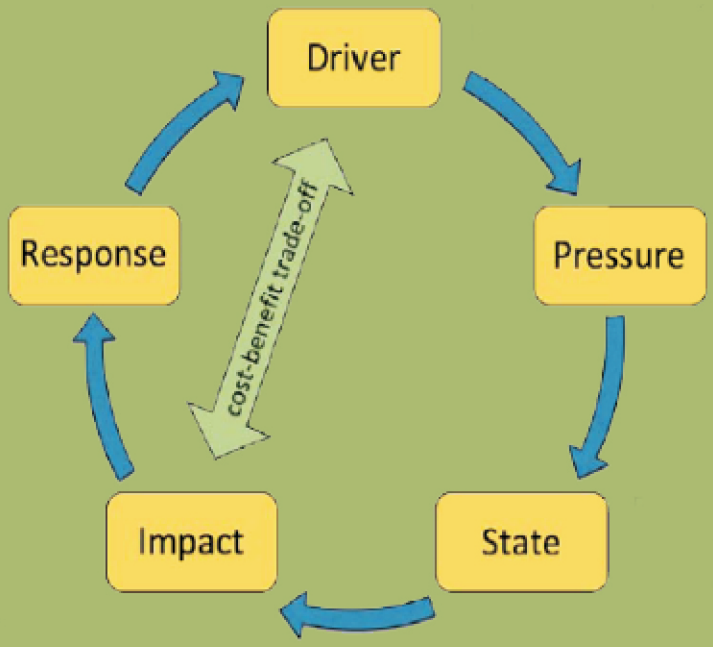
STRATEGIES FOR CONTROLLING PLASTIC POLLUTION IN INDIA

Climate Change Research Institute

Policy Paper



India International Centre

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Strategies for Controlling Plastics Pollution in India

Policy Paper

Climate Change Research Institute
In Association with India International Center
New Delhi
India

Climate Change Research Institute

Policy Paper on Strategies for Controlling Plastics Pollution in India

Preface

With the growing concern for environment degradation caused by increasing plastic pollution on Land and Sea, the theme of World Environment Day 2018 has been chosen to be *Beat Plastic Pollution*. India was the global host for the event held on 5th June 2018. Ways and means of exploring sustainable alternatives and reducing the production and excessive use of single-use plastics threatening human health as well as polluting oceans & damaging marine life were the issues discussed this year.

Reverberating the global theme, the Climate Change Research Institute (CCRI) organized an "Awareness Workshop on Implementing Sustainable Development Goals in India: Beating Plastic Pollution" on 8th June, 2018 for youth in association with India International Center. High level dignitaries, policy planners, and industry experts shared their views on Plastics- boon or Bane? The topics related to plastics sources, plastics waste management, relation with SDGs sub-targets, landfills, micro-plastics, impact on health, marine debris, policies and how to make India litter free were covered.

We are extremely thankful to Prof D. P. Agrawal, Chairman, Governing Council and the eminent speakers who addressed the gathering as well as the membersof CCRI for their support and encouragement. I feel indebted for the overwhelming response from the dignitaries and delegates from premier academic institutes like IIT Delhi, JNU, Delhi University and TERI among others as well as from industry. The association with IIC for providing excellent facilities for the workshop is thankfully acknowledged.

Dr. (Mrs.) Malti Goel
President & Chief Executive
Climate Change Research Institute

Climate Change Research Institute

Policy Paper on
Strategies for Controlling Plastics Pollution in India

Executive Summary

The Climate Change Research Institute (CCRI) organized an Awareness Workshop on "Implementing Sustainable Development Goals in India: *Beating Plastic Pollution"* in New Delhi on 8th June 2018. This echoed the UN World Environment Day theme for the year 2018 "Beat Plastic Pollution".

It emerged that Plastics have extreme versatility and ability to tailor-made to meet very specific technical needs. Plastics have proved to be very useful in all walks of life and their use in food packaging, agriculture, and automobile industry and many others are indispensable**.** Plastics can be broadly classified into two categories; (a) Thermoplastics - Melt when heated, then harden again when cooled, and (b) Thermosets - cracks or char at high temperatures, ideal for high-heat applications such as electronics and appliances, generate e–waste.

Single use plastics are a topic of great debate, whether it's a boon or a bane. Lightweight plastics have been researched for many years so as to replace conventional materials. India has built strengths in plastic technology and engineering by starting the Central Institute of Plastics Engineering and Technology (CIPET) in Chennai way back in 1968, under the Ministry of Chemicals and Fertilizers. Today CIPET campuses exist in many cities across the country generating skilled manpower.

Plastics use helps in reducing greenhouse emissions during operation of a device, consuming less energy and reducing CO_2 footprints. However, plastics are also a source of greenhouse gas pollution on burning. They add to many other contaminants in the atmosphere. Due to the long life of plastics, approximately 450 years, plastics get disposed on land and collected into landfills. From there it travels to rivers and to oceans, or sometimes directly disposed of in oceans. In oceans, it floats beyond the EEZ of countries and became a trans-boundary problem as marine debris.

The Institute recommends Five Strategies to be adopted at the national level:

1. Implementation of Plastics Regulations, both at government and state levels
2. Integrated management of plastic waste through recycling and reuse, for implementation of Sustainable Development Goals.
3. Controlling plastics pollution in oceans through International Agreement
4. Alternate incineration techniques for conversion of plastics into fuel
5. Innovation in Technology to produce Bio Plastics or Green Plastics

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Strategies for Controlling Plastics Pollution in India

(Awareness Workshop on Implementing Sustainable Development Goals: *Beating Plastic Pollution held on 8th June 2018)*

Policy Paper

1. Background

The Climate Change Research Institute (CCRI) celebrated World Environment Day 2018 in collaboration with India International Centre and organized an Awareness Workshop on "Implementing Sustainable Development Goals in India: *Beating Plastic Pollution"*. The workshop was held on June 08, 2018 at Lecture Room II, India International Centre Annex, New Delhi for spreading climate change education and awareness about plastics use and strategies for control of environmental pollution.

This echoed the UN World Environment Day theme for the year 2018 "Beat Plastic Pollution". Attempting to look for the scientific solutions to this issue, keeping our national priorities in view, the Institute specially held the event 'Beating Plastic Pollution'.

On this occasion, high level dignitaries and industry experts shared their personal and professional views on controlling plastic pollution in India? Deliberations included; how to beat plastic pollution? Are plastics boon or bane? How to effectively use plastics? This paper on 'Strategies for Controlling Plastic Pollution in India' is synthesis of experts' views. Plastic use cannot be eliminated, while the judicious use of plastics can definitely give a bright future. Recommendations have been made.

2. Introduction to Plastics

Plastic – the most wide spread material in use is synthetic or semi-synthetic polymerized product. As hydro carbon compound they are petroleum derived products from fossil feedstock. Plastics are polymeric materials comprising of thousands of 'monomers', i.e., a single molecule repeated in a long chain to make a polymer. Commercial plastics got a boost after the crude oil industry by-products were converted into plastics in 1950s.

