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SOLID WASTE IN OCEANS -A GLOBAL ENVIRONMENTAL THREAT

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ABSTRACT:

Oceans are huge reservoirs of water, occupying ~70% area of the planet earth. More than 60% of human population live along the coastal areas and depend largely on the oceans for food. Oceans regulate the Earth's climate and produces ~70% of oxygen. They are important sources for transport and thereby plays a vital role in the global commerce and trade. They are very rich sources of mineral and biotic wealth. Despite of these advantages, the oceans have become victim of increased anthropogenic activities. Huge number of wastes have been dumped in the oceans every year. An exponential increase in the wastes such as 8.3 million tons plastic is dumped in the sea yearly, from 1950-1998 over 100 nuclear blast tests occurred under the oceans. About 80% of the global marine pollution comes from the sources of agriculture runoff, untreated sewage, discharge of nutrients and pesticides. The largest single marine disposal site on the earth is known as the great pacific garbage patch, located in the north pacific subtropical gyre. Debris from Asia and north America contribute ~80% of the great pacific garbage patch and 20% constitute of offshore debris, oilrigs, pacific cargo ships, boater dumping various debris into the water. The present-day situation of ocean dumping is alarming, the solid wastes are increasing day by day and there are hardly any efforts to remediate them. Global communities are concerned about increasing toxicity of oceans, but proper regulatory tools and policy initiatives are needed to combat the menace of ocean dumping. In this context, the present paper gives a critical look at the ocean dumps and the critical issues that must be addressed to curb the menace of solid wastes in oceans.

Keywords **- marine waste, ocean dumping, plastic, solid wastes, sustainability.**

1. INTRODUCTION

A major part of the product manufactured or won from the natural resources is discarded as waste. Secondly, every product has a specific lifetime beyond which it goes into scrap. With the use-and-throw approach of modern society, enormous number of solid wastes in the form of nano plastic, radioactive

waste, mine tailings, pharmaceutical waste etc., is being generated resulting in huge quantities of dumping. Somehow this trend got an extra edge with outbreak of Novel- Corona virus in 2020 (Tripathi et al., 2020). The sudden rise of production in plastic items with context to endless demand of items like PPE kits, sanitizing bottles, masks, etc. have caused a stir in global market. As a repercussion, it led to enormous production of solid wastes. There are various techniques used for the disposal of these materials; among which ocean dumping is globally practiced since long time.

Oceans are major sources of salinity and the largest water reservoirs on the planet with a land expanse of ~331 million sq. kms (Thurman and Trujillo, 2011) and average mass of ~1.41 billion metric tons. A huge number of solid wastes, including airplane and ship wreckages, plastic materials, broken vessels, mining wastes, oil spillage etc., are regularly dumped in oceans (Kindt et al., 1984). Such man-made artefacts are dumped in ocean and contaminates it and takes a heavy toll on the marine resources, and eventually deteriorates entire ecosystem. According to recent statistics (Jambeck et al., 2015), China has highest contribution in polluting oceans with plastic waste followed by other Asia pacific countries (Fig.1). However, there is a lack of global monitoring mechanism and also regulatory framework within individual nations. This is partly because of inadequate regulations, lack of infrastructure and continually expanding demand and consumption, and partly due to lack of awareness about the adverse effects releasing trash and other toxic substances into the ocean. On this backdrop, the present study outlines the sources, pathways, and detrimental effects of solid wastes dumped in oceans.

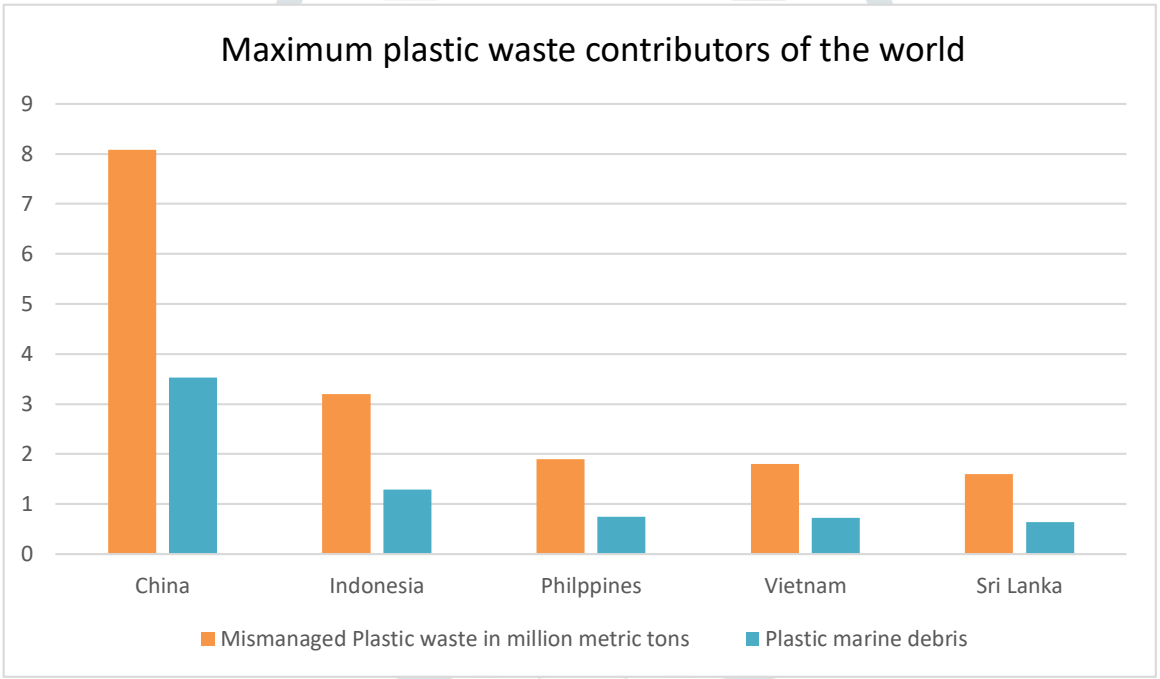


Fig.1 Maximum Plastic waste contributors of the world (Jambeck et al., 2015)

