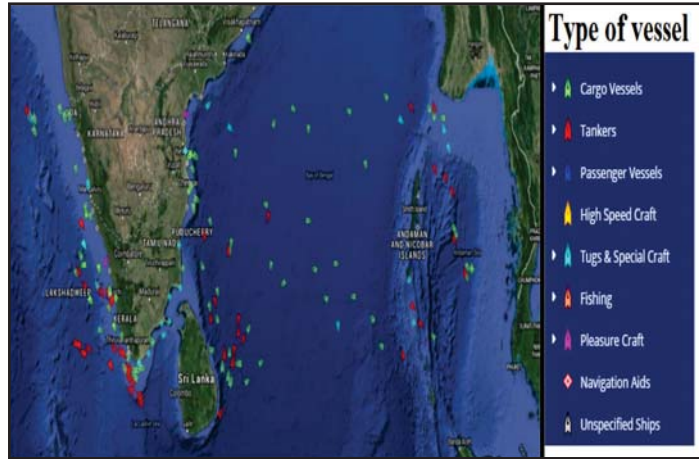


Fig 7. The Automatic Identification System map shows the shipping traffic in the Arabian Sea and Bay of Bengal.

**Ecological and chemical risks of microplastics**

Microplastic pollution is a global issue, which affects everything from the environment to economy. Microplastics are small enough to be ingested by many marine species. For example, filter feeders ranging from plankton to baleen whales and basking sharks. Sea birds are also very vulnerable to microplastic litter, especially floating plastics, which will be easily confused for prey like fish eggs. In addition, organisms breathing with gills such as fish and crabs as well as other filter feeders such as mussels and barnacles are also likely to be affected by microplastics (Fig 8). Ingestion of microplastics by species in aquacultures or fisheries may potentially pose a risk for human food safety. Sea salt is typically produced by crystallization due to the combined effects of wind and sunlight. A recent research study found that the abundance of microplastics in sea salts is significantly higher than that in the lake salts (Yang et al., 2015).

Microplastic itself a pollutant, since it contain additives and may potentially be an exposure route of harmful chemicals. Microplastics can also act as vectors

for transporting persistent organic pollutants (POPs) from the environment to the biota. The harmful substances within the microplastics include antimicrobials, hydrocarbons and flame retardants, which often persistent and may reduce health and biodiversity.

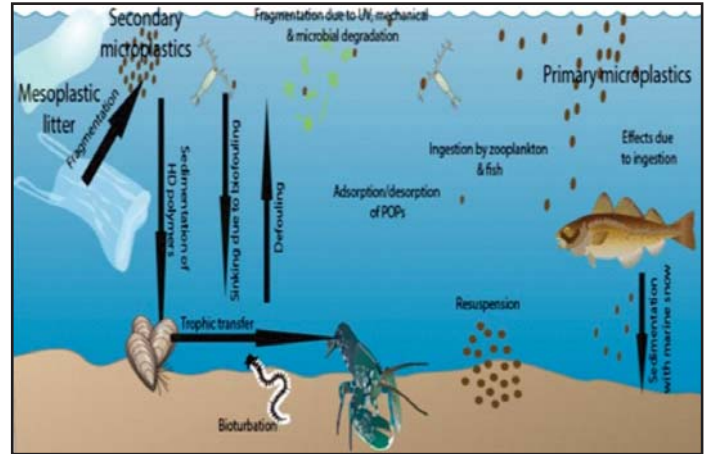


Fig 8. Potential fate and pathways and biological interactions of microplastics (modified from Wright et al., 2013)

**Anticipated future trends**

Global production of plastics has increased from around 5 million tons per year during 1950s to over 300 million tons today. However, majority of these plastics are used to make single-time use items, which are disposed of within a year of production. The amount projected by 2050 is about 40 billion tons, which is enough to wrap 6 layers of cling film around the planet (Zalasiewicz et al., 2016). Considerable quantity of end-of-life plastics is getting accumulated in landfills and in the natural environment. The quantity of end-of-life plastics in the marine environment is substantial, but only a few reliable estimates of the total amount or, the relative proportions of different types of debris such as microplastics is available at present. Recent studies attempted to assess global plastic distributions (Cozar et al., 2014; Eriksen et al., 2014), and the logical next step could be to estimate total production, current tonnage in use and disposal of accumulated plastics via approved waste management in order to establish a mass balance of the amount of plastics that is missing in the environment (Jambeck et al., 2015).An initial

survey suggested abundance in the deep sea than in shallow water habitats (Van Cauwenberghe et al., 2013). Recent evidences show that the deep sea could be a substantial sink for microplastics. However, detailed investigations are required to confirm that deep sea is a sink for microplastics, and understand their long-term fate in the deep sea and the extent of any subsequent deterioration or biodegradation over extended time scales (Thompson, 2015).