Sandstones and limestone are the major habitats of oil. Planktons and Algae matter under a chemical reaction in anoxic environment forms Kerogen. Kerogen when buried deep, under high temperature and pressure within the sedimentary basins forms Oil, which being lighter than water moves upwards till they are entrapped in geological structures formed mainly due to tectonic or depositional processes. Drilling through the habitats produces crude which is then subjected to fractional distillation to produce naphtha and other lighter hydrocarbons like ethane besides other petroleum products. Cracking of naphtha and ethane is carried out to form Ethylene. Ethylene is a

monomer and polymerization of ethylene using different catalysts forms plastics of various types. Usually elements like N, S, O, Cl etc. are added in different proportions to give wider variety of plastic resins. These resins are heated, coloured and combined to form the end product. The oil is the source of plastics and we can presume if the reserves of oil will end, then the plastics would also come to an end.

The plastics are moldable, durable, low density, lightweight, corrosion resistant, inexpensive and water and shock resistant. Plastic use came into every walk of life; it completely changed the living styles after it was introduced. Fifty years back, advent of commercial plastics was a Disruptive Technology.

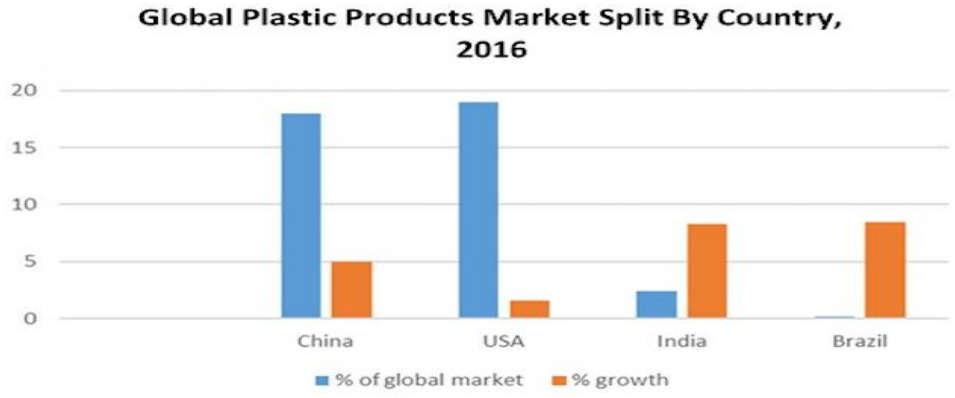
Plastics as organic polymers of high molecular mass comprise mainly the following:

- Polyethylene (PE)
- Polypropylene (PP)
- Polyethylene Terephthalate (PET)
- Polyvinyl Chloride (PVC)
- Polystyrene (PS)
- Polyamide (PA)/nylon

Among these PE and PP are less dense than sea water and tend to be buoyant, whereas PS, PA and PET are denser and tend to sink.

The global plastic product market is growing @ 3% /year and was worth $ 1.06 trillion in 2016 with expected worth $ 1.175 trillion in 2020. Global plastic production and global product market is shown in Fig. 1.

Fig. 1 Global plastic production growth and product market growth



Source: The Business Research Company, 2017

In India growth of plastic market is higher than its GDP growth at 7%. Plastics industry has been an important contributor to the Indian economy, employing around 4 million people. Plastic consumption in India is estimated as 12.8 million ton/year.As of 2017, India's total plastic waste generation was about 25,940 tonnes per day. This comprises of thermoplastic products like: Polyethylene (PE), Polypropylene (PP), Polyvinyl Chloride (PVC) and Polystyrene (PS) and Polyethylene terephthalate (PET). Composition of plastic waste in India is shown in Fig. 2. All of such waste is primarily generated by households followed by commercial centres and institutions namely; hotels, restaurants, markets, office buildings, schools, hospitals, prisons etc. In some cases, large amount of plastic waste is generated due to the nature of industry at a location.

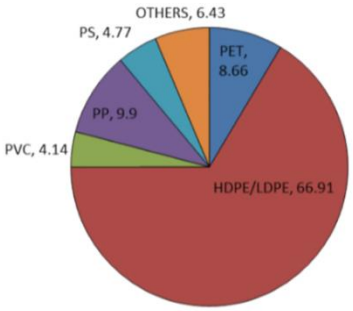


Figure 2: Composition of Plastic Waste in India (CPCB, 2015)

On an average, 9-10% waste is recycled. In India about 40% of plastic is recycled. India's per capita plastic consumption is 11kg/year against the world average of 28 kg. With increasing urbanization and rising proportion of middle class consumers, the Indian packaging industry is expected to grow at a notable compound annual growth rate (CAGR) of 9.2% over 2016-2021, as compared to a CAGR of 6.2% during 2011-2016.

During the period of 2016-2021, the soft drinks and food industry will be the highest packaging market share gainers, with a growth share of 3.4% and 1.3% respectively. If not managed properly, these plastic items such as thermocol, Styrofoam, transparent and colored plastics, only tend to break down into smaller particles and stay in the environment for long duration. Due to long life of plastics of about 450 years, plastics gets disposed on land and collected into landfills. On reaching the water bodies they either continue to stay suspended, or settle in the sediments, blocking transfer of oxygen and percolation of water through the soil. The critical issue is plastics pollution impact on human health.

The list of the various types of plastics, their uses in everyday life, which generate garbage and cause plastic pollution, is given in Table 1. Each plastic is given a recycling number.

Table 1: Types of Plastics and Applications

Recycle Number	Polymer Type	Application Products
1 PETE	**PET**- Polyethylene Terephthalate	Water bottles, Salad trays.
2 HDPE	**HDPE**- High Density Polyethylene	Milk bottles, Shampoo bottles.
3 V	**PVC**- Polyvinyl Chloride	Pipes, fittings, toys and credit card. Thermal insulation, automotive parts.
4 LDPE	**LDPE**- Low Density Polyethylene	Carry bags, Bin liners and Packaging films.
5 PP	**PP**- Polypropylene	Microwave trays, fibers and ropes and vehicle upholstery.
6 PS	**PS**- Polystyrene	Plastic cutlery, protective packaging material.
7 OTHER	Others	Polycarbonate -Car Windows, glazing for the aircraft, Polyamides – cloths, tooth brushes.

Plastics in oceans are a global problem as when plastic from land transfers to ocean. In oceans it floats beyond the country's Exclusive Economic Zone (EEZI and became a trans-boundary problem as marine debris. In presence of salted sea water and sunlight, plastic fragment into Micro particles, which are consumed by the fish and then to the human body which affects the system once it goes inside the body. From there it travels to rivers and to oceans, or sometimes directly disposed in oceans. It is said that by 2050 there could be more plastic in oceans than fish measured by weight.

3. Workshop Deliberations

Beat Plastics Pollution (Prof. D. P. Agrawal)

The Prime Minister of India Shri Narendra Modi said on the Environment Day "This is the duty of each one of us, that the quest for material prosperity does not compromise our environment. The choices that you make today will define our collective future". The choices may not be easy but through Awareness, Technology, Engineering, Global partnership we can make it happen. A recent study shows that water bottles produced in millions across the world per minute are collected in oceans, which is going to affect our life. In 1972 someone quoted that "there cannot be a future without plastics". In 1992, we needed to reduce use of paper. Paper bags were replaced

by plastic bags. Today the discussion is about beating the pollution caused by plastic bags. Plastic use cannot be eliminated, while the judicious use of plastics can definitely give a bright future.