2. SOURCES AND PATHWAYS

There are several sources of ocean dumping (Fig. 2) such as ships, industries, factories, spillage from offshore rigs and oil tankers, mining of metal ores etc. The sewer drainage systems and the flowage from the land—runoffs, are also the major pathways of waste to ocean. Various cargo activities, while the wastes including slag, charcoal and calcareous materials removed from the deck contributes to ocean dumping. Metal ores (for example arsenic, iron, sulphur associated with deep-sea gold mining) are continuously accumulated at rivers and streams in regions where mining is carried out and discharged to the ocean by the water systems. Non-degradable products, such as plastic, often make their way into the oceans as a result of direct disposal. Solid waste can be classified by considering the point of origin, e.g., dead body remains, wood scraps that are typical forms of consumable biodegradable waste and the others are steadily degrading waste such as plastics, polymers, metal scraps (Table 1).

Table 1: - Classification of waste

Bio-degradable waste	Low degradable waste	Very low degradable	Non-degradable
Dead bodies of fishes	Oil tankers	Satellite debris	Plastic waste
Aquatic plants	Oil spills	Chemical waste	Rubber waste
Wooden waste	Eroded sunken debris	Plaster of Paris dumping	Various polymers waste
Aquatic excreta	Metallic debris from human colonies	Construction waste	Artificial leather waste

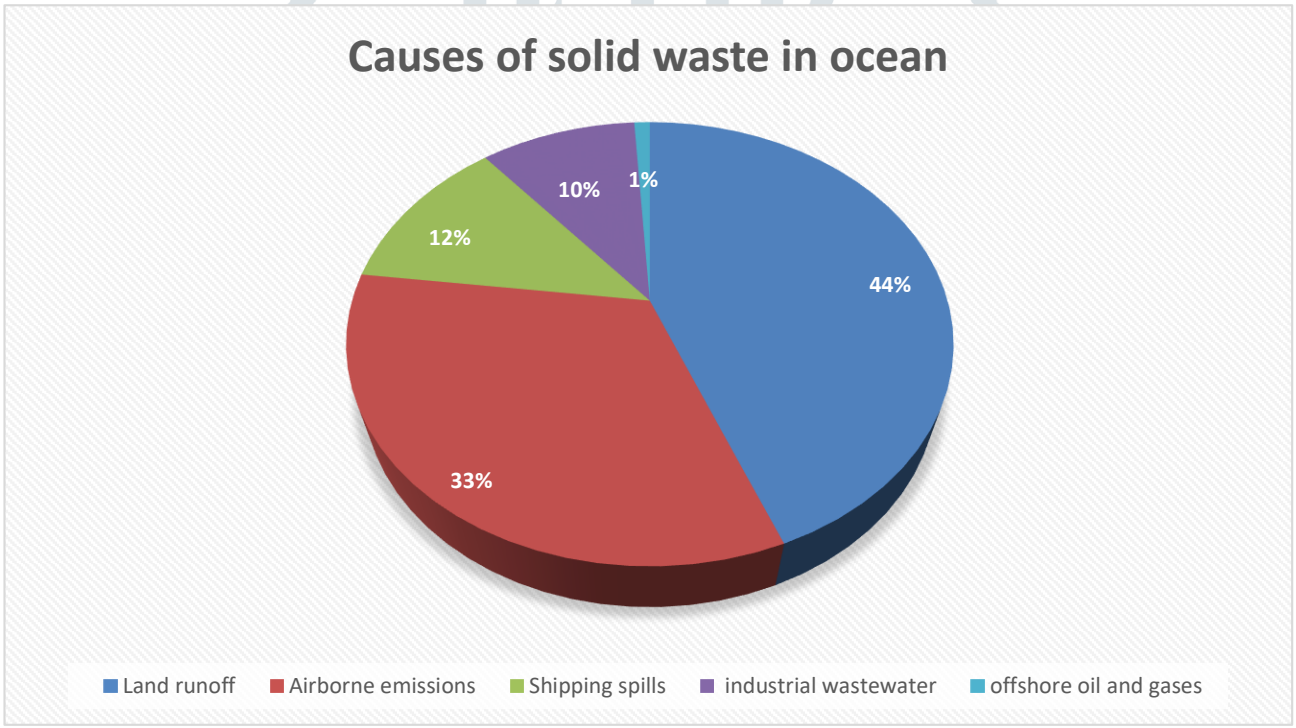


Fig. 2 Causes of solid waste in ocean (data from Mambra, 2020).

3. CONSEQUENCES

Solid waste is spread over the surface of the ocean or on the column of water, or even on the sea floor, and serves as a conduit for the transmission of harmful contaminants to the marine environment. One can assume that solid waste dumping is just the tip of marine pollution iceberg (Kindt et al.,1984).

3.1 THREAT TO MARINE FLORA AND FAUNA

Aquatic species are often trapped in marine plastic litter and are destroyed by choking, suffocation, or strangulation. Entangled animals often damage themselves by striving to free themselves and may suffer

limited motion efficiency due to accidents that leave them disabled to grab food or escape predators (Mambra, 2020).

