Ministry of Housing and Urban Affairs
Government of India

150 YEARS OF CELEBRATING THE MAHATMA

स्वच्छ भारत
एक कदम स्वच्छता की ओर

PLASTIC WASTE MANAGEMENT

ISSUES, SOLUTIONS & CASE STUDIES

MINISTRY OF HOUSING & URBAN AFFAIRS
GOVERNMENT OF INDIA

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March 2019

Swachh Bharat Mission (Urban)

PLASTIC WASTE MANAGEMENT
Issues, Solutions and Case Studies

सत्यमेव जयते

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हरदीप एस पुरी
HARDEEP S PURI

सत्यमेव जयते

आवासन और शहरी कार्य
राज्य मंत्री (स्वतंत्र प्रभार)
भारत सरकार
MINISTER OF STATE (I/C)
HOUSING AND URBAN AFFAIRS
GOVERNMENT OF INDIA

Message

Rapid population growth, urbanization and industrial growth have led to severe waste management problems around the world. The growth in the usage of plastics is a major contributor of environmental degradation today.

Swachh Bharat Mission (Urban), under the Ministry of Housing & Urban Affairs, is bringing out various guidelines to assist Urban Local Bodies in combating the menace of Solid Waste Management. In this series, 'Plastic Waste Management: Issues, Solutions & Case Studies', a book containing various methods of Plastic Waste Management i.e. reduce, reuse, recycle and recover, is being published. The motto of this advisory is to lend knowledge support to ULB officials and Waste Managers on various initiatives and efforts taken to deal with the issue of plastic waste management. Additionally to help Waste Managers, this booklet also covers analysis of various National and International case studies and a variety of resource recovery technologies.

I am confident that this booklet will encourage ULBs to effectively deal with issues of plastic waste management to enable us to achieve sustainable development and make Swachh Bharat Mission a success.

(Hardeep S Puri)

New Delhi
27 February 2019

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Government of India
Ministry of Housing and Urban Affairs
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MESSAGE

With growing urbanization, India's urban population is expected to grow from nearly 38 crores to 60 crores in 2030. Higher incomes and consumption due to increased urbanization will lead to three times the current waste generation from 62 million tonnes to 165 million tonnes by 2030. High consumption of plastic due to its durability, low cost, flexibility, moisture resistance, superior insulation, low maintenance etc. combined with its resistance to decomposition is causing severe environmental pollution and health problems.

India generates 26,000 TPD of plastic waste amounting to 9.4 million TPA. Even though 60% of the plastic produced in India is recycled - thanks to our informal sector, it still leaves 9400 TPD of plastic waste unattended. This waste can be gainfully utilised through various initiatives: recycling, plastic to fuel (pyrolysis) and plastic to alternate fuel etc.

Swachh Bharat Mission (Urban) has inter-alia mandate of 100% solid waste management of which plastic constitutes major portion of dry waste. Keeping this mandate in mind, this book contains different aspects of plastic waste management including the current scenario, the harmful effects of plastic waste, the 3R approach (Reduce, Reuse, Recycle) and resource recovery alternatives to deal with plastic menace.

I believe this book will help ULBs and Waste Managers in updating themselves with the relevant initiatives and technologies to deal with plastic waste and further pave the way in our collective journey towards "Swachh Bharat".

(Durga Shanker Mishra)

New Delhi
22 February, 2019

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सत्यमेव जयते

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GOVERNMENT OF INDIA
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26th Feb, 2019

Preface

Plastic as a synthetic polymer substitute of natural materials has become an essential aspect of our lives. We have witnessed a considerable intensification in the production of plastics in the last few decades and simultaneous increased consumption of plastic materials. It is estimated that approximately 70% of plastic packaging products are converted into plastic waste in a short span. Studies show that consuming plastic could lead to cancer, effects on hormone levels, and heart damage. It is also estimated that 83% of drinking water contains plastic and in 30 years there is likely to be more plastic in oceans than fish.

Considering the growing plastic usage and the associated environmental challenges, plastic waste management is very critical for effective municipal solid waste management. 'Plastic Waste Management: Issues, Solutions & Case Studies' aims to help ULBs in understanding and managing growing plastic waste in a scientific manner. Managing plastic waste will also help us in honouring our commitment to Sustainable Development Goals, specifically SDG 6 and SDG 12 thereby ensuring international standards of living for our growing urban population.

This book covers the benefits of reducing and reusing plastics with real life case studies. It also highlights the methodology that may be used for recycling or recovering used plastic waste, and suggests way forward for stakeholders along with snapshot of success stories implemented across the continents and within India.

I am certain that this book will encourage the stakeholders to deal with the menace of plastic waste using appropriate technologies and case studies, and make Swachh Bharat Mission a success.

V. K. Jindal
(V.K.Jindal)

Contents

1. Plastic Waste: A Global Concern[1]

Plastic products have become an integral part of our daily life as a result of which the polymer is produced at a massive scale worldwide. On an average, production of plastic globally crosses 150 Million tonnes per year. Its broad range of application is in packaging films, wrapping materials, shopping and garbage bags, fluid containers, clothing, toys, household and industrial products, and building materials.

It is estimated that approximately 70% of plastic packaging products are converted into plastic waste in a short span. Approximately 9.4 million TPA plastic waste is generated in the country, which amounts to 26,000 TPD[2] . Of this, about 60% is recycled, most of it by the informal sector. While the recycling rate in India is considerably higher than the global average of 20%[3] , there is still over 9,400 tonnes of plastic waste which is either landfilled or ends up polluting streams or groundwater resources. While some kinds of plastic do not decompose at all, others could take up to 450 years to break down. The figure captures per capita plastic consumption in FY 2014-15.

Plastics are not inherently bad, and they have many redeeming ecological features. Many of the techniques we utilize in our designs involve targeted use of plastic products. Their durability and low maintenance reduce material replacement, their light weight reduces shipping energy, their formulation into glue products allows for the creation of engineered lumber and sheet products from recycled wood, and their formulation into superior insulation and sealant products improves the energy performance of our structures.

Once plastic is discarded after its utility is over, it is known as plastic waste. It is a fact that plastic waste

1 Source: Overview of Plastic Waste Management by CPCB (http://cpcb.nic.in/displaypdf.php?id=cGxhc3RpY3dhc3RlL21hbmFnZW1lbnRfcGxhc3RpY3dhc3RlLnBkZg==)
2 Source: UNIDO Report- Recycling of Plastics in Indian perspective by Dr. Smita Mohanty
3 Source: https://ourworldindata.org/faq-on-plastics

never degrades, and remain on landscape for several years. Mostly, plastic waste is recyclable but recycled products are more harmful to the environment as this contains additives and colors. **The recycling of a virgin plastic material can be done 2-3 times only, because after every recycling, the plastic material deteriorates due to thermal pressure and its life span is reduced. Hence recycling is not a safe and permanent solution for plastic waste disposal.** It has been observed that disposal of plastic waste is a serious concern due to improper collection and segregation system.

Only 60% of the plastic produced is recycled, balance 9400 Tonnes of plastic is left unattended in environment causing land, air and water pollution.

70% of Plastics packaging products are converted into plastic waste in a short span

1.1 Harmful Effects of Plastics

Plastic is versatile, lightweight, flexible, moisture resistant, strong, and relatively inexpensive[4]. Those are the attractive qualities that lead us, around the world, to such a voracious appetite and over-consumption of plastic goods. However, durable and very slow to degrade, plastic materials that are used in the production of so many products, ultimately, become waste. Our tremendous attraction to plastic, coupled with an undeniable behavioral propensity of increasingly over-consuming, discarding, littering and thus polluting, has become a combination of lethal nature.