Dissemination of information could be one of the great jobs for awareness purpose. The Climate Change Research Institute has committed to celebrate Environment Day every year and conducting programmes, particularly to educate young children to make them aware.

Beating Plastic Pollution for Implementing Sustainable Development Goals
(Dr. Mrs. Malti Goel)

In India Central Institute of Plastic Engineering and Technology (CIPET) first came up in Chennai, way back in 1968 under Ministry of Chemicals & Fertilizers. India gave boost to plastic industry which was a growing phenomenon. Plastics have been used in all sectors of economy. Innovation in plastics helped in the pursuit of excellence, in sectors like Automobiles with lightweight cars or in Packaging with versatile options and it is impossible to imagine life without plastics today. Plastics are wonder materials because they make life better; problem arises only when they are not properly used.

World plastics have grown from 2 million tonnes in 1950s to 380 million tonnes in 2018, projecting an exponential growth. China is the largest producer of plastics in the world; it has produced more than the European Union. About 9-10% of total production is only recycled, another is 12% is incinerated. The remaining 80% is waste which is coming from the plastic industry. The USA produces 38 billion water bottles as a waste in one year.

How plastics are related to the climate change?

Plastics are seen as a solution for climate change. Source for both plastics and climate change are fossil fuels. When materials like glass fibers or carbon fibers are added in plastics they make composites. Composites could replace the wood or steel or even glass. There is saving in energy when plastic is used. There is savings in natural resources when materials like wood or iron ore used in making steel are replaced. The CO_2 footprints become smaller when we use plastics in place of metals and greenhouse gas emissions are reduced.

Waste Reduction and Relevance to Sustainable Development Goals

Paris Agreement on Climate Change and Sustainable Development Goals both were agreed during 2015 and all countries have committed to achieve targets set in 17 Goals and 169 sub-goals. Plastics are relevant directly with two of these, SDGs 14 and SDG 12.

SDG 14- Life below water; targets to prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris by 2025 is concerned on the issue of marine pollution of all kinds including plastic which damages the ecosystem.

SDG 12.4- By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment.

Preventive actions requires by 2025 so that marine pollution is reduced. The SDG 14.2 stresses on sustainably managing and protecting marine ecosystem. By 2030 overall waste generation must be significantly reduced through prevention, reduction, recycling and reuse protect marine ecosystem.

Plastic Pollution a cause of concern in India's context (Mr. Gautam Sen)

Plastics are mainly of two types; Thermoplastics have long, linear polymer chains that are only weakly chemically bonded or connected to each other. When a thermoplastic object is heated, these bonds are easily broken, and therefore they can readily be melted, remoulded and reshaped into other products i.e. they are recyclable. Most of the plastics produced are of this variety. Thermosets are formed by curing linear polymers, which involves high pressure, temperature and catalyst. The linear chains are cross linked - strongly chemically bonded and do not melt. On high heat, thermosets cracks or char, and thermosets are used in electronics and appliances, which can work at relatively high temperatures. Thermosets are hard to recycle, but today there are methods of crushing the objects into a fine powder form for use as fillers in reinforced thermosets.

Bio- plastics which are bio - degradable and microorganisms can break it into CO_2 and H2O, are plastics derived from renewable biomass sources, such as vegetable fats and oils, corn starch, or microbiota. Bioplastic can also be made from agricultural by-products and also from used plastic bottles and other containers using microorganisms. Bio-plastics can therefore be the ideal candidate for single use plastics.

With all its advantages Plastics are one of the major sources of pollution in land and in marine environment globally. As per Roland Geyer's, (Professor in the University of California Santa Barbara) findings in 2015 more than 8.3b tons of plastics has been produced since inception, 6.3bn tons is now waste 79% of that is in landfills or the natural environment, 9.1m tons ended up in sea. Seven of the EU Member States plus Norway and Switzerland recover more than 80% of their used plastics. These countries adopt an integrated waste and resource management strategy to address each waste stream with the best options. India generates 25000 t/d of plastic waste, at least 10000 t/d is non- recycled.

China, which maintained a high economic growth in recent decades is a major contributor to Marine plastic pollution. According to same studies 95 percent of plastic polluting the world's oceans comes from just 10 rivers and eight of these ten worst plastic polluted rivers are in Asia. The other two are in Africa as per Dr. Christian Schmidt hydrogeologist, Helmholtz Centre of environmental research, Germany. Marine life consequently is under threat and there are ample evidences to show that.

Plastic pollution has therefore emerged as a matter of serious concern. Integrated waste management like adopted in EU can be the solution, and to the extent possible plastics should be recycled. Thermoplastics wastes could be used in road construction, and bio-plastics could only be used for single use plastics. It is also possible to reconvert waste plastics back to Oil but the process may lack economic viability in most cases. Blanket banning of plastics can never be a solution, statutory bodies can work out guidelines but it is for the government of the day who has to ensure its implementation.

Impact of Plastic Pollution in Urban India (Shri A K Jain)

Depending on their chemical composition, plastics have properties of contaminant, absorption and adsorption. Polymer degradation takes much longer. It is estimated that a foam plastic cup takes 50 years, a plastic beverage holder 400 years, a disposable nappy 450 years, and fishing line 600 to 1000 years to degrade.

Entanglement in plastic debris has been responsible for deaths of many birds, animals and water organisms, such as fish, seals and turtles. Plastics can be carcinogenic or promote endocrine disruption. Chemicals used in plastic production can cause dermatitis upon contact with human skin

Chlorinated plastics release harmful chemicals into the soil, which seep into groundwater and the ecosystem. Bacteria such as Pseudomonas, nylon-eating bacteria, and Flavobacteria break down nylon through the activity of the nylonase enzyme. Breakdown of biodegradable plastics releases methane, a very powerful greenhouse gas that contributes to global warming. Toxic chemicals such as bisphenol A and polystyrene leach into water. The toxins of plastic include diethylhexyl phthalate (toxic carcinogen) lead, cadmium, and mercury.

A 2017 study found that 83% of tap water samples taken around the world contained plastic pollutants. The United States was the most polluted, followed by Lebanon and India. People may be ingesting between 3,000 and 4,000 micro-particles of plastic from tap water per year.

Plastic pollution is the accumulation of plastic products in the environment that adversely affects wildlife, water bodies, habitat and humans. Plastic pollutants are categorized into micro (between 2mm-5mm), meso (5 mm to 20 mm) and macro (more

than 20 mm). Micro-plastics contaminate water and air. Municipal Waste Management has no system of segregation of plastics, except by rag pickers and it often ends up in drains, rivers, open spaces and mountains.

Mitigating Plastic Pollution: Strategy of Four R's

REFUSE Whenever and wherever possible, choose items that are not packaged in plastic and carry your own bag, container and utensil. Heavy tax and penalty on plastic carry bags, styrofoam, single use plastics, water bottles and straws can diminish their use. Plastics can be replaced by more sustainable options like reusable steel, glass bottles and non-disposable utensils. Disposable sanitary napkins can be replaced by menstrual cups and cloth pads.

REUSE Choose glass, paper, stainless steel, wood, ceramic and bamboo over plastic. non-toxic straws, utensils, to-go containers, bottles, bags, etc. which can be reused.