3.2 THREAT TO MARINE ECOSYSTEM

Marine debris and the litter spread over beaches and ocean surface are not just aesthetically unpleasant, it also highly detrimental for the marine life. The ocean dumps are eradicating number of species which brought them to near extinction. Marine mammals and birds ingest plastic and other debris which leads them to starvation and eventual death. Ingested plastic may affect an animal's intestines and stomach and the central nervous system (CNS) thus blocking its digestive tract and entire metabolism arresting their locomotion. Large quantities of ingested plastics can cause an illusion of food and nutrients, which generates false feeling of satiation leading to malnutrition and eventual death. There are documented evidences of mammals dying entangled in nets, but the actual mortality rate is difficult to assess because many aquatic animals die at sea and calculations cannot be precise. Fishes have been drastically affected by banned pelagic drift nets which are lost at sea but continue fishing for long periods, and by lost bottom traps (Valavanidis et al., 2012).

3.3 IMPACT ON HUMAN HEALTH

The marine fauna consumes microplastic pellets which accumulates into their body. Once humans consume them, it adversely affects human health. Microplastics, which are synthetic resins, are absorbed in the gastro-intestinal track and sometimes form tumours, which leads to the damage of cardiovascular system of such people. Toxicity also can occur from the monomers and plastic additives, which can cause carcinogenesis and endocrine disfunction (Wright et al. 2013). The accumulated wastes can release poisonous constituents into back waters, and therefore jeopardize the health of swimmers, fishermen, and ordinary residents near costal area. Since the Fifties, over 2000 cases of a dangerous sickness referred to as Minamata with mercury food poisoning are recorded in China, Greenland, Canada, Brazil, and Columbia (Smith et al., 2018).

3.4 DAMAGE TO CORAL REEFS AND SEA GRASS BEDS

Coral reefs are highly threatened by items like abandoned or lost fishing gears and net. The debris get accumulated on the reef bodies, which creates pressure on the reef heads due to continuous wave action, and ultimately leads to the breakup of coral heads (Katsanevakis, 2011). Many a times, the growth of sea grasses gets hampered due to piling-up of solid wastes over them. In India, coral reefs from Periyapattinam, Mandapam, Kilakkarai, Erwadi were greatly influenced by the plastic wastes (Kripa et al., 2016). Pollutants and sediments which enter into marine cycle catalyse expansion of poisonous algae and reduce water quality, and even cuts back the coral growth. Pollution can introduce additional liability to sickness. Similarly, changes in food chain are also possible due to reduced coral fertility (Smith et al., 2018).

3.5 ASSISTING INVASION OF ALIEN SPECIES

Floating plastic debris usually accompanies marine species which may be transported from one place to another because of waves and current and may invade the realm, at the cost of degradation of native species (Gall and Thompson, 2015). This unnatural invasion of alien species can bring about catastrophic result for the native marine species, as alien species will fritter away resources as well as food, or take advantage of them in bringing about ecological change to the antecedental stable setting (Das et al., 2020)

3.6 POOR OCEANIC SCENERY AFFECTING TOURISM

Plastic debris on coastal beaches decreases the aesthetic charm of beaches that eventually impact the leisure outing of tourists (Kirkley and MacConnell, 1997; Smith et al., 1997). Contaminated oceans and accumulated garbage dumps over the beaches give a filthy appearance, which is often coupled with nasty smell. As a result, the landscape is highly affected because the colour of the water might appear black or green. This poses serious constraint over the business and sporting activities like seafaring, sailing, fishing and swimming, leading to significant losses of revenue and employment related to coastal tourism. Coastal tourism losses in the United Kingdom have been estimated to be between £5.49 million and £16.46 million (Lee, 2015). According to McIlgorm et al. (2011), marine debris affects marine tourism in the Asia-Pacific region to a tune of ~$0.622 million.

4. PLASTIC AS A PROXY IN ENVIRONMENTAL CHANGE

Plastic tends to intermingle with other environmental pollutants resulting into excess toxicity. Once this plastic gets accumulated within the food chain the associated toxins like PCBs and dioxins, will start entering into fats and tissues through bio-accumulation and influence the entire food chain. Also, some chemicals get added-up with the plastic during the production process, and eventually makes plastic even more toxic. These chemicals get leached out of the plastic once they enter the body, causing fatalities to animals. Plastic has a significant nano-scale role in bio accumulation of poisons as compared to exposure via animals daily dietary habits. When these animals excrete their body actually gets detoxed as all the toxins in the body gets attached to the plastic and come out. Although it is very difficult to know the total number of species affected by plastic is arduous, however, there have been efforts in the past to provide rough estimates. In 2015, Dutch scientists found that the quantity of marine species that ingest or have been trapped in plastic had almost doubled from 267 to 557 since 1997 (Kühn, 2015). This rate is currently higher than 2000, that portrays only restricted variety of animal species are investigated. If the present trend of litter production per annum continues, an extra thirty-three billion heaps of plastic can accumulate around the globe by 2050 (Rochman et al., 2013).

5. GLOBAL INPUT TO OCEAN DUMPING

Plastic is one of the greatest environmental threat facing the world. The U.S. dissipated about 33.6 million tons of plastic, and only 9.5% was recycled. Recent statistics suggest that India ranks on twelfth position in

case of plastic waste production. Overall studies show that the marine debris production per year is more than 10.72 million metric tons per year (summed up from top 20 countries) (fig 3).