The disposal of plastics is one of the least recognized and most highly problematic areas of plastic's ecological impact. Ironically, one of plastic's most desirable traits: its durability and resistance to decomposition, is also the source of one of its greatest liabilities when it comes to the disposal of plastics. Natural organisms have a very difficult time breaking down the synthetic chemical bonds in plastic, creating the tremendous problem of the material's persistence. A very small amount of total plastic production (less than 10%) is effectively recycled; the remaining plastic is sent to landfills, where it is destined to remain entombed in limbo for hundreds of thousands of years, or to incinerators, where its toxic compounds are spewed throughout the atmosphere to be accumulated in biotic forms throughout the surrounding ecosystems

• Groundwater and soil pollution

Plastic is a material made to last forever, and due to the same chemical composition, plastic cannot biodegrade; it breaks down into smaller and smaller pieces[5]. When buried in a landfill, plastic lies untreated for years. In the process, toxic chemicals from plastics drain out and seep into groundwater, flowing downstream into lakes and rivers. The seeping of plastic also causes soil pollution and have now started resulting in presence of micro plastics in soil.

• Pollution in Oceans

The increased presence of plastic on the ocean surface has resulted in more serious problems. Since most of the plastic debris that reaches the ocean remains floating for years as it does not decompose quickly, it leads to the dropping of oxygen level in the water, severely affecting the survival of marine species. Materials like plastic are non-degradable which means they will not be absorbed and recycled. When oceanic creatures and even birds consume plastic inadvertently, they choke on it which causes a steady decline in their population. The harmful

4 Source: https://www.motherearthliving.com/health-and-wellness/harmful-effects-of-plastic-ze0z1205zsch
5 Source: https://plasticpollutioncoalition.zendesk.com/hc/en-us/articles/222813127-Why-is-plastic-harmful-

PLASTIC WASTE POSES A HUGE THREAT TO MARINE ECOLOGY

There are **8 million** tonnes of plastic waste entering the ocean every year

The total plastic in the ocean amounts to **150 million tonnes**

Plastic packaging accounts for **62%** of all items recovered in coastal clean-up efforts

In 2014, there was **1 kg of plastic in the ocean for every 5 kg of fish, and by 2050 there will be more plastic than fish**

effects of plastic on aquatic life are devastating, and accelerating. In addition to suffocation, ingestion, and other macro-particulate causes of death in larger birds, fish, and mammals, the plastic is ingested by smaller and smaller creatures (as it breaks down into smaller and smaller particles) and bio accumulates in greater and greater concentrations up the food chain—with humans at the top.

Even plankton, the tiniest creatures in our oceans, are eating micro plastics and absorbing their hazardous chemicals. The tiny, broken down pieces of plastic are displacing the algae needed to sustain larger sea life who feed on them. Some important facts about Plastic:

1. Plastics are made from oil with a highly polluting production process. Plastics just do not dissolve; they break down into micro-particles that circulate in the environment. A single water bottle can take up to 1000 years to break down.
2. Asia is the world leader in plastic pollution. The Philippines alone dumped over 1 billion pounds of plastics into our oceans. That is over 118,000 trucks worth. In 30 Years there is likely to be more plastic in our oceans than fish.
3. 83% of our drinking water contains plastic. Studies show that consuming plastic could lead to cancer, effects on hormone levels, and heart damage. Plastics have been found in the blood of even new born babies
4. Over 600 marine species are affected by plastics. Nearly 45000 marine animals have ingested plastics and 80% were injured or killed. Plastics can pierce animals from inside or cause starvation, entanglement, loss of body parts and suffocation.
5. As plastics travel with ocean currents, an island of trash called the "Great pacific Garbage Patch" has been created. There are now many islands of trash in our seas.

- **Dangerous for human life**

Burning of plastic results into formation of a class of flame retardants called as Halogens. Collectively, these harmful chemicals are known to cause the following severe health problems: cancer, endometriosis, neurological damage, endocrine disruption, birth defects and child developmental disorders, reproductive damage, immune damage, asthma, and multiple organ damage.

Figure: Whale killed by plastic waste

Figure: Plastics recovered inside the whale

Figure: Great pacific Garbage Patch

2. Plastic Waste Generation in India

According to the reports for year 2017-18, Central Pollution Control Board (CPCB) has estimated that India generates approximately 9.4 Million tonnes per annum plastic waste, (which amounts to 26,000 tonnes of waste per day), and out of this approximately 5.6 Million tonnes per annum plastic waste is recycled (i.e. 15,600 tonnes of waste per day) and 3.8 Million tonnes per annum plastic waste is left uncollected or littered (9,400 tonnes of waste per day)[6].

Out of the 60% of recycled plastic[7]:

- 70% is recycled at registered facilities
- 20% is recycled by Unorganized Sector
- 10% of the plastic is recycled at home.

While these stats are 38% higher than the global average of 20%, there is no comprehensive methods in place for plastic waste management. Additionally, there is a constant increase in plastics waste generation. One of the major reasons for this is that 50% of plastic is discarded as waste after single use. This also adds to increase in the carbon footprint since single use of plastic products increase the demand for virgin plastic products.

Figure: Plastic waste recycled in India

Figure: Rise of Plastic Consumption in India

Figure: Top 5 Plastic Waste producing States of India

6 Source: UNIDO Report- Recycling of Plastics in Indian perspective by Dr. Smita Mohanty

7 Source: http://cpcb.nic.in/Plastic_waste.php/

3. Plastic Waste Management

3.1 Types of Plastics

The Society of the Plastics Industry, Inc. (SPI) introduced its resin identification coding system in 1988 at the urging of recyclers around the country. The seven types of plastic include:

1. Polyethylene Terephthalate (PETE or PET)
2. High-Density Polyethylene (HDPE)
3. Polyvinyl Chloride (PVC)
4. Low-Density Polyethylene (LDPE)
5. Polypropylene (PP)
6. Polystyrene or Styrofoam (PS)
7. Miscellaneous plastics (includes: polycarbonate, polylactide, acrylic, acrylonitrile butadiene, styrene, fiberglass, and nylon)

Figure: Types of Plastic

Figure: Examples of different types of Plastic

Plastics are generally categorized into two types[8]:

- Thermoplastics: Thermoplastics or Thermo-softening plastics are the plastics which soften on heating and can be molded into desired shape such as PET, HDPE, LDPE, PP, PVC, PS etc.
- Thermosets: Thermoset or thermosetting plastics strengthen on heating, but cannot be remolded or recycled such as Sheet Molding Compounds (SMC), Fiber Reinforced Plastic (FRP), Bakelite etc. are the examples of the same.

Nowadays, an alternate to petro-based plastic carry-bags/films has been introduced i.e. compostable plastics (100% bio-based)carry-bags/films conforming IS/ISO: 17088.The Plastic Waste Management (PWM) Rules 2016 also encourage the use of compostable carry-bags and products by exempting minimum thickness criteria of 50μm.Further, as per provision 4 (h) of PWM Rules, 2016, the manufacturers or sellers of compostable plastic carry bags shall obtain a certificate from the Central Pollution Control Board (CPCB) before marketing or selling their products. The manufacturers/sellers of compostable carry-bags/products are required to apply to CPCB asper Standard Operating Procedure (SOP) available on CPCB's Website[9].