REDUCE plastic waste by half in next five years. Cut down the consumption of goods that contain excessive plastic packaging. The Ministry of Drinking Water and Sanitation, Government of India has requested various government departments to avoid the use of plastic bottles for drinking water during meetings.
The States of Maharashtra, Uttar Pradesh, Bihar and Sikkim have banned the plastic carry bags and have restricted the usage of plastic water bottles in government functions and meetings.

The 2015 National Games of India (Thiruvananthapuram) aimed at "zero-waste" venues to make the event "disposable-free" and banned the usage of disposable water bottles, plastic tableware and tumblers.

RECYCLE Plastic waste can be recycled keeping in view the entire life cycle of items, from source to manufacturing, distribution and disposal. Segregate plastic waste from rest of the waste to ensure maximum recovery and recycling. Waste plastic (HDPE) can be recycled into plastic timber, pallets, tiles, waste containers, liners, railway sleepers, fence posts, park benches, street furniture, lumber, tables, roadside curbs, benches, truck/cargo liners, stationery, etc. Recycled plastic can be used for road surfacing with aggregate and bitumen (asphalt) at a temperature of 220°C (428°F). Biodegradable and degradable plastics help to reduce plastic pollution. Adopt ecosystem-based adaptive management for plastic waste.

Specific Impacts of Plastic Pollution in India (Er. Saurabh Manuja* and Ritu Ahuja)

Marine debris

Plastic commodities made out of thermocol, styrofoam, transparent and coloured plastics tend to break down into smaller particles. On reaching to water bodies they continue to either stay suspended or settle in the sediments, blocking transfer of oxygen and percolation of water through the soil. Through their continual existence these plastic articles also tend to be consumed by plankton consuming animals and hence enter the food chain as well. Micro plastics present in marine debris are often ingested by freshwater fauna, and thereby enter the food chain.

River Yamuna in India faces discharge of industrial waste of which phthalic acid esters, hazardous compounds that are found in PVC (also blended in plastics to enhance their plasticity). These phthalates leach out in the vicinity- both land and water causing serious concerns to the biota of the river and indirectly to human health as well.

Landfills

One of the common ways of dumping plastic waste is in landfills. Waste is dumped in low lying areas and because these areas are prone to flooding, there is higher possibility of contamination of surface water especially during rains. Leachate from plastic waste is highly toxic and it deteriorates the ground water quality as it permeates through the soil. Plastic additives, such as phthalates, often used by manufacturing industries and also in recycling plastic, are capable of escaping the plastic article and into the surroundings (solid and waters), especially in landfilled situations. This leachate leads to contaminated soil as well as ground water contamination.

Emissions from plastic pollution

Incineration of plastic waste or fires on landfills (caused due to release of landfill gas due to decomposition of waste. About 50% if this gas is methane thus highly combustible) have the potential of leading to incomplete combustion of PP, PE and PS which can lead high concentrations of carbon monoxide (CO) and noxious emissions. Similarly burning of PVC generates dioxins, carbon black and aromatics like pyrene and chrysene.

In case of chlorinated and brominated plastic, incineration leads to emissions of dioxins and furans. More specifically, it leads to emissions of Carbon di-oxide, Nitrogen oxide, and Sulphur oxide. It is also known to generate volatile organic compounds, smoke, polychlorinated dibenzofurans.

Other methods of managing plastic waste such as pyrolysis which involves heating plastic materials at high temperatures in the absence of oxygen, leading to emissions of pollutants such as H2S (Hydrogen Sulfide), HCl (Hydrogen Chloride), NH3(Ammonia) and HCN (Hydrogen Cyanide).

Health impacts

Population living close to a landfill or dumping site is at high risk. Leachate from landfills containing toxins such as phthalates contaminates water quality thus triggering health problems. Further, as seen above, there are high chances of plastic toxins

entering the food chain either by way of ingestion of micro plastics by marine or aquatic animals or by way of contaminated soil and water used for agriculture.

Plastic Waste Management

Some key steps to avoid plastic pollution are 1) Minimize/refuse single-use plastic packaging and find sustainable alternate materials which can be used for longer duration before it gets into the waste stream and can be easily recovered and treated. 2) Make brand-owners responsible for the environmentally sound management of the packaging at the end of its life. 3) Introduce incentives for the collection and recycling of plastic packaging: Beverage container deposit return systems are one successful example of such incentives. 4) Increase the value of plastics to incentivize plastic collection in countries where informal systems of waste picking and recycling prevail. Evolving and implementing the concept of Design for Recyclability (DfR).

Prevention and Reduction

Creating awareness about impact of single use plastics (such as straws, disposable food-service cups and plates, plastic bags) and encouraging reduction in their use can be a preventive measure. Banning plastic use of polybags in cities or of one time plastic use in educational campuses (Singh, 2018), for instance are preventive measures.

Enhancing Producer Responsibility

Making brand-owners responsible for the environmentally sound management of plastic packaging introduced by them will encourage proper waste collection and its management. Regulations by the government, such as that introduced in the Plastic Waste Management Rules of 2016, to 'phase-out' or 'scientifically dispose' multi-layered packaging has encouraged proper management of this waste.

Introduction of incentives for collection and recycling

Under a recent initiative by forest department in Koratpur, Odisha, the forest department pays individuals for each plastic bottle given to them. Such initiatives can be useful for encouraging waste collection and segregation by larger populations. Further, increasing value of different types of segregated plastic waste will encourage extensive waste picking and collection especially in a developing country like India where the network of informal waste collectors is large.

Design for Recyclability (DfR)

This includes designing and fabricating a product for easy dismantling after end of life (e.g. automobiles are required to be 90 % recyclable in Europe at the end-of-life), promoting products with modular designs with longer life where different components can be replaced/changed as the need may be so that the product's entry into the waste stream is delayed (e.g. Dell computers), and controlling use of dyes and additives and looking for non-hazardous substitutes.

Recycling

Plastic can be recycled by usage of various mechanical or chemical/feedstock recycling techniques. Mechanical recycling involves processing of waste into a product of which characteristics are similar to those of the original product.

Chemical or Feedstock recycling involves breaking down of polymer into its basic components. This includes techniques such as Pyrolysis, Gasification, and Incineration etc.

Alternative Uses

Energy recovery is one of the important ways of utilising plastic. Processes such as incineration and pyrolysis are used in waste-to-energy plants and allow converting plastic waste into oil, Refuse Derived Fuel from Plastic is utilised in cement and brick kilns. Plastic waste when mixed with bitumen aggregate is also used in construction of roads.

Specific Health Aspects of Micro Plastic Pollution (Shri Satish Sinha)

Plastic toxins are many and these impacts on health are as below,

(i) Phthalates: estrogenic compound, disrupt endocrine function & reproductive systems, acute & chronically toxic to aquatic microbes, algae, fish, invertebrate.
(ii) BFRs: considered the most hazardous, neurotoxic effect, alter thyroid hormone function.
(iii) BPA: endocrine disruptor, neuro-, reproductive & developmental toxicity, cancer risk (breast, prostate, etc.)
(iv) Styrene & vinyl chloride: carcinogenic, mutagenic.
(v) Solvents, initiators, catalysts used are toxics, can be flammable, cause respiratory & skin problems.
(vi) Heavy metals- Lead, cadmium.