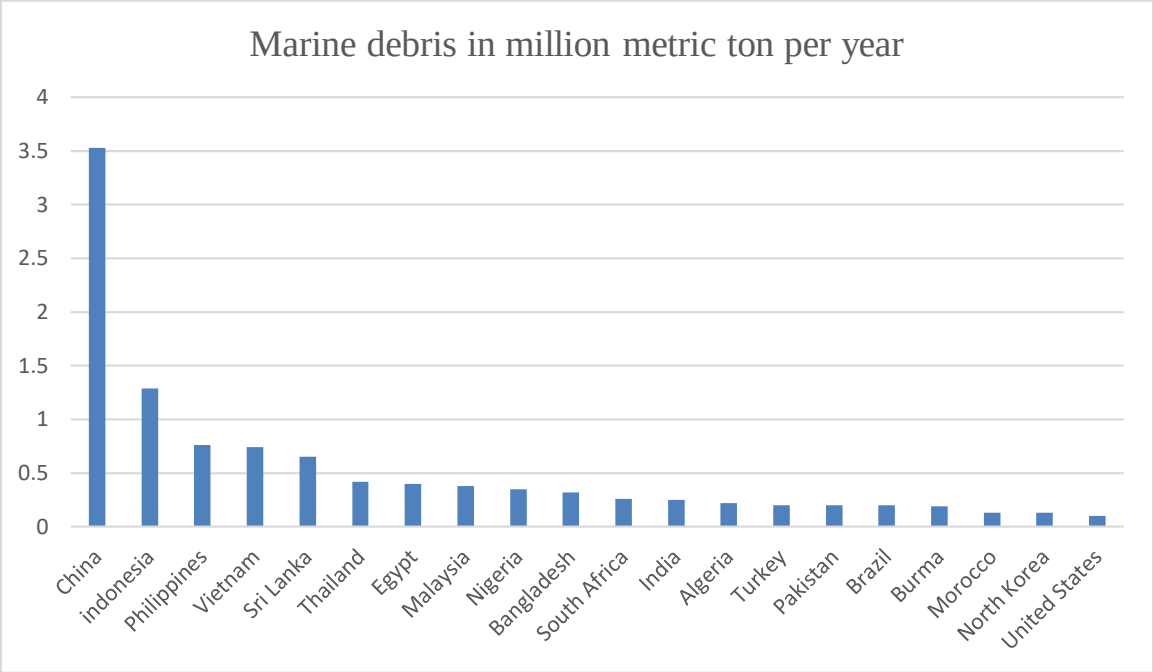


Fig. 3 Marine debris in million metric ton per year (Jambeck et al.,2015)

Studies have also revealed that the solid waste in US per capita is around 2.58 kg while Canada 2.33 kg, Australia 2.23 kg, Germany 2.11 kg, south Africa 2 kg, France 1.21 kg, United Kingdom 1.79 kg, Japan 1.71 kg, Saudi Arabia 1.3 kg, Mexico 1.24 kg, South Korea 1.24 kg, Brazil 1.24 kg, China 1.02 kg and India 0.34 kg (Desjardins, 2018). Compared to the rest of the world, southeast Asia is a major benefactor to land-based plastic waste escaping into the world's oceans, with half of it coming from five nations, namely, China, Indonesia, Philippines, Vietnam, and Thailand (Tanakasempipat, 2019; Fig. 4). Globally there is lack of consistency in a way the countries manage the plastic waste and the parameters adopted for the waste disposal in the environment. Opinions are divided on who would play a key role in reducing solid waste worldwide; whether the industries producing or selling packaged goods, the government, the consumers, or combination of entities. Solid wastes in oceans are present globally, and their ill effects are taking heavy toll on the environment and human health.