3.2 Plastic Waste Management (PWM Rules), 2016 [10]

The Government of India notified Plastic Waste Management (PWM) Rules, 2016 on 18thMarch, 2016, superseding Plastic Waste (Management & Handling) Rules, 2011. These rules were further amended and named as 'Plastic Waste Management (Amendment) Rules, 2018

Salient features of Plastic Waste Management (PWM Rules), 2016

- These rules shall apply to every **Waste Generator, Local Body, Gram Panchayat, Manufacturer, Importer, Producer and Brand Owner**.
- Carry bags made of virgin or recycled plastic, shall not be less than fifty microns in thickness. The provision of thickness shall not be applicable to carry bags made up of Compostable plastic, complying IS/ISO: 17088.
- **Waste Generators** including institutional generators, event organizers shall not litter the plastic waste, shall segregate waste and handover to authorized agency and shall pay user fee as prescribed by ULB and spot fine in case of violation.
- **Local Bodies** shall encourage use of plastic waste for road construction or energy recovery or waste to oil or co-processing in cement kilns etc. It shall be responsible for development and setting up of infrastructure for segregation, collection, storage, transportation, processing and disposal of the plastic waste either on its own or by engaging agencies or producers
- **Gram Panchayat** either on its own or by engaging an agency shall set up, operationalize and co-ordinate for waste management in the rural area under their control and for performing the associated functions, namely, ensuring segregation, collection, storage, transportation, plastic waste and channelization of recyclable plastic waste fraction to recyclers having valid registration; ensuring that no damage is caused to the environment during this process; creating awareness among all stakeholders about their responsibilities; and ensuring that open burning of plastic waste does not take place

8 Source: Toolkit on Plastic Waste Management Rules 2016
9 Source: http://cpcb.nic.in/Plastic_waste.php
10 Source: Plastic Waste Management Rules, 2016

- **Producer, Importers and Brand Owners** need to work out modalities for waste collection system for collecting back the plastic waste within a period of six months in consultation with local authority/State Urban Development Department and implement with two years thereafter.
- **State Pollution Control Board (SPCB)/ Pollution Control Committee (PCC)** shall be the authority for enforcement of the provisions of PWM Rules, 2016, relating to registration, manufacture of plastic products and multi-layered packaging, processing and disposal of plastic wastes.
- Concerned **Secretary-in-charge of Urban Development** of the State or a Union Territory and concerned **Gram Panchayat in the rural area** of the State or a Union Territory shall be the authority for enforcement of the provisions of PWM Rules, Rules relating to waste management by waste generator, use of plastic carry bags, plastic sheets or like, covers made of plastic sheets and multi-layered packaging.
- **District Magistrate or Deputy Commissioner** shall provide the assistance to SPCBs/PCCs, Secretary-in- Charge, Urban Development Department and Gram Panchayat under his jurisdiction, whenever required for enforcement of provisions of PWM Rules, 2016.

3.3 Reduce, Reuse, Recycle, and Recovery

Plastic bags are popular with consumers and retailers as they are a functional, lightweight, strong, cheap, and hygienic way to transport food and other products[11]. Most of these go to landfill and garbage heaps after they are used, and some are recycled. Once littered, plastic bags can find their way on to our streets, parks and into our waterways. Although plastic bags make up only a small percentage of all litter, the impact of these bags is nevertheless significant. Plastic bags create visual pollution problems and can have harmful effects on aquatic and terrestrial animals. Plastic bags are particularly noticeable components of the litter stream due to their

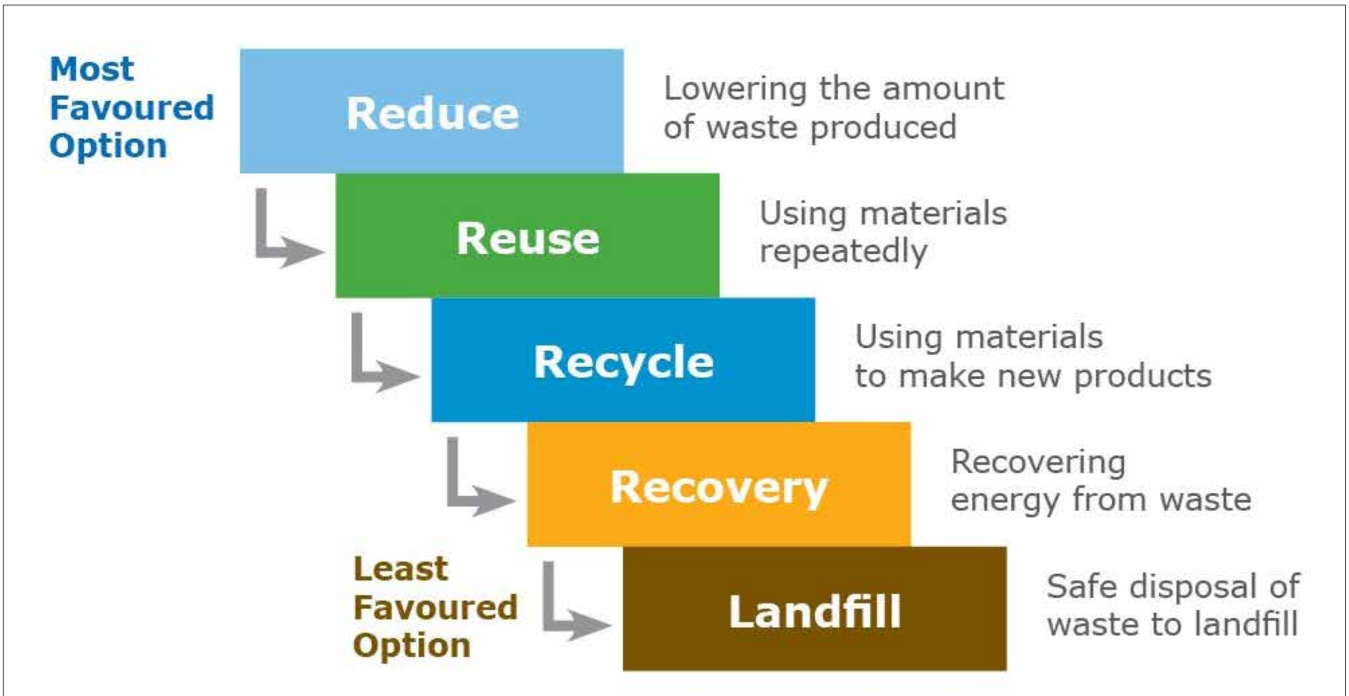


Figure: Management of Plastic Waste

11 Source: *https://saferenvironment.wordpress.com/2008/10/06/plastic-wastes-%E2%80%93-reduce-reuse-and-recycle-of-plastics-are-essential-to-make-environment-greener-and-safer/*

size and can take a long time to fully break down. Many carry bags end up as unsightly litter in trees, streets, parks and gardens which, besides being ugly, can kill birds, small mammals and other creatures. Bags that make it to the ocean may be eaten by sea turtles and marine mammals, who mistake them for jellyfish, with disastrous consequences. In developed countries billion bags are thrown away every year, most of which are used only once before disposal. The biggest problem with plastic bags is that they do not readily break down in the environment. It has been found that, the average plastic carrier bag is used for five minutes, but takes 500 years to decompose.

3.3.1 Reduce

Plastic, of course, is uniquely problematic because it's non-biodegradable and therefore sticks around for a lot longer than the other forms of waste. Few small steps in day to day life would help to keep plastics a possible out of the waste stream. Some of these steps may include:

1. Discourage the use of disposal plastics

Ninety percent of the plastic items in our daily lives are used once and then abandoned: grocery bags, plastic wrap, disposable cutlery, straws, coffee-cup lids. Take note of how often we rely on these products and replace them with reusable versions. It only takes a few times of bringing our own bags to the store, silverware to the office, or travel mug to office tea areas before it becomes habit.