Hazards of Single Use Plastics arise as these plastics break up, not break down – permanent pollution, mostly down recycled or landfilled. Escape & become 'accidental litter' and end up in waterways and the ocean. Gettransfer to the food chain carrying pollutants.

Microplastics are synthetic or semi-synthetic, solid, water insoluble, high polymer plastic particles of a size range below 5mm. They are used both as a raw material for a number of products and produced from degradation of any plastic product. Small size allows them to pass through wastewater treatment plants and reach the oceans through surface water bodies and rivers. Microplastics are non-biodegradable and persistent in marine and freshwater.

Microplastics are used, tested rinsed-off and leave-on cosmetic products, 28% of all the tested products contain microplastics, 38% of the rinse-off products are detected with microplastics (include international) and 50% of the face wash products and **67%** of the facial scrubs are found to contain microplastics. Predominating microplastics detected in the product samples is polyethylene.

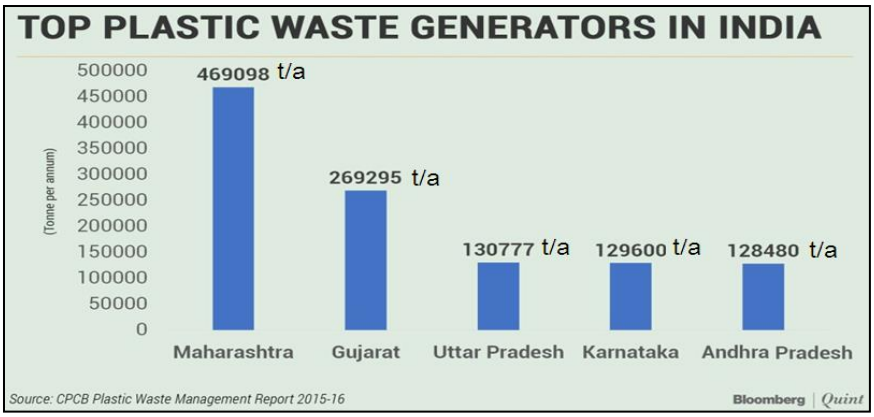


Fig. 3. Five top Plastic Generating States in India (Source: Centre for Science and Environment, 2018)

Way forward for controlling plastic pollution requires

(i) More research, new data and policy design, (ii) Global action, (iii) EPR, (iv) Reduce single use plastics, (v) Recycling Infrastructure, (vi) Use of alternative materials.

Policies for Addressing Plastic Pollution in India (Prof. R.K. Khandal)

Plastics Boon or Bane

When we said plastics are Boon, we meant it is absolutely pollution free, as plastic materials are the most environment friendly materials. Only those products which are not thermoplastic but are thermosets the pollution arises. These are about 17 to 18% of all plastics used as thermosets. Besides thermosets, there is another category of plastics which is multilayer plastics.

A product is banned when it is highly toxic, or its substitute is available or it can't be handled. Plastics unfortunately will never become obsolete. USA's per person consumption of plastics is 109 kg plastics per year. India is only 11 kg person/year, which is also much less than the average world, i.e. 28 kg person/year. Economists feel that the economic power of the country is directly proportional to country's consumption of plastics so we prefer to increase use of plastics for growth. We need to understand the whole problem of plastic use and disposal, so as to address the key environmental issues. I am happy that Climate Change Research Institute is working on to spread awareness about the science of plastics for finding technological solutions. For example, there was lot more methods and techniques to drink and store water before few years ago, like Pyau, Pots, Hand pumps, instead of plastic bottles which we currently use.

The plastic production has grown exponentially in these 20 years and it looks impossible to ban the plastics. India has vast plastic industry and there are about 4000 in organized sector, and 25000 in un-organized sector which are involved in recycling of plastic waste. India is on the top in plastic recycling because we are recycling about 60-70% of plastics we use and give employment to vast manpower. There are five top

polymer manufacturers and they must be employing and responsible for millions of jobs per year. The world average of recycling of the plastic which they are producing is 8%. India has a share of about 2% in world plastic use. Among the application areas, India is world leader in packaging because it has 43% share in packaging, but the world average is only 35%. The plastic business is worth about 1 lakh crore. There are 11 lakh people employed as technical manpower, which are diploma holders and engineers and the growth rate is about 10%. Whole ranges of Industries are dependent on the use of plastics. We are making missiles using the fluoro-polymer which is highly temperature stable and could not be substituted by other materials. In cars without the use of plastics we could not get the mileage and energy efficiency.

Elaborating on the practical experience, he highlighted that 12-13 years ago, we did a project on Plastic Waste Management and developed the technology to process it into engineering fuel. India developed for the first time in the world, which is a very sophisticated technology. We used some agro waste in cow dung so that we could use plastic as fuel. Plastics, like petrol comprise of Carbon and Hydrogen and therefore it could be used as fuel.

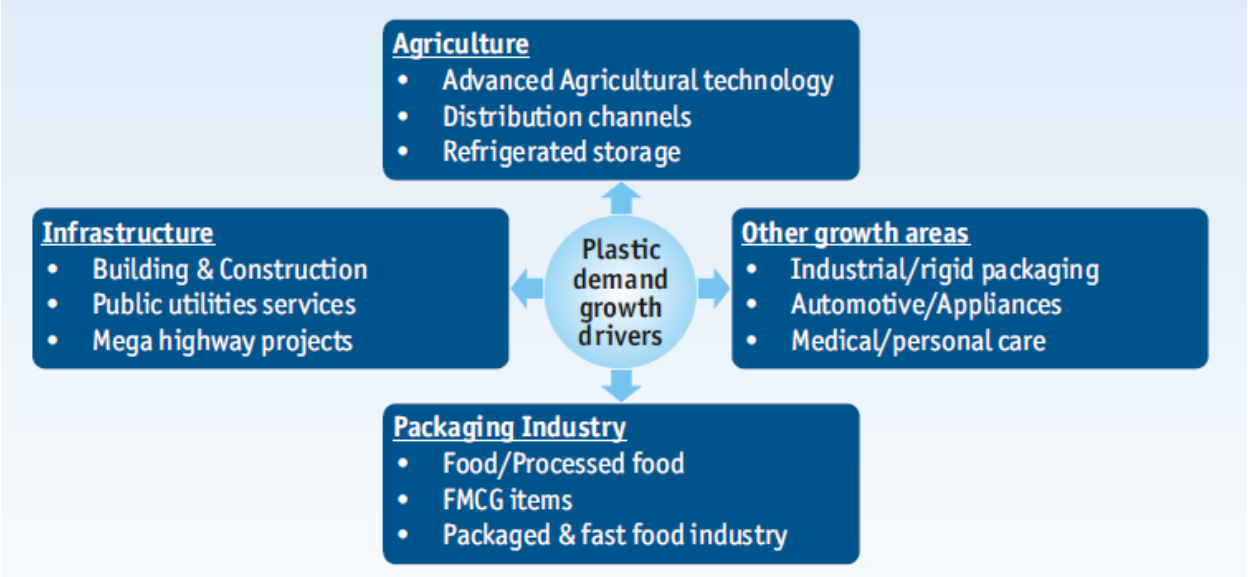


Fig. 4 Sectors driving growth of plastic products

The second application was for non-recyclable plastics, which can be used to build roads. All the roads use bitumen, we can easily use plastic mixed with bitumen for building roads. First time in Delhi, when Shri Rakesh Mehta was the Chief Commissioner of Delhi, we developed technology for road using non-recyclable plastics. A half kilometer road was built just behind the Governor's house in Delhi and even today that road is so fantastic. Why we are not doing it routinely, because of our standards for making road get violated by use of plastics.