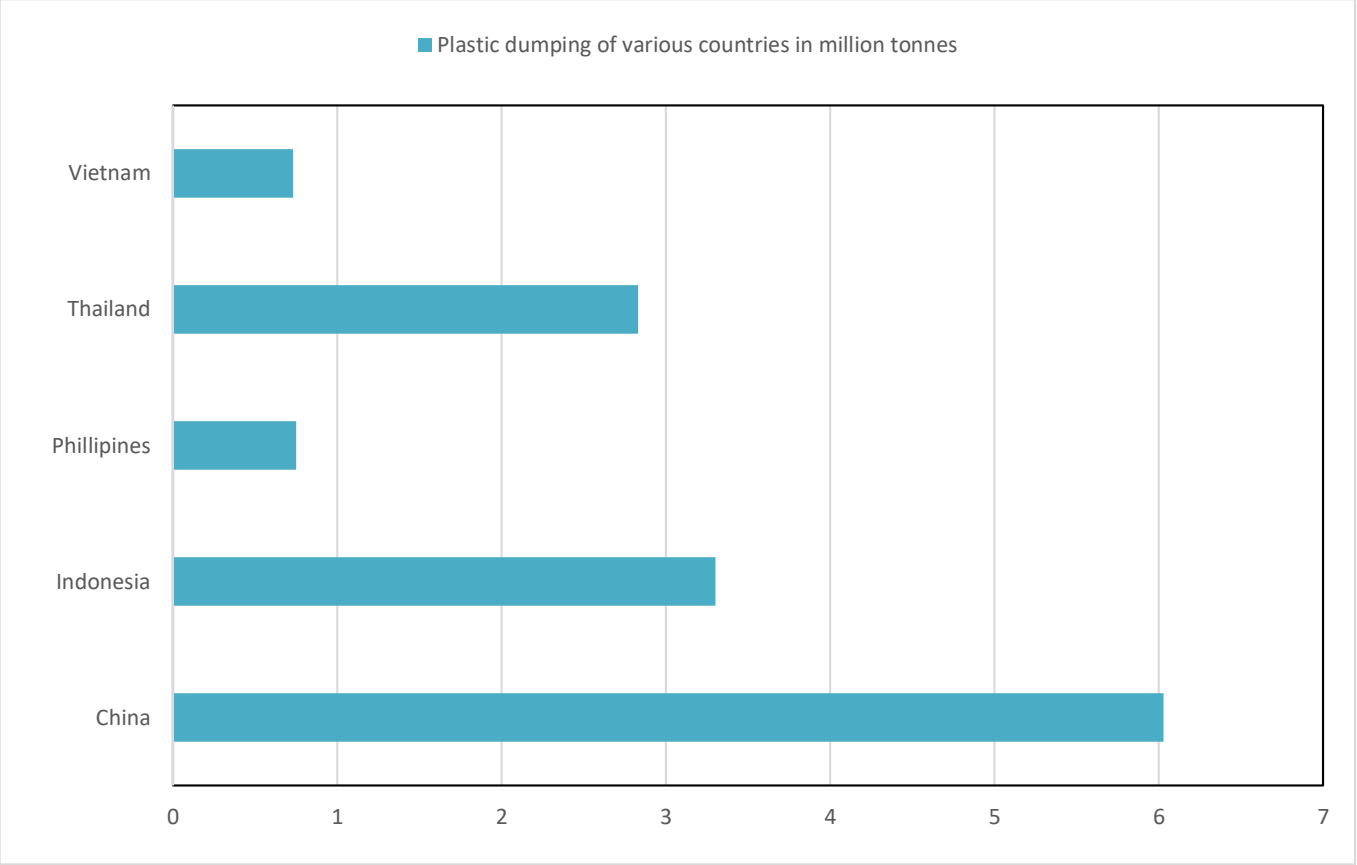


Fig. 4 Plastic dumping of various countries in million tonnes (worldindata.org)

6. INDIA'S INVOLVEMENT IN OCEAN DUMPING

The solid waste management in India is quite inefficient as recycling of plastic waste is not standardized yet. Reports suggest that 87% of the solid waste is mismanaged in India. According to UNEP report, India scrapped 0.6 tonnes of plastic waste into oceans annually and ranked 12th among the top 20 countries involved in marine pollution in 2015 (Dutta, 2018). The average percentage of plastic materials in beach waste along the Indian coast registered highest percentage value from Maharashtra 81% and the lowest value from beaches of Andhra Pradesh 7% (Kaladharan et al., 2017). Two main union territories summed up 40% (Lakshadweep) and 47% (Andamans) of plastics over the total debris, while the national value was only 14%. Out of the total 254 beaches surveyed, 51 beaches were demarcated as very clean (<1 g/m^2), and 122 beaches were demarcated as clean (Kaladharan et al., 2017).

The solid waste issue looked quite crucial in Odisha, probably due to low plastic usage which is having a trajectory with low standard of living and most importantly use of bio packaging material like palm leaves basket, earthen pots etc. Plastic debris issue seemed to be more prominent in Kerala, Maharashtra, and Goa, hence the respective governments are taking essential steps in order to control solid wastes flown to the oceans.