2. Minimize Buying Water

Each year, close to 20 billion plastic bottles are thrown in the trash. Making a habit of using reusable bottle in the bag, use of water from office, home and work areas where the quality of the water can be trusted

3. Minimize use of Plastics Cutlery

Making a habit of using metal utensils instead of plastic cutlery would help saving a lot of plastics that is thrown in thrash every year.

4. Purchase item Secondhand

The newer items comes with lot of packaging materials instead try to use secondhand materials until it is very necessary

5. Support a bag Tax or Ban

Support legislations and by laws which put taxes on ban of single use plastics

Snapshot of Public-Private initiatives to REDUCE single use plastic bags and Styrofoam products

The table[12] below is organized by continent and country, summarizing examples of retailers, Municipalities and other public-private cooperation instituted to reduce the use of plastic bags and Styrofoam without the implementation of a policy measure. The column "Features" overviews the initiative and the measures implemented as well as the impact, as per the information available.

Area	Country	Year	Action Taken	Type	Features
Asia	Indonesia	2017	Government commitment	Memorandum of understanding	Type: Because of a four-year campaign organized by citizens to get plastic bags banned in Bali, the governor signed a memorandum of understanding to phase out plastic bags by January 2018 (Prisco, 2017).
Europe	Germany	2016	Public private agreement	Ban or levy	Type: Voluntary ban or levy on plastic bags (retailers can decide whether to phase out plastic bags or to apply a fee of €0.05 to €0.50 (about $0.06 to $0.60). The agreement was made by the Ministry, the German Retail Federation and participating companies to curb the use of plastic bags. Many more companies participate without having signed the agreement.). (German government, 2016, Surfrider, 2017)
	Switzerland	2016	Public private agreement	Levy	Type: Switzerland's largest supermarket chains introduced a plastic bag levy based on a voluntary agreement, which was approved by the parliament as an alternative to a total ban (Swiss supermarkets, 2016). Impact: Demand for plastic bags dropped by 80- 85% (Price tag, 2017).
	Luxemburg	2004	Public private agreement	Levy	Type: 85 brands (including all big distributors) participate in the "Eco-sac" ("Öko-Tut") initiative, a cooperate project between the Ministry of the Environment, the Luxembourgian Trade Confederation and the non-profit association Valorlux to reduce the consumption of lightweight plastic bags by replacing them with the so-called "Öko-Tut" (a reusable bag). Impact: Plastic bag consumption dropped by 85% in nine years and the "Öko-Tut" has replaced most free plastic bags at supermarkets across the country (Luxembourger leads way, 2013; Bänsch-Baltruschat et al., 2017). has replaced most free plastic bags at supermarkets across the country (Luxembourger leads way, 2013; Bänsch-Baltruschat et al., 2017).
North America	Canada	2016	Private Initiative	Levy	Type: A big supermarket chain announced that it will start charging consumers CAD 0.05 (around $0.04) per single-use plastic bag and CAD 0.25 per reusable bag (The Canadian Press, 2016).
Oceania	Australia	2017	Private Initiative	Ban or Levy	Type: Some major supermarkets announced that they will phase out lightweight plastic bags or provide bags but charge AUD 0.15 ($0.12) per bag (Pearlman, 2018).

12 Source: UN Environment: Single Use Plastics- A Roadmap for Sustainability

Reducing and refusing plastic: Ban on usage

Altogether 18 States and Union Territories have taken initiative and imposed some kind of ban on plastic manufacture, stock, sale, or use of plastic carry bags, namely Andhra Pradesh, Arunachal Pradesh, Assam, Chandigarh, Chhattisgarh, Delhi, Goa, Gujarat, Himachal Pradesh, Jammu & Kashmir, Karnataka, Maharashtra, Odisha, Sikkim, Tamil Nadu, Uttar Pradesh, Uttarakhand and West Bengal.

Successful Case Studies on Plastics Ban within India:

CASE STUDY: **OPERATION BLUE MOUNTAIN IN NILGIRIS, TAMIL NADU**

Operation Blue Mountain campaign was led by Supriya Sahu, the district collector in 2001 to ban the use of plastic in the district. The campaign was crucial to unclog the river sources and springs in the popular hill station of Nilgiris. The experiment has been documented by erstwhile Planning Commission and UNDP as the best practice on governance from Indian States. In order to make people understand, the campaign used pictures of choking animals. They also explained how plastic clogs drains and also seeps into the lake and other water bodies.

CASE STUDY: **SIKKIM: FIRST STATE TO BAN PLASTICS BOTTLES & DISPOSABLE FOAM PRODUCTS**

Sikkim, which is often applauded for being one of the cleanest states in India has now taken one more step to reduce its carbon footprint. In two recent notifications issued by the state's home department, the Sikkim government has decided to manage its waste in a more efficient and eco-friendly manner by banning the use of plastic water bottles in all Government meetings and programmes. Further, it has banned the use of disposable foam products across the entire state.

A huge quantity of municipal waste is created in the form of disposable products which are environmentally hazardous, and claim a lot of space in landfills. It was found that a lot of disposable foam containers were being used not just in bazaar areas at food stalls, but also in rural pockets. Owing to this, there is now a state-wide ban on the use and sale of cups, plates, spoons, containers, and other foam items.

It is also stated that rampant use of packaged drinking water in departmental meetings and programmes has led to the piling up of disposable plastic bottles that add an unnecessary burden on dump yards. Therefore, in order to reduce creation of garbage in the form of used drinking water plastic bottles it is notified that the packaged drinking water bottles may not be used during any government meetings or functions. The alternative proposed is to switch to filtered water, water from large reusable dispensers or reusable water bottles at such government functions and meetings.

The government has been initiating various measures to manage the waste and maintain a clean environment. Sikkim was also the first state in the country to ban the use of plastic bags in 1998.

CASE STUDY: **MAHARASHTRA- BAN ON PLASTICS**

Maharashtra will be the 18th state in India to ban single-use disposable plastic. Maharashtra has banned disposable products manufactured from plastic and thermocol (polystyrene). Maharashtra plastic ban carries penalties starting at Rs. 5,000 and goes up to Rs 25,000 and 3 months of imprisonment. The government has played a major role by bringing in the law, mechanism of imposing it, the fines and the paraphernalia that goes with the implementation. Now, flower vendors are sending flowers to people's home in cloth bags. Vegetables are being sold in cloth bags. Women in self-help groups are looking at making jute or cotton bags as a major source of income. Medicines are coming in small paper pouches. Tea and coffee stalls, college canteens and restaurants are doing away with plastics. Also, the corporates like Starbucks, Coca Cola and Bisleri have risen to the occasion and taken up responsibility of collecting waste plastics from Mumbai and recycle it or up-recycle it to different use. People participation can be seen as NGOs, schools, celebrities, industrialists have begun campaigns to beat plastic pollution.

CASE STUDY: **HIMACHAL PRADESH- SUSTAINABLE PLASTIC WASTE MANAGEMENT PLAN**

The Government of Himachal Pradesh enacted the Himachal Pradesh Non-Biodegradable Garbage (Control) Act, 1995, to deal with the menace of plastic and other non-biodegradable waste. This Act embodied a move towards scientific disposal of non-biodegradable waste and also imposed a ban on coloured plastic carry bags produced from recycled plastic. The Government of Himachal Pradesh introduced the Sustainable Plastic Waste Management Plan in 2009. The Plan focusses on controlling the use of plastic and developing a systematic disposal mechanism. In order to achieve the objectives of its Clean Himachal and Healthy Himachal drive, the Government also prohibited the use of plastic cups and plates in 2011; conducted Information, Education and Communication (IEC) activities to generate awareness about the harmful impact of plastic waste, and encouraged citizens to stop using plastic products

Objectives:

The initiative aims to establish environment-friendly plastic waste disposal solutions. In the process it seeks to ban the use of plastic bags and plastic products, and reduce plastic littering across the state. Further, in order to ensure sustainability and continued community participation, the initiative seeks to spread environmental awareness among the local population.