By 2021, you would have three times more requirement of bottles for packing milk. There are many other food products which are packed in plastics. Uses are increasing and plastics are considered as a boon. Thermoplastics are very useful, and

should not be banned. The plastics like thermosets, or multi-layer plastics, which are not recyclable, should be banned.

Plastics are getting banned because they are going to touch 34 billion tonnes by the year 2050. We generate everyday 690 tonnes of plastic waste per day in Delhi, Chennai 429, Kolkata 436, Mumbai 408, Bengaluru 314 Plastic waste. The plastic waste should become a resource and not waste. In the company to which I currently associated is using molasses, which is toxic for us, but is very valuable resource for use in cosmetics and personal care pharmaceuticals. Molasses is a sugar industry waste and we use this kind of material for making value added products. How others are dealing with plastic, we need to focus and work accordingly. We can learn from the examples from other countries; Sweden is the country where there is no policy of banning plastics, they are using plastics and recycling it and burning it, if they are not able to recycle it. Ireland has passed a plastic bag tax in 2002. France passed a plastic Ban law in 2016.

About 10-20 years ago China was having the largest capacity to recycle PET waste and India exported all plastic PET waste to them. But now India has the capacity to recycle almost each and everything. The plastic problem is rather organizational than technical. Refuse disposal is non-profit business and is looked as an unwanted side effect of development. As a key step for management, proper operation and monitoring is required at every functional element of MSW management.

Litter-free India, We Can Make it Happen (Shri Rakesh Solanki)

When addressing the plastic waste, we found every Waste Law is plastics centric. In 1998, the Biomedical Waste rules were in making. The Plastics burning causes emissions of Dioxins and Furans. Controlled recycling to plastic waste is prepared. Mixed in organics waste of MSW, makes all waste dangerous, to our birds, cattle', and whole eco-system.

Considering other Socio-economic factors, Plastics are good, in plastics waste - litter is the problem. Our experience shows that it is not commercially viable for the waste pickers to pick and separate plastic. Though most of the plastics gets recycled, the small pieces of multilayer metalized plastics and carry bags are the main contentious issues in the littered waste and as well as in most of the other waste streams, Litter picking needs a separate viabi*lity* gap funding, and plastic recycling, is not profitable either. Therefore litter picking, source segregation, recyclable dry waste collection from every house shop and institution, needed a system innovation, and implementation.

The cost analysis suggests that it we do source segregation and decentralised composting, the existing tipping fee parameter in transportation and processing does not hold good, however the costs of these operations almost remains same. There fore cost of waste management is considered per capita. Grants and subsidies are based on these parameters. With proper technology integration, we will be able to achieve the total costs to be half of it within 3 years of optimisation i.e. approximately Rs. 2 per

capita per day. Of this a rupee a day per capita contribution may be of public, and a rupee a day per capita contribution from outside sources like VGF, EPR and CSR.

There are two major components of waste stream which need innovation are;

1. Collection and Transportation: (C&T)

Very interactive with community, service delivery pays. Larger the community cost reduces. IT based/app based logistics and revenue collection proposed. Labour intensive–co-operative on help.

2. *Processing and Disposal: (P&D)*

Success depends on efficiency of above. Decentralised facilities promotion is advantageous. Capital intensive, operations need to be self- sustainable.

Action points for handling plastic waste can be summarized as below.

(i) Integrated waste collection mechanism which is app based and with proof of service delivery, Capex cost educes heavily.
(ii) Collection hubs, networked logistics and integrated services and supply chain.
(iii) Decentralised composting facilities in communities and cities.
(iv) Dry waste sorting and processing facilities.
(v) Project management and awareness campaigns.

<u>Concept Proposal</u>

A Proposal concept for litter free India has been developed. In this innovative and pioneering Waste management protocols take in to account the extended producer responsibility (EPR) of plastic industry, as well as the responsibility of the urban local bodies (ULB), in organizing IT based waste collection from houses, shops, and also the littered- dry waste. This is through the recyclable waste collection centers, recycling facility and litter free campaign. It also harnesses most of the informal sector workers in a formal set up, as is mandated in various regulatory guidelines. This self-sustaining model have to be on Public Private Partnership with plastics/recycling industry for viability gap support for litter picking and recycling the metalized plastics and thin films.

Waste Exchange Centres (WECs) are conceived for handling dry waste bares having uniform design Portacabins, of approx. 5x5x5 meters sizes. WECs will arrange to provide free bags for plastics dry waste collection to every household, collect it periodically and purchase recyclable waste. WECs will provide self-sealing yellow bags for every house for sanitary waste, collect and send them to BMW facility under a service charge scheme with the ULB. Dry recyclable waste collected at various WEC's will be sold to authorized recycling industry with well supervised and synchronized modalities. The remnant plastic waste, the noncommercial and non-recyclable waste, could be sent to the sorting/ recycling plant set up for approximately every one million population.

Approximately 11 to 17% of noncommercial plastics waste goes to a mixed waste collection mechanism. Plastics could be harnessed approximately 85 to 95 % in this system and after segregation and sales, the non-recyclable plastic waste can be converted into fuel oil and lumber, besides RDF, and Bitumen Mix for roads. Sorting technologies for dry waste are successful with robotics, x-rays, infrared or ultraviolet. Other options are of giving it to cement plants for co processing and waste to energy if exists. The disposal of littered plastics and from household in landfills can be avoided. Plastics wastes can be of commercial value

4. Summary Recommendations

In these deliberation Five Strategies emerged to control plastic pollution and for further action.

I. Strict Implementation of Plastic Rules and Regulations, both at government and state levels (Annexure I)

Hazards of single use plastics are many; they break up, not break down and are permanent pollution in landfills, 'ESCAPE' &become 'accidental litter', end up in waterways and the ocean and transfer to the food chain carrying pollutants. Increased plastic waste is a growing concern for Indian cities. Many states in India namely, Maharashtra, Bihar and Sikkim have restricted the usage of plastic water bottles. Sikkim became the first Indian State to ban disposable plastic bags in 1995. To address the issue of plastic pollution Government of India has come out with regulations since 1999 (Annexure I). The regulations have been amended to address the specific concerns and widen the ambit of plastic management to tackle the growing waste. The regulations play a very critical role in outlining how to manage the plastic from various sources.

II. Integrated management of plastic waste through recycling and reuse, also has relevance to implementation of Sustainable Development Goals.

The **SGD 12** is about minimization of waste generation on the planet. Plastics forms 10 % of total waste generated and a Strategic framework integrated management of waste with a roadmap is desirable.

III. Controlling plastics pollution in oceans through International Agreement

The SDG 14 is about managing marine pollution for protecting marine ecosystem. Marin debris comprising of plastics is resulting into a so called plastic ocean. Global ocean pollution would require a strategy to control marine pollution through international agreements.