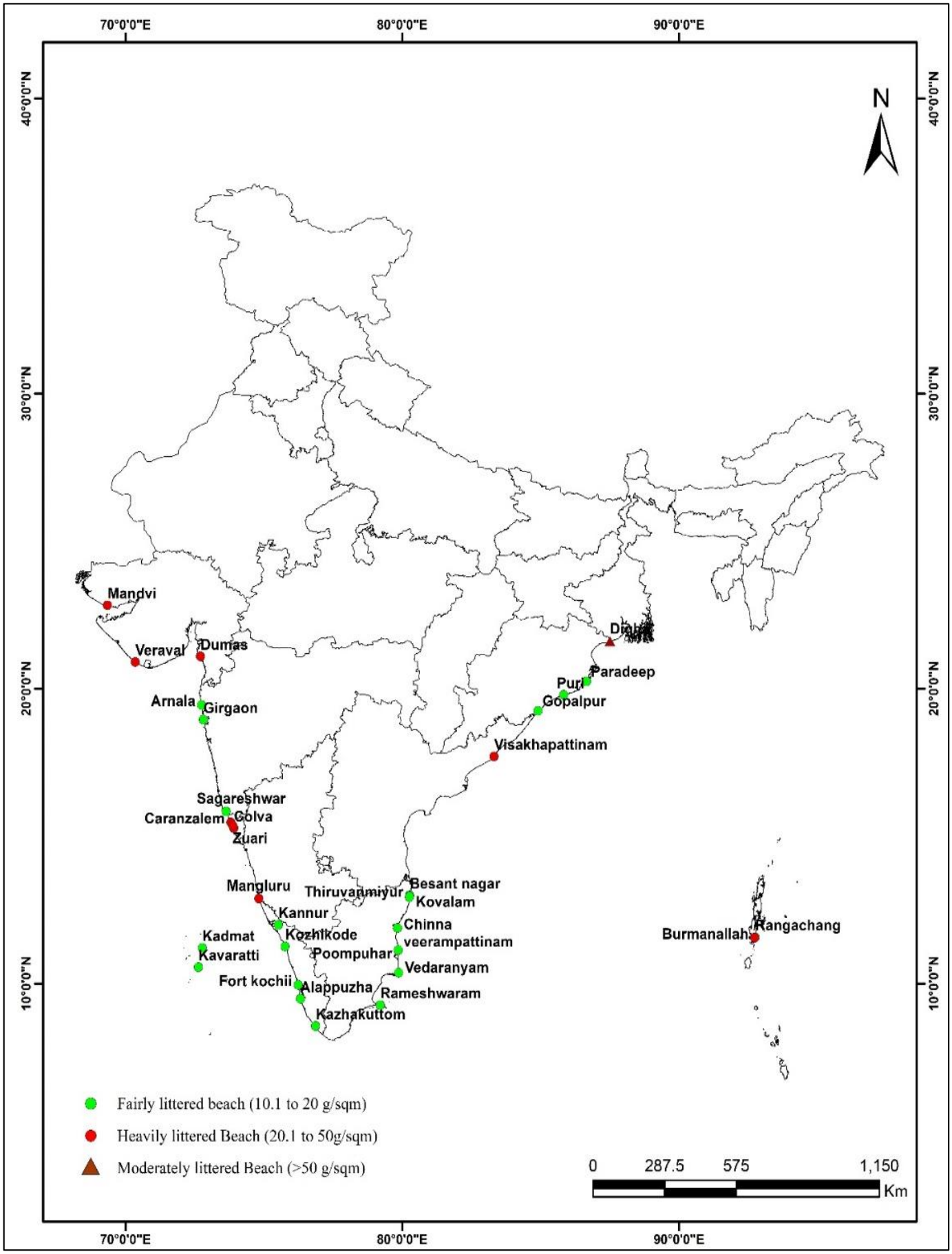
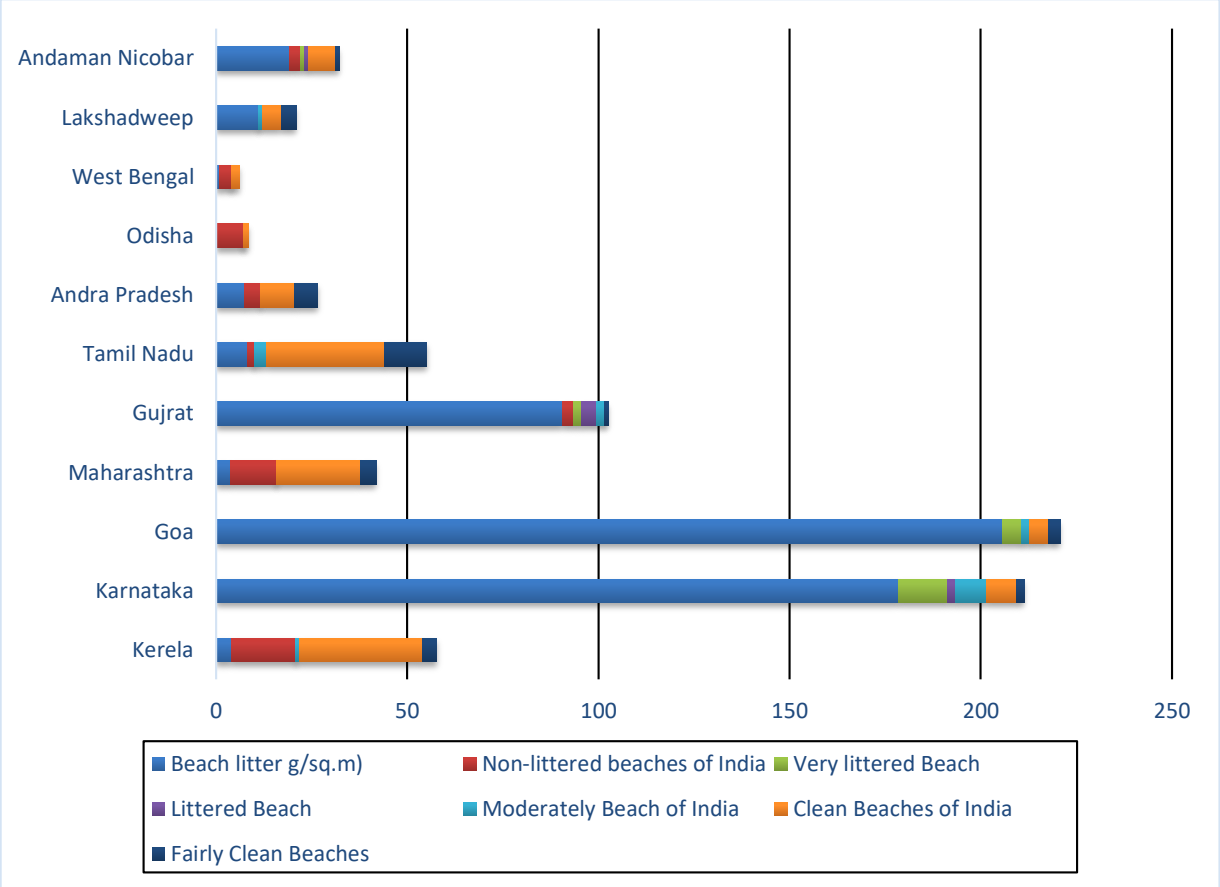


Fig. 5 Most littered beaches in India (modified after Kaladharan. et al., 2017)



. Fig.6 Diagram indicating amount of litter in g/sq.m for different states of India (modified after Kaladharan et al., 2017)

7. FUTURE OF SOLID WASTE MANAGEMENT

Looking at the current situation, it can be estimated that North America and Europe will emerge as the largest per capita waste generator in the world till the next few decades. We roughly assume that America will project 2.5 kg of waste per day per capita. Urbanization also tends to increase the generation of waste. Additionally, rapid urbanization makes waste collection more difficult as well as finding lands for disposal. The waste collection and disposal services can be quite expensive and may be one of the highest budget items. Waste operators may often have to compete in reference with other essential priorities such as clean water, energy, and education.

7.1 SOLID WASTE AS A VARIABLE IN PLANETARY BOUNDARY THREAT

Solid wastes, especially plastic, has experienced an exponential increase in modern society; but its poor management has aggravated the crisis in marine ecosystem. This eventually impacted the ecological community and functioning of ecosystem. Marine solid waste pollution is a global phenomenon and completely irreversible, therefore it satisfies two of the three proposed conditions for pollution across planetary boundary. Among the nine planetary boundaries, ocean acidification is considered to be an important one. Recent studies have shown that the ocean acidification has increased by about 30% post industrialisation (Gruber et al., 1996). Similarly, the plastic dumped in ocean also operates at the scale of planetary boundary and has been noted as an imminent threat by many (Gomez et al.,2018) As large number of Marine Plastic Pollution (MPP) effects are detected and their implications for humans is becoming more

conspicuous, multi-level approaches are being adopted. These responses range from waste management, trade, transitions, and innovations in material used, political and governmental arenas and social activism. Irrespective of whether marine plastic is segregated into the planetary boundary's framework, its reportage is that marine plastic pollution is closely intertwined with global factors to a point that deserves sustainable and precautionary management (Gomez et al.,2018).