Stakeholders:

The Sustainable Plastic Waste Management Plan has been implemented by the Department of Environment, Science and Technology (DEST), Government of Himachal Pradesh.

Implementation Strategy:

The Sustainable Plastic Waste Management Plan has been implemented in three stages. Stage I aimed at creating an enabling framework, Stage II focused on creating awareness through campaigns, and Stage III on consolidation and sustainability.

Stage 1: Creating an enabling Framework:

The DEST began by establishing an environmentally sound solution for plastic littering and disposal. Its aim was to adopt replicable and sustainable solutions for the state. After much deliberation, the DEST took the decision of processing household waste in cement kilns and using plastic waste in road construction. As the Public Works Department (PWD) plays a major role in the construction of roads, the first step was to convince it to adopt the solution.

The DEST and PWD jointly conducted a pilot project in Shimla to test the technology. While DEST identified a supplier of plastic waste shredders, PWD procured and used the output in the construction of a road in Shimla The pilot demonstrated that the technology was cost effective and replicable, and provided a solution to utilize plastic waste in an innovative and prudent manner. Thereafter, the DEST developed a comprehensive plan for the identification of roads, modalities for collection and storage of plastic waste at collection centers, and shredding for use in tarring. The PWD was trained on a technology that involved shredding and mixing of various kinds of plastic food packets, aluminium foil etc., with bitumen for tarring roads. Typically, each kilometer of road consumes a tonne of plastic, used directly without cleaning. This cost effective technology allows savings of approximately Rs. 35,000–40,000 per kilometer through reduced bitumen use.

Stage 2: Creating an enabling Framework:

In this stage of the project, the government launched the Polythene Hatao – Paryavaran Bachao campaign. The first phase of the campaign focused on voluntary participation in schemes and actions aimed at cleaning the state and encouraged citizens to understand the problem of plastic waste and the need to keep the state clean. This campaign created awareness and encouraged the participation of Mahila Mandals, Urban Local Bodies (ULBs), NGOs, associations of Panchayati Raj Institutions etc. Plastic waste was collected from hill slopes, forest areas, rivers, drains etc., and IEC activities, such as video clippings and documentary films, were used to sensitize the public. In this phase, 142 tonnes of polythene was collected from 10 districts for use in road construction.

Stage 3: Ensuring Consolidation and Sustainability:

Stage III of the campaign addressed the need for developing a sustainable mechanism for collection and disposal of plastic waste, and focused on allocation of responsibilities and tasks to various departments. Role allocation and monitoring, constitution of teams to curb offences related to littering and use of plastic bags, involvement of eco-clubs to educate the general public and imposition of challans (monetary fines/penalties) were the highlights of this stage.

An environment audit scheme was started in Stage III to monitor the environmental performance of the project as well as to facilitate training and capacity building among school students, teachers and citizens.

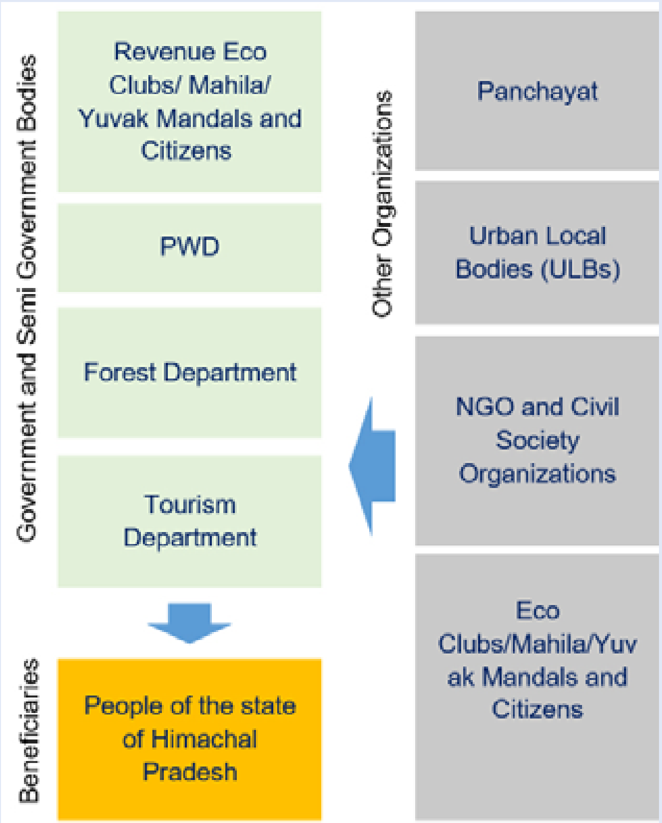
Impact:

1. Cleaner environment and reuse of waste plastic for roads:

The ban on plastics and the systematic waste recycling model have not only ensured cleaner surroundings and contributed to environmental conservation but also supported infrastructure development through road construction. The institutional mechanism for collection, transportation and utilization of plastic waste has become functional and has been adopted across the state.

2. Public Awareness and Participation:

The plan has made a significant impact in building awareness and securing people's cooperation. It is encouraging people to collect plastic waste to minimize its negative environmental impact, and assume responsibility for the maintenance of their local environment.



Key stakeholders in sustainable plastic waste management plan

Successful Case Studies[13] on Plastics Ban across the continents

CASE STUDY: **CHINA: NATIONAL AND PROVINCIAL POLICIES**

Regulations at national and local level

Context:

Prior to 2008 about 3 billion plastic bags were used in China every day, creating more than 3 million tonnes of garbage each year. Due such large volume of plastic waste, plastic litter in China is now being called as “white pollution”.

The National ban and levy

To curb the production and consumption of plastic bags, in 2008 the Government of China introduced a ban on bags thinner than 25 microns and a levy on thicker ones, promoting the use of durable cloth bags and shopping baskets. Exemptions were allowed for bags used in the handling of fresh food such as raw meat and noodles for hygiene reasons.

Impact:

One year after the introduction of the legislation, the distribution of plastic bags in supermarkets fell on average by 70%, avoiding the use of 40 billion bags. Within seven years, the number of plastic bags used by supermarkets and shopping malls shrank by two-thirds, with 1.4 million tonnes of bags avoided. However, plastic bags do remain common, especially in rural areas and farmers’ markets, due to weak enforcement. China has recently (January 2018) introduced a ban on the import of plastic scraps

CASE STUDY: **COSTA RICA: TOTAL SINGLE-USE PLASTIC BAN**

First to pledge phasing out all single-use plastic bags

Context:

Costa Rica has emerged as an environmental leader in many ways. It was successful in doubling its forest cover from 26% in 1984 to more than 52% in 2017 and plans to be carbon neutral by 2021. Costa Rica now aims to become the first country in the world to ban all single-use plastics by 2021.

The ban

On 5 June 2017, World Environment Day, the government announced a National Strategy to phase out all forms of single-use plastics by 2021 and replace them with alternatives that biodegrade within six months. The ban aims at eliminating not only plastic bags and bottles, but also other items such as plastic cutlery, straws, Styrofoam containers and coffee stirrers. The Strategy promotes the substitution of single-use plastic through five actions:

i. Municipal incentives,
ii. Policies and institutional guidelines for suppliers,
iii. Replacement of single-use plastic products,
iv. Research and development, and
v. Investment in strategic initiatives.