IV. Alternate incineration techniques for conversion of plastics into fuel

Plastic can be incinerated without segregation at plasma temperatures and can be a source of energy fuels. Energy recovery is one of the important ways of utilising

plastic. Processes such as incineration and pyrolysis are used in waste-to-energy plants and allow converting plastic waste into oil.

V. Innovation in Technology to produce Bio Plastics or Green Plastics

Conventional plastics release chemicals in the soil and water. Safer bio plastics could be a substitute for the single use plastics. Bio plastics can be derived from renewable biomass sources, such as vegetable fats and oils, corn starch, or agricultural by-products. Bio plastics are biodegradable and microorganisms can break it into CO_2 and H_2O.

Annexure I

Plastic Regulations in India (Dr. Neha Tripathi)

Increased plastic waste is a growing concern for Indian cities. To address the issue of plastic pollution Indian government has come out with regulations since 1999. These regulations have been amended to address the specific concerns and widen the ambit of plastic management to tackle the growing waste. The regulations play a very critical role in outlining how to manage the plastic from various sources.

In particular, the plastic carry bags are the biggest contributors of littered waste and every year, millions of plastic bags end up in to the environment vis-a-vis soil, water bodies, water courses, etc., and it takes an average of one thousand years to decompose completely. Therefore, to the address the issue of scientific plastic waste management, new regulations have been notified for plastic waste management in India.

To give thrust on plastic waste minimization, source segregation, recycling, involving waste pickers, recyclers and waste processors in collection of plastic waste and adopt polluter pays principle for the sustainability of the waste management system, the Central Government has proposed regulations, reviewed the existing rules and drafted revised rules to make the plastic management more effective.

In 1997, a National Taskforce was constituted under the CPCB Chairman to formulate a strategy to deal with plastic waste. Based on the report of the taskforce, the Central government notified the Recycled Plastics Manufacture and Usage Rules, 1999.

The Recycled Plastics (Manufacture & Usage) Rules, 1999: The intent of this regulation was to control the packaging of food products in recycled plastics. There were three main specifications in the Rule:

- The use of recycled and virgin colored polybags for non-food applications was allowed but discouraged for packaging food items.
- All carry bags of size less than 20 microns were banned
- The guidelines for the recycling of plastics were made mandatory

In 2002, the Justice Ranganath Mishra Committee examined the environmental hazards posed by the indiscriminate littering and disposal of plastic wastes and made recommendations on methods of collection segregation, treatment and disposal of plastic waste. The recommendations of this report became the basis for 2003 Amendment to the plastic rules 1999.

The Recycled Plastics Manufacture and Usage (Amendment) Rules, 2003: These main specifications under these rules are:

- Prohibition of the manufacture, stocking, distribution, or selling of carry bags made of virgin or recycled plastic less than 20 x 30 centimeters in size and 20 microns in thickness.
- Banning the use of recycled plastic bags and containers for storing, carrying, dispensing or packaging of food items.
- Units manufacturing plastic bags are required to register with the respective State Pollution Control Board (SPCB) or Pollution Control Committee (PCC) before starting production.

Another Committee under the chairmanship of Justice (Retd) Shri R.C. Chopra was constituted by the High Court of Delhi to study the environmental hazards related to the use of plastic bags in the city of Delhi. The Chopra Committee made in-depth deliberations on each clause of the draft notification. It took into account the various comments that were received by the ministry on the draft rules and invited technical experts and representatives of firms and industry associations. The Committee recommended in line with the polluter-pays principle, *Extended Producer Responsibility* (EPR) should be introduced into the waste management system. In the draft Plastics (Manufacture, Usage and Waste Management) Rules, 2009, the emphasis in the rules was on plastic carry bags and multi-layered packaging. (GOI, 2010)

The Plastics (Manufacture, Usage and Waste Management) Rules, 2009: In a further drive to regulate plastics waste were intended to supersede the Recycled Plastics Usage and Manufacture Rules 1999. The rules are designed to regulate the use of plastics in its various purposes. These rules stipulate that:

- The use of carry bags or containers made of recycled or biodegradable plastics for storing, carrying, dispensing or packaging of food stuffs shall be prohibited
- Carry bags and containers made of recycled or biodegradable plastics and used for purposes other than storing and packaging food stuffs, shall be manufactured using pigments, colorants as per the Bureau of Indian Standards' specifications, entitled "List of pigments and colorants for use in plastics in contact with foodstuffs, pharmaceuticals and drinking water";
- No person shall manufacture, stock, distribute or sell carry bags made of virgin or recycled plastics or bio-degradable plastics, which are less than 12 x 18 inches (30 x 45 cm) in size and less than 40 microns in thickness
- No person shall manufacture carry bags, containers, pouches or multilayered packaging from biodegradable plastics unless these meet the Bureau of Indian Standards' specifications, entitled "Specifications for Compostable Plastics".
- In any other instance than the packaging of food stuffs, no persons shall manufacture, stock, distribute or sell non-recyclable laminated plastic or metallic pouches, multi-layered packaging and other non-recyclable plastics.
- Recycling of plastics are to be undertaken in accordance with the Bureau of Indian Standards specifications: IS 1453: 1988, entitled “The Guidelines for Recycling of

Plastics".

Plastic Waste (Management and Handling) Rules, 2011: The 2011 Rules sought to regulate the use, collection, segregation, transportation and disposal of plastic waste. The rules established a framework which assigned responsibilities for plastic waste management to the urban local body (ULB) and set-up a state-level monitoring committee. The rules further addressed the issue of carry bags by setting minimum standards for the thickness and a mandate for retailers to charge a fee for each plastic bag made available. According to the new rules:

- The minimum thickness of plastic bags has been raised to 40 microns
- Recycled carry bags made from compostable plastics shall conform to specific BIS (Bureau of Indian standards) standards.
- Use of plastic sachets for storing, packing or selling tobacco based products (and local versions) has been banned.
- The Plastic Rules also require the municipalities to be responsible for the safe management of plastic waste and demand the creation of a State Level Advisory Board to monitor the implementation of these Rules.
- The municipal authorities are required to constructively engage waste pickers, agencies or groups working in waste management.

The Plastic Waste Management Rules, 2016: The 2011 rules were succeeded by the Plastic Waste Management Rules 2016. The Plastic Waste Management Rules sought to extend the responsibility of the plastic producers and generators to create an effective waste management system, including collection, recycling, and a phase-out of plastic which could not be recycled. They allocated responsibilities to all the stakeholders and provided that all the tasks mentioned under the rules be implemented within six months of their notification. The measures include:

- producers are required to develop a waste collection system based on extended producer responsibility (EPR)
- primary responsibility for collection of used multi-layered plastic sachets or pouches or packaging is the producers, importers or brand owners who introduce them in the market, who must establish a collection system
- manufacture and use of non-recyclable multilayer plastic should be phased out within two years
- plastic sachets for storing, packing or selling gutkha, tobacco and pan masala are banned
- non-compostable carry bags are to be no less than 50 microns in thickness
- every local body is responsible for setting up infrastructure for segregation, collection, storage, transportation, processing and disposal of plastic waste, and shall 'seek assistance' of producers
- waste generators are required to segregate waste for recycling and not litter

- These rules extended its purview and applicability to rural areas and plastic importers in the supply chain.
- Further, the minimum thickness of plastic carry bags was increased from 40 micron to 50 micron.