**Policy development and management**

Worldwide, microplastic contamination and accumulation on beaches and oceans have been identified as a serious environmental issue and several research programs have been initiated. Despite the difficult task of avoiding plastic consumption and reducing the pollution, it is time to involve industrial manufacturing, shipping and harbour stakeholders to make a step forward in preventing the microplastics entering into the marine environment from land and/or ocean based sources. Finally, it is suggested that government can play an active role in addressing the issue of plastic waste by introducing legislation to control the sources of plastic debris and the use of plastic additives. In addition, plastic industries can find the possibility of shouldering the responsibility for the end-of-life of their products by introducing plastic recycling or upgrading programmes.

Reduce, reuse and recycle are the current solutions to the overuse of plastics. Solutions to ensure materials are recycled or disposed off properly need to be developed. Even with research, recycling, and new technologies, alternate packaging material should be utilized to reduce the dependence on plastic goods. There should be awareness of the threats posed by microplastics to marine ecosystems and human health to prevent plastic littering.

**References**

Cózar, A., Echevarría, F., Gonzalez-Gordillo, J. I., Irigoien, X., Ubeda, B., Hernandez-Leon, S., et al. 2014. Plastic debris in the open ocean. *Proceedings of the National Academy of Sciences of the United States of America*, 111, 10239–10244.

Duhec, A.V., Jeanne, R.F., Maximenko, N., Hafner, J., 2015. *Composition and potential origin of marine debris stranded in the Western*

*Indian Ocean on remote Alphonse Island, Seychelles. Marine Pollution Bulletin*, 96, 76–86.

Eriksen, M., Lebreton, L. C. M., Carson, H. S., Thiel, M., Moore, C. J., Borroero, J. C., et al. 2014. Plastic pollution in the world's oceans: more than 5 trillion plastic pieces weighing over 250,000 tons afloat at sea. *PLoS ONE*, 9, 111913.

Jambeck, J.R., Geyer, R., Wilcox, C., Siegler, T.R., Perryman, M., Andrady, A., Narayan, R., Law, K.L., 2015. Plastic waste inputs from land into the ocean. *Science*, 347, 768 – 771.

Thompson, R.C., 2015. Microplastics in the marine environment: Sources, consequences and solutions. In: *Marine Anthropogenic Litter* (Eds.) Bergmann, M., Gutow, L., and Klages, M. pp 185–200.

Van Cauwenberghe, L., Vanreusel, A., Mees, J., Janssen, C. R. 2013. Microplastic pollution in deep-sea sediments. *Environmental Pollution*, 182, 495–499.

Veerasingam, S., Vethamony, P., Mugilarasan, M., Venkatachalapathy, R., 2016a. Occurrence and spatial distribution of microplastic pellets in sediments around Kavaratti Island, Lakshadweep Archipelago, National seminar on approaches to CSD in coastal zones of India, CSIR – National Institute of Oceanography, Regional centre, Mumbai.

Veerasingam, S., Saha, M., Vethamony, P., Rodrigues, A.C., Bhattacharyya, S., Naik, B.G., 2016b. Characteristics, seasonal distribution and surface degradation features of microplastic pellets along the Goa coast, India. *Chemosphere*, 159, 496–505.

Veerasingam, S., Mugilarasan, M., Venkatachalapathy, R., Vethamony, P., 2016c. Influence of 2015 on the distribution and occurrence of microplastic pellets along the Chennai coast, India. *Marine Pollution Bulletin*, 109, 196–204.

Wright, S.L., Thompson, R.C., Galloway, T.S., 2013. The physical impacts of microplastics on marine organisms: a review. *Environmental Pollution*, 178, 483–492.

Yang, D., Shi, H., Li, L., Li, J., Jabeen, K., Kolandhasamy, P., 2015. Microplastic pollution in table salts from China. *Environmental Science and Technology*, 49, 13622 – 13627.

Zalasiewicz, J., Waters, C.N., Ivar do Sul, J.A., Corcoran, P.L., Barnosky, A.D., et al. 2016. The geological cycle of plastics and their use as a stratigraphic indicator of the Anthropocene. *Anthropocene*, 13, 4 – 17.

**Need for Conservation and Management of Indian Coral Reefs in Light of Changing Climate**

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Coral reefs cover only about 0.2% in area of the marine environment but are among the most biologically diverse and economically important ecosystems. They are important breeding, spawning, nesting and feeding areas for many economically important fishes and other marine organisms.

Corals and coral reefs all over the globe are in an ecological crisis due to a multitude of anthropogenic activities such as coastal development, agricultural runoff, tourism, pollutants, sedimentation, overfishing

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