In implementing this project, the government is supported by the United Nations Development Programme (UNDP), local governments, civil society and private sector groups.

13 Source: UN Environment: Single Use Plastics- A Roadmap for Sustainability

CASE STUDY: **KENYA: PUNITIVE TOTAL BAN**

Severe plastic bag ban

Context:

Prior to 2017, about 100 million plastic bags were used in Kenya every year in supermarkets alone, impacting the environment, human health and wildlife especially in areas where waste management systems are inadequate. In Western Kenya, veterinarians claimed that in their lifetime cows ingest a considerable amount of plastic bags, among other plastics

The ban

In February 2017, the Government of Kenya announced a ban on the production, sale, importation and use of plastic carry bags, which came into full effect after six months (in August 2017). Under the new law, representing the third attempt in the past decade, offenders can face fines of up to $38,000 or four-year jail terms, making Kenya's plastic bag ban the most severe in the world. Before the law entered into force, UN Environment supported the organization of a stakeholder dialogue where national and local-level officials could engage with private sector representatives to exchange views on how best to implement the regulation

Large supermarket chains are selling reusable cloth bags, as the government encourages retailers to offer consumers alternatives to plastic bags. Kenyans are slowly adjusting to life without plastic bags but there is not yet a clear account of the impact of the ban. The government is now starting an analysis to measure the overall act of the ban. On one hand local 'green' businesses see this as an opportunity for new innovative solutions to succeed and prosper, on the other hand, during this transition period - where there is lack of affordable eco-friendly alternatives – hygiene and food loss concerns are being raised by small-scale vendors (selling for instance pre-cooked foods, fruits and vegetables in markets).

CASE STUDY: **RWANDA: TOTAL BAN**

Total plastic bag ban: Cleaner cities and rural areas

Context:

In 2004, the Rwandan Ministry of Environment, concerned by the improper disposal of plastic bags, as they were often burned or clogged drainage systems, commissioned a baseline study which revealed that plastic bag litter was threatening agricultural production, contaminating water sources and creating visual pollution.

Introduction of the ban

In 2008 the Rwandan government banned the manufacturing, use, sale and importation of all plastic bags. Paper bags replaced plastic ones, and citizens also started using reusable bags made of cotton. Along with the new ban, tax incentives were provided to companies willing to invest in plastic recycling equipment or in the manufacturing of environmentally friendly bags.

Critics claim that stakeholders were insufficiently consulted during the policy design and that the poorest fractions of the population were not considered. Despite the good intentions, after the entry into force of the ban, investments in recycling technologies were lacking, as were good and cheap alternatives. As a result, people started smuggling plastic bags from neighboring countries and a lucrative black market emerged.

What worked well

With time, enforcement of the law became stricter, and if caught, offenders would face high fines and even jail. In the long run, citizens became used to the new regulation and, Kigali, the capital of Rwanda, was nominated by UN Habitat in 2008 as the cleanest city in Africa.

CASE STUDY: **ANTIGUA AND BARBUDA**

In January 2016, Antigua and Barbuda prohibited the importing, manufacturing and trading of plastic shopping bags. In July of the same year, the distribution of such bags at points of sale was banned, leaving enough time for retailers to finish their stocks. Since plastic bags sold in large retailers accounted for 90% of the plastic litter in the environment, the ban was first implemented in major supermarkets, and later extended to smaller shops.

What worked well

Key elements of policy's success include four rounds of stakeholder consultations to ensure engagement and acceptance of the policy. Stakeholders engaged include major retailers, the National Solid Waste Management Authority, the Ministry of Trade and the Department of Environment. After approval by the Cabinet, it was decided that the ban would be incorporated in the existing legislation, as this was more expedient than instituting a new law. An awareness-raising campaign titled "I'm making a difference one bag at a time" included frequent television short clips by the Minister of Health and the Environment providing information on the progress of the ban and feedback from stakeholders. A jingle was produced to promote the use of durable bags for a cleaner and healthier environment. Moreover, shoppers were provided with reusable bags outside supermarkets, and seamstresses and tailors were taught how to manufacture such bags so as to meet increasing demand. Major supermarkets were also required to offer paper bags from recycled material, in addition to reusable ones. To encourage the manufacturing and use of alternatives to plastic bags, the legislation includes a list of materials that will remain tax free, such as sugar cane, bamboo, paper, and potato starch.

Impact

In the first year, the ban contributed to a 15.1% decrease in the amount of plastic discarded in landfills in Antigua and Barbuda, and paved the way for additional policies targeting the reduction of plastics. For instance, the importation of plastic food service containers and cups was prohibited in July 2017. As of January 2018, single-use plastic utensils were banned, as well as food trays and egg cartons. At a later stage, Styrofoam coolers are also expected to be outlawed.

3.3.2 Reuse

Reuse is a step up from recycling. It diverts plastic and takes pressure off the recycling services. In fact, reuse is the middle-man between reduce and recycle, and some would be surprised at how many opportunities for reuse there really are.

One can reuse plastic-produce bags for sandwiches, plastic grocery bags for small trash bags, and re-use plastic silverware. Most people skip this step and go directly to recycling, but reusing plastics can reduce the demand for new plastics to be created.
For instance, since refillable plastic containers can be reused for many times, container reuse can lead to a substantial reduction in the demand for disposable plastic and reduced use of materials and energy, with the consequent reduced environmental impacts.

3.3.3 Recycle

Recycling and re-utilization of waste plastics have several advantages. It leads to a reduction of the use of virgin materials and of the use of energy, thus also a reduction of carbon dioxide emissions.

Benefits of Recycling:

- Reduces Environmental Pollution
- Energy savings : 40 - 100 MJ/kg (depends on the polymer)
- Economic Benefits
- Reduces demand for virgin polymer
- Preferred to Land Filling
- Generates Employment
- Reduces depletion of Fossil fuel reserves

Difficulties in Recycling:

- Hard to separate from non-plastics (no 'magnet' equivalent)
- Differing composition of plastic resins means they are largely incompatible
- Degradation of polymer chains on recycling
- Recycled polymer is of lower quality than virgin polymer
- Most waste plastics films specially thin plastics films have limited market value, therefore effort is not spent in collecting them
- Identification of reuse and recycling opportunities
- Markets for Plastics; Lack of Infrastructure
- Low value of recovered Plastics
- Subsidies for recycling program

A number of factors can complicate the practice of plastics recycling, such as the collection of the plastics waste, separation of different types of plastics, cleaning of the waste and possible pollution of the plastics. A further complicating factor is the low-value nature of most of the products that can be manufactured from recycled plastics. Reusing plastic is preferable to recycling as it uses less energy and fewer resources, however recycling plastic takes less energy than making plastic from raw materials.
It has been observed, to reduce bad effects of waste plastics, it is better to recycle and re-utilize waste plastics in environment-friendly manners. In addition to reducing the amount of plastics waste requiring disposal, recycling and reuse of plastic can have several other advantages, such as:

- Conservation of non-renewable fossil fuels – Plastic production uses 8% of the world's oil production, 4% as feedstock and 4% during manufacture
- Reduced consumption of energy
- Reduced amounts of solid waste going to landfill
- Reduced emissions of carbon-dioxide (CO2), nitrogen-oxides (NOx) and Sulphur-dioxide (SO2).