7.2 Future Indian scenario on solid waste management

There has been a significant increase in (Municipal solid waste) MSW generation in India. The amount of waste generated per capita is estimated to increase at a rate of 1-1.33% annually. Fig.7 indicates that there will be significant increase in solid waste up to more than 260 million tons by the year 2050 which is around 5 times the present level. This vast expanse in solid waste generation will have significant impact in terms of land required for depositing the waste as well as methane emissions.

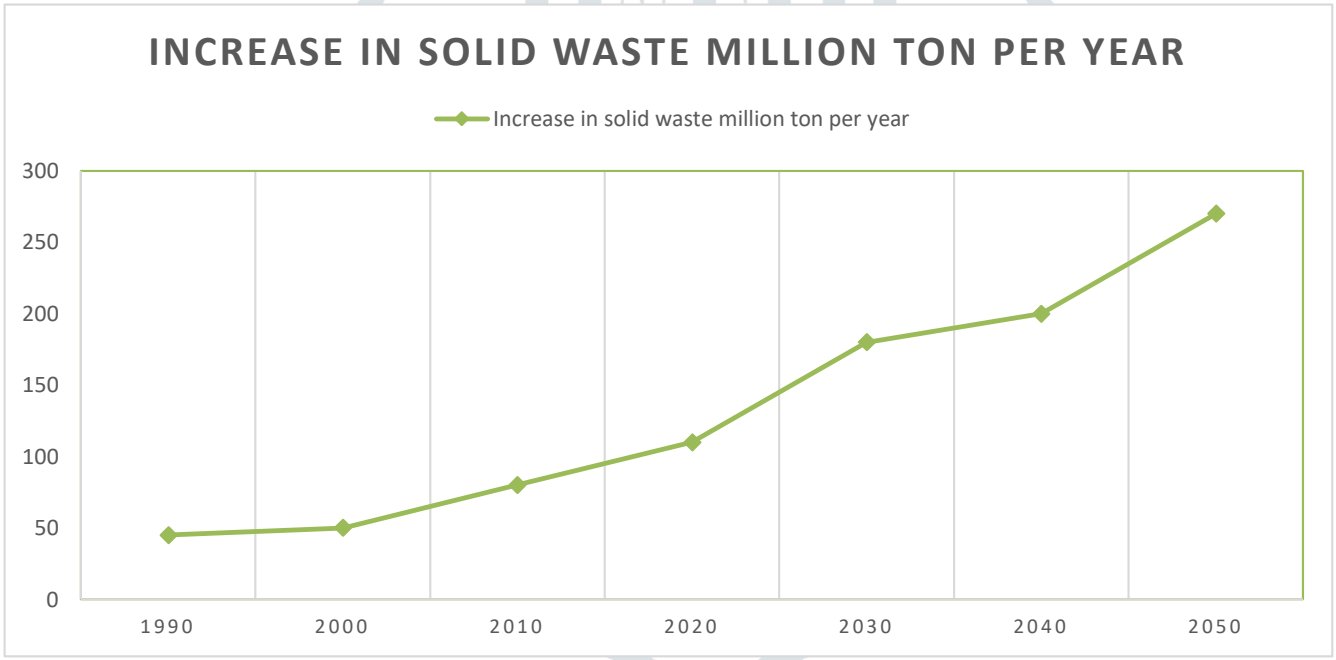


Fig. 7 Increase in solid waste million tons per year (modified after Singhal et al., 2001)

8. LAWS AND REGULATIONS

The laws and regulations for solid waste management mainly emphasises on land ownership, public health standards and accountability, environmental and social benefits, other issues.

8.1 MARINE PROTECTION, RESEARCH, AND SANCTUARIES ACT (MPRSA)

The Marine Protection, Research and Sanctuaries Act (MPRSA) also refereed as ocean dumping act enacted in 1972 has two basic aims (USEPA, 2020):

1)To manage international disposal of material in the oceans

2) To control its related research

The MPRSA carries out the provisions of the London Convention on the Prevention of Marine Pollution caused by the Dumping of Wastes and Other Matter. On the basis of these rules the further guidelines are distributed among 5 titles as follows:

Title1-This title of MPRSA prohibits all kinds of ocean dumping except the ones which are permitted, in any ocean water. Materials like chemical and biological war prone agents, high level radioactive waste, medical waste, sewage sludge and industrial waste should not be dumped in the ocean.

Title 2-This protocol of MPRSA emphasizes on two types of research,1) general research on ocean resources and 2) EPA research related to phasing out ocean activities of disposal. The general research capitalises pollution, over fishing and other human induced changes in marine ecosystem. EPA`s research includes research investigations, demonstration surveys, experiments, training and studies to reduce or eradicate sewage dumping and industrial waste.

Title 4-In this protocol they have incorporated 9 regional marine research boards for developing prominent marine research plan, while taking water quality and ecosystem into account and monitoring research, priorities and objective in each region.

Title 5-This protocol of MPRSA is established in the form of national coastal water quality monitoring programme. It directs EPA and NOAA together to establish a fundamental long-term programme to collect and study scientific data on the environmental quality of coastal ecosystem (Copeland 2010).

8.2 THE MARPOL CONVENTION

The MORPOL convention is basically an International Convention for Prevention of Marine Pollution for Ships. It emphasizes regulations targeting on prevention and minimization of pollution from ships, both accidental pollution and from routine operations. The MORPOL convention is broadly classified into 6 rules.

Rule 1-Law on prevention of Oil pollution. This law covers the prevention of oil pollution from accidental discharges as well as operational measures.

Rule 2-Law on control of pollution by toxic liquid substances. This law holds on discharge criteria and measures for the pollution by noxious liquid substance. In any condition it is not allowed to discharge noxious substances within 12 miles from the nearest land.