The rules also mandated the producers and brand owners to devise a plan in consultation with the local bodies to introduce a collect back system. This system known as the Extended Producers Responsibility (EPR) would help assist the municipalities in tackling the plastic waste issue. As a part of the EPR, it also provides for collection of a fee from the producers, importers of plastic carry bags/ multilayered packaging in order to strengthen the financial status of local authorities and, therefore, the plastic waste management systems.

The Plastic Waste Management (Amendment) Rules 2018 The 2016 rules have been revised to be known as the Plastic Waste Management (Amendment) Rules 2018. The Rules were amended again in 2018 to include energy recovery as well as material recovery as the preferred solution for end of life management of multi-layered plastic packaging. Implication of this amendment is that this in effect reverses the complete ban on these materials, which was supposed to take effect in March 2018. The change was primarily due to a lack of large-scale solutions for recycling/reprocessing of multi-layer plastic waste.

Major changes amongst others have been incorporated which are:

- The rules notify that under Section 9(3), the term 'non-recyclable multilayered plastic' have been substituted by 'multilayered plastic which is non-recyclable or non-energy recoverable or with no alternate use'.
- The new rules attempt to establish a centralized registration system by mandating brand owners and producers operating in more than two states to register with the CPCB.

Table 2: Summarising Plastic Management Rules

Regulation	Specific provisions	Intent
Recycled Plastics Manufacture and Usage Rules, 1999	The use of recycled and virgin coloured polybags for non-food applications was allowed but discouraged for packaging food items. Stipulated both size and thickness restrictions on plastic bags, requiring them to be at least 8 X 12 inches in size and 20 microns in thickness.	To regulate the manufacture, sale, use and recycling of plastic bags

Plastic Waste (Management and Handling) Rules, 2011	Prohibition of the manufacture, stocking, distribution, or selling of carry bags made of virgin or recycled plastic less than 20 x 30 centimetres in size and 20 microns in thickness. Units manufacturing plastic bags are required to register with the respective State Pollution Control Board (SPCB) or Pollution Control Committee (PCC) before starting production	To regulate the use, collection, segregation, transportation and disposal of plastic waste
Plastic Waste Management Rules,2016	Producers are required to develop a waste collection system based on extended producer responsibility (EPR) Primary responsibility for collection of used multi-layered plastic sachets or pouches or packaging is the producers, importers or brand owners who introduce them in the market, who must establish a collection system Manufacture and use of non-recyclable multilayer plastic should be phased out within two years	To extend the responsibility of the plastic producers and generators to create an effective waste management system, including collection, recycling, and a phase-out of plastic which could not be recycled -allocated responsibilities to all the stakeholders and provided that all the tasks mentioned under the rules be implemented within six months of their notification. To expand its jurisdiction to rural areas, to Gram Panchayats, because plastics has reached rural areas as well.
Plastic Waste Management (Amendment) Rules 2018	The new rules attempt to establish a centralized registration system by mandating brand owners and producers operating in more than two states to register with the CPCB.	The Rules were amended again in 2018 to include energy recovery as well as material recovery as the preferred solution for end of life management of multi-layered plastic packaging

Source: Various Plastic Rules, 1999, 2011, 2016 and 2018,Government of India

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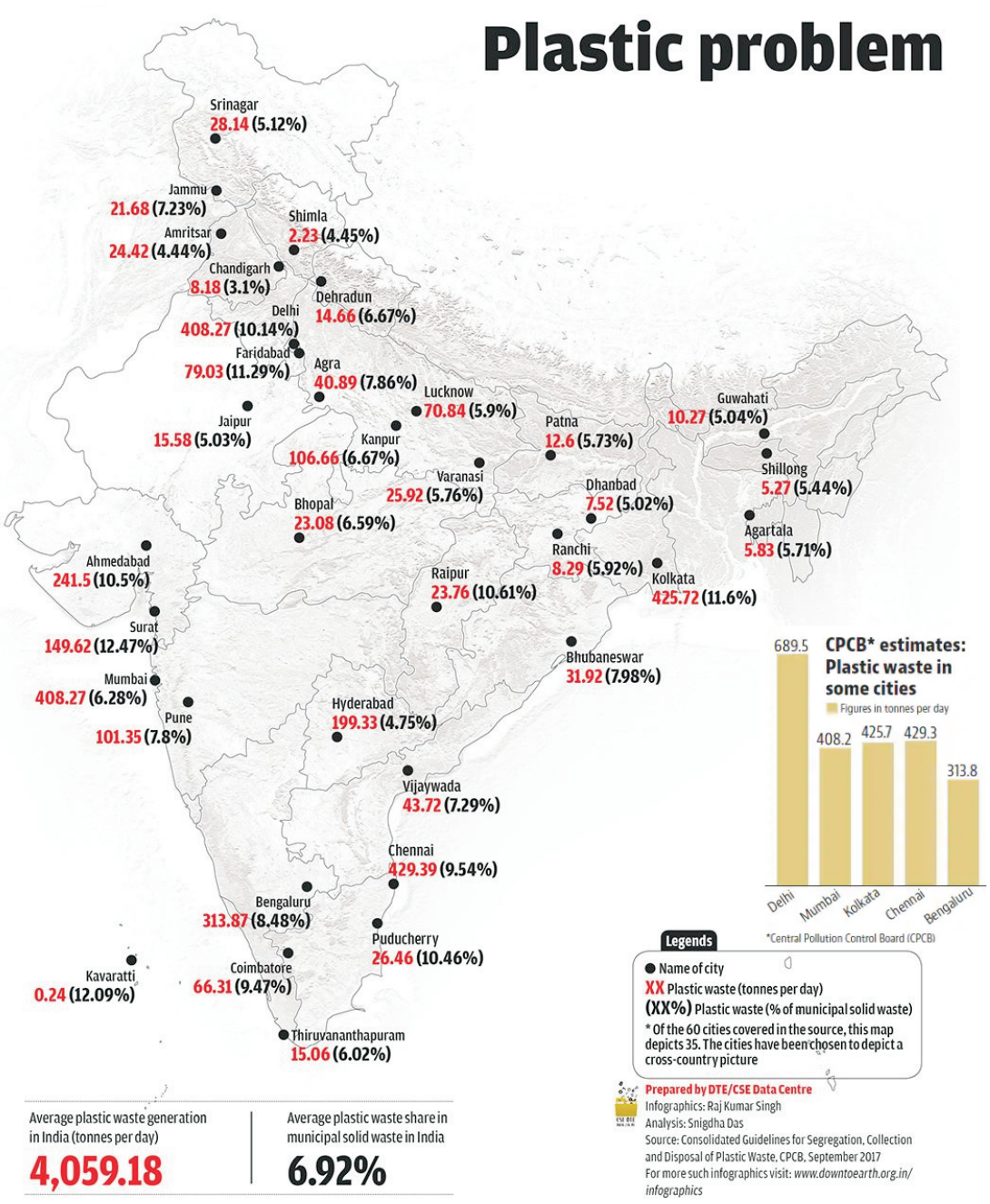
Plastic Waste Generation in Major Cities in India



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