Segregation of waste at source is also a very important step in managing plastic waste generated. There are several cities which are excelling in this. In addition to segregation of waste at source, some cities have set up segregation centers in the entire city to facilitate secondary segregation of plastic waste into 25- 27 categories and assist in recycling of plastic.
A number of recycling techniques of the plastics have been collected which can be adopted by the

municipality in dealing the issue of plastic waste. It includes technology like

1. Mechanical Recycling
2. Feedstock Recycling
3. Plastic to Road Construction
4. Plastic to Toilet / Pavement Blocks
5. Recycling of Multi-layered plastic

3.3.3.1 Mechanical Recycling

Techniques for Sorting and Separation of Plastic Waste:

1. Air Classifier (also known as a Zig Zag Separator): A technique used for Separating of light films or contaminating paper/foil, or for separating fine dust from reclaimed material such as plastic flake or other granular materials. It is usually used after Granulation or Dry Cleaning Operations and is very effective.
2. Air Tabling: A density concentration technique in which particles of mixed sizes, shapes, and densities are separated from each other due to the differential settling in an upward airflow with controllable velocity and under the influence of a vibrating action.
3. Ballistic Separator: It is designed to separate solid waste at the inlet, depending on size, density & shape
4. Dry and Wet Gravity Separation (or Sink Float Tank): In this technique, different types of plastics are separated based on their density. The heavier plastic fractions sink to the bottom of the tank whilst the lighter fractions float to the surface. It is used in the recycling of plastic bottles and their caps. Mostly the lids and caps of these bottles are

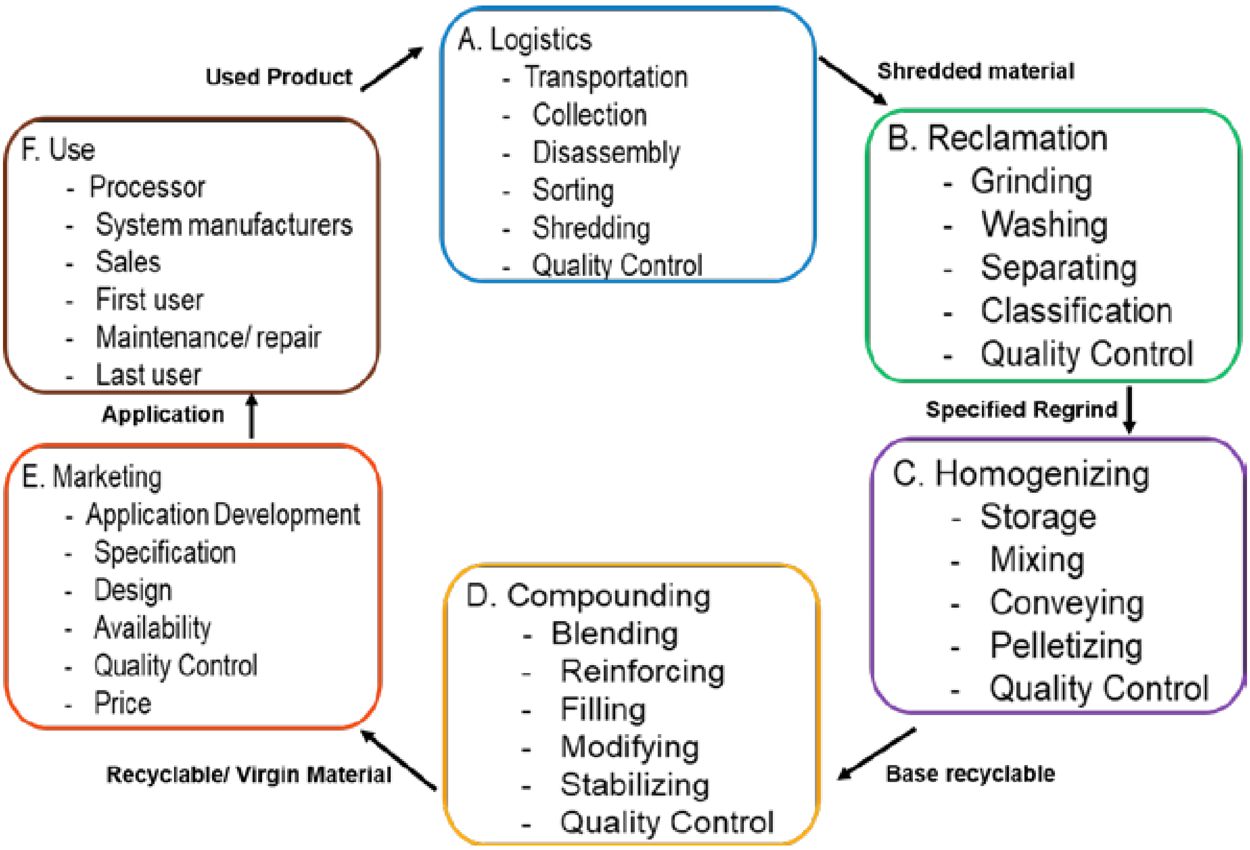


Figure: Mechanical Recycling

made from colored HDPE plastic and the bottles from PET plastic. Within the Sink-Float Tank the HDPE floats, whilst PET sinks.

5. Froth Flotation: It is an intensive rinsing process with the addition of either fluid or steam and it has the ability to extract large volumes of fluid making it an effective choice for recycling. Friction Separation dissolves and separates impurities sticking to the product, utilizing a high level of rotation and friction. Often used to clean mixed plastics and for highly contaminated films. This technique is an ideal choice for soiled plastics to be treated in the recycling process.

6. Electrostatic Separation (or Triboelectric Separation): In this techniques, electrostatically charged particles are passed through a tribo-cyclone, and negatively charged particles gravitate towards the positively charged plate and vice-versa, thereby classifying 3 or more resins at once.

Apart from the techniques mentioned above, there are sensor based separation technologies also available for plastic waste:

1. Plastic Color Sorting:
In this technique, ultra-violet light is used in combination with excellent digital camera technology to identify materials as small as 0.04mm.This range of plastics colour sorting machines cover material throughputs of 300-1800 kgs/hr. The machine throughputs are dependent upon material type and quantity of contamination. The sorting accuracy is typically up to 99.99%.

2. Near Infrared (NIR)
When materials are illuminated they mostly reflect light in the near infrared wavelength spectrum. The NIR sensor can distinguish between different materials based on the way they reflect light. This uses optical sorting to positively identify different resins. It is usually used for whole bottles & jugs and requires a minimum particle size of 50mm

Extrusion & Palletisation
Plastics extrusion is a high-volume manufacturing process in which raw plastic is melted and formed into a continuous profile. Extrusion produces items such as pipe/tubing, rods, fencing window frames, plastic films and sheeting, thermoplastic coatings and wire insulation. This process starts by feeding plastic material (pellets, granules, flakes or powders) from a hopper into the barrel of the extruder. The material is gradually melted by the mechanical energy generated by turning screws and by heaters arranged along the barrel. The molten polymer is then forced into a die, which shapes the polymer into a shape that hardens during cooling.

Figure: Extrusion and Palletisation method of plastic waste recycling

3.3.3.2 Feedstock Recycling

a) Depolymerisation
The process De-polymerization is degradation of bonds to break down into monomers. This process is utilized for the degradation of plastic to lower hydrocarbons. Chemical Depolymerisation has successfully been employed to recover monomers from PET, polyamides such as nylons and polyurethanes. It has the ability to return a recovered resin to virgin resin-like quality, and the potential to

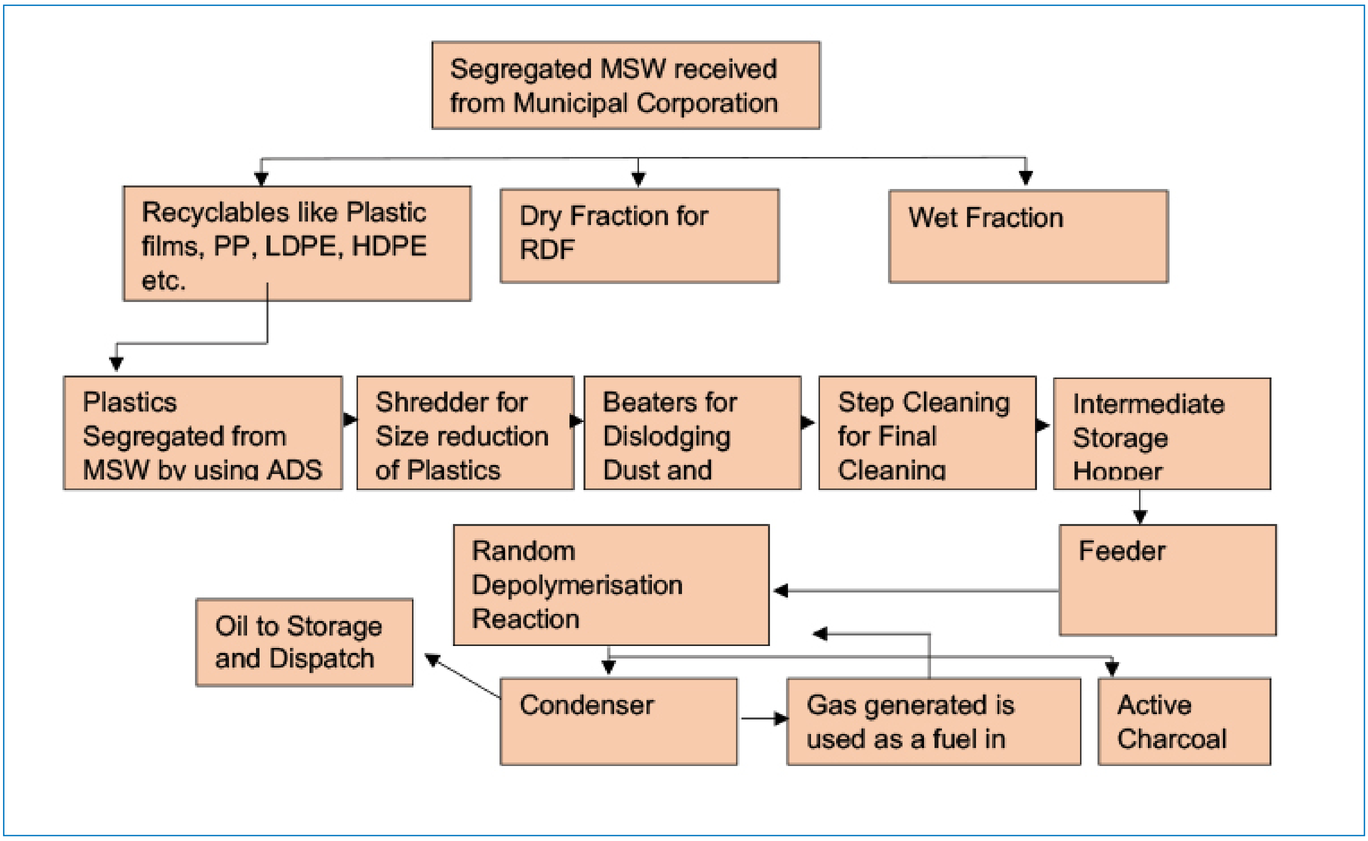
recover a valuable feedstock from products that are economically challenging to recycle. The De-polymerization is carried out in a specially designed Reactor, in absence of oxygen and in the presence of certain catalytic additives. The maximum reaction temperature is 350°C. The entire feed material is converted into either of the products: Liquid RDF, gases and solids. The solids can be reused as fuel in cement industries while the gas is reused in the system as a fuel. The unused hot Air from the reactor is released through chimney.

FEEDSTOCKS AND OUTPUT WITH THERMAL DEPOLYMERIZATION
(Note: Paper/cellulose contains at least 1% minerals, which was probably grouped under carbon solids.)

Average Thermal Depolymerisation (TDP) Feedstock Outputs

Feedstock	Oils	Gases	Solids (mostly carbon based)	Water (Steam)
Plastic bottles	70%	16%	6%	8%
Medical waste	65%	10%	5%	20%
Tires	44%	10%	42%	4%
Sewage sludge	26%	9%	8%	57%
Paper (cellulose)	8%	48%	24%	20%

Process flow diagram for production of Liquid RDF from waste plastic



b) Plastic to Fuel (Pyrolytic Conversion Technologies)

A new generation of conversion technology, specifically designed to manage non-recyclable plastics, has been developed, and commercial scale facilities that use pyrolysis technology to convert plastics into oil and fuel are being established in Europe and Asia. Pyrolysis is the thermal decomposition of materials at elevated temperatures in an inert atmosphere.

The benefits presented by plastic to fuel (PTF) technologies are two-fold:

(1) Transforming non-recyclable plastics into a valuable commodity

(2) Creating a reliable source of alternative energy from an abundant, no/low cost feedstock.

Steps in pyrolysis to convert scrap plastic to fuel sources:

- **Segregation and Pre-treatment:** Plastic waste (only HD, LD, PP and multilayer packaging except PVC) is segregated and pretreated. The pretreatment could be as minor as size reduction or as involved as cleaning and moisture removal.
- **Conversion:** Pyrolytic processes are used to convert the plastic to gas. It is undertaken in close reactor vessel where waste plastics is heated at high temperatures to convert it into vapour state. The catalyst is added whereby the pyrolysis requires less energy and results in the formation of more branched hydrocarbons. The gas generated in the process is reused as fuel in the process thus making the process economically viable and also help in minimizing air pollution.
- **Distillation:** The gas is collected in condensation chamber and is converted in the form of liquid fuel. The oil has properties similar to LDO and can be safely used as an alternative to LDO in industries thus conserving the already depleting natural resources.
- **Acid removal process:** Acids that form in the breakdown are required to be removed as they can be corrosive to the plastic to fuel systems as well as the engines that will consume the fuel.
- **Separation / final blending / refining:** As per the end-use.

Fuel yield estimates will be different and yields will vary from batch to batch depending on the quality of the feedstock being used. The more contamination and non-resin materials present, the less the fuel yield will be. Higher presence of PS, PP and LLDPE, will result in higher yield.

Output	Percentage of Overall Output
Char	Ranges on average from 2% -13% (one system claims negligible amounts of char when the system is run on a continuous feed vs a batch feed)
Natural gas	Ranges average from 8% to 10%
Fuel/Oil	Ranges average from 80% - 90%
One gallon (3.78 liters) of oil = 138,095 BTUs (40 kWh) One pound (0.45 Kg) of mixed plastic = 15,500 BTUs (when incinerated) (4.5 kWh)	

c) Plasma Pyrolysis Technology (PPT):

Plasma Pyrolysis is a state of the art technology, which integrates the thermo-chemical properties of plasma with the pyrolysis process. The intense and versatile heat generation capabilities of Plasma Pyrolysis technology enable it to dispose of all types of plastic waste including polymeric, biomedical and hazardous waste in a safe and reliable manner. Pyrolysis is the thermal disintegration of carbonaceous material in oxygen-starved atmosphere. In Plasma Pyrolysis, firstly the plastics waste is fed into the primary chamber at 8500°C through a feeder. The waste material dissociates into carbon monoxide, hydrogen, methane, higher hydrocarbons etc. Induced draft fan drains the pyrolysis gases as well as plastics