Rule 3-Prevention from pollution by hazardous substances carried by the sea in packaged form. This law covers the basic necessity for details standards on packing, labelling, documentation, marking, stowage, quality limitations. According to this rule harmful substances are those which are declared as marine pollutants in the International Maritime Dangerous Goods Code (IMDG Code).

Rule 4-Prevention from pollution by sewage of ships. This law incorporates the requirements to control pollution of the sea by sewage. The discharge of waste into the sea is strictly prohibited. It is allowed only

when the ship have an approved sewage treatment plant or when sewage is discarded using an approved system at a distance of 3 nautical miles from the nearest land.

Rule 5-Prevention of pollution by garbage from ships. This law incorporates the variety of garbage and specifies the distance from the land and the way in which it has been disposed. The significance of this rule is to completely ban the disposal of all forms of plastics into the sea.

Rule 6-Prevention of air pollution from ships. This rule imposes restrictions on sulphur oxide and nitrogen oxide emissions from ships and prohibit deliberate emissions of ozone depleting substances.

9. Measures to ocean dumping

Ocean dumping is a serious global concern and in today's pandemic situation, it becomes more challenging to impose some serious regulations on ocean dumping (Fig.8). Government should induce some methodologies and techniques which can be used as a substitute for plastic waste. They should take the initiative by replacing silicon fibre and other hazardous polymers with bio-degradable products. If we manage to substitute plastic with some other organic degradable material, this ever-rising issue of solid waste dumping can be fruitfully managed. It's not just the government's responsibility, but also of the citizens, Attempts should be made to completely substitute plastic with organic materials like bamboo sheet, paper, cotton, degradable fibres, jute etc. By introducing these natural substitutes, marine plastic dumping can be greatly controlled and management by implementing three R's (Reduce, Recycle, Reuse).

Fig. 8 Litter accumulate on beachside

9.1 PRODUCTION EFFICIENCY IMPROVEMENT

At production level, the utilization of plastics may be reduced by

(a) using different (e.g., glass), recycled, or perishable materials.

(b) strategic planning to scale back the quantity of plastic used, extend product life, enable repair and recycle, and improve recyclability by limiting the number of polymers, additives, and mixtures.

c) banning of single-use plastics. Recycled plastics are costlier than fresh plastics, but they're helpful at environmental and social group level and therefore ought to be inspired by volunteers (as a selling strategy) or necessary incorporation of proportion of recycled materials), that cannot be too high because of losses in recycling cycle. Regarding waste, the manufacturing firms should focus at reducing its production through voluntary and obligatory measures.

9.2 AVOIDING PLASTIC BOTTLES, SAYING NO TO MICRO BEADS

The enormous increase in the usage of domestic products like tooth paste, shower gel, face wash, bodywash, scrub etc. have sophisticatedly indulged in our day-to-day life. These products are usually manufactured and stored inside plastic tubes and bottles which have hazardous implications. These bottles and containers are made up of some cheap plastic materials which eventually is dumped into the ocean for final disposal. This dumping has two major hazardous consequences, firstly plastic destroys the natural habitat of the ocean and secondly the leftover material inside these bottles and tubes results into ocean water toxicity. The solid microbeads are also dumped into the ocean which are consumed by many marine species and it proves fatal for them. (Passportocean., 2018).

9.3 MANAGEMENT AND MINIMIZATION OF WASTE DUMPING AT THE PORT

Problem of solid waste dumping in ocean is increasing day by day. These solid wastes can be prevented from disposal to oceans with proper management and minimization of the dumping. Primarily, efforts should pivot on managing and observing freight activity at the seaport and at the same time, curbing the amount of waste products dumped into the ocean from the ships (Löhr1 et al., 2017).

9.4 AVOID USAGE CUTLERIES AND PLASTIC UTENSILS

The excess production of plastic cutlery items like spoons, straws, plastic container to store food etc lead towards proliferation of plastic pollution. As this waste cannot be potently managed due to their lack in biodegradable features, they are eventually disposed into the oceans. The entire globe follows this strategy to dump all the waste into ocean which eventually hampers the ocean's well-being. The waste items which are used in ships, cruise and tankers are also dumped into ocean as it is an easy alternative rather than carrying that from place to place for further disposal. These factors as a whole affects the rich biota of the ocean and also initiates the debut of solid waste into ecosystem (Passportocean.,2018).

9.5 ORGANIZING A CLEAN-UP

In order to prevent or mitigate ocean dumping, it is important that every individual should participate in cleaning up the clutter. And, in order to make it happen, the clean-up drives could be organized regularly to clean the coastlines. Clean Seas global campaign on marine litter by United Nations Environment (UN Environment) also aims at worldwide elimination of microplastics in cosmetics and the excessive, wasteful usage of single-use plastic by the year 2022 (Löhr et al., 2017).

SUMMARY

Mankind has always regarded the oceans as a convenient and infinite repository for wastes. therefore, after industrialization, ocean dumping of perilous and deleterious substances have grown exponentially. Although, initially the disposal of solid wastes has taken place into rivers and estuaries, that drive them into the oceans, however, subsequently the direct ocean dumping was practiced. At present China followed by Indonesia, Philippines, Vietnam, and Sri Lanka, while India stands 20th among the major contributors of ocean dumping. Within the Indian states Maharashtra contributes about 81%, followed by, Andaman Islands (47%), and Lakshadweep (40%) over total debris. Among the solid wastes, marine plastic pollution is of great environmental concern. Therefore, marine solid waste is not just contaminating the ocean waters, but it is disrupting the ecosystem via food chain. This is slowly disturbing the delicate balance of the ecosystem, and likely to affect every living species thriving on oceans. As the human beings are a part of this ecosystem, this destabilization of ecological balance is going to affect the human race in a larger picture. Nevertheless, there are some positive efforts in the form of legislations and international monitoring mechanisms, which despite of being less effective, are steps in the right direction.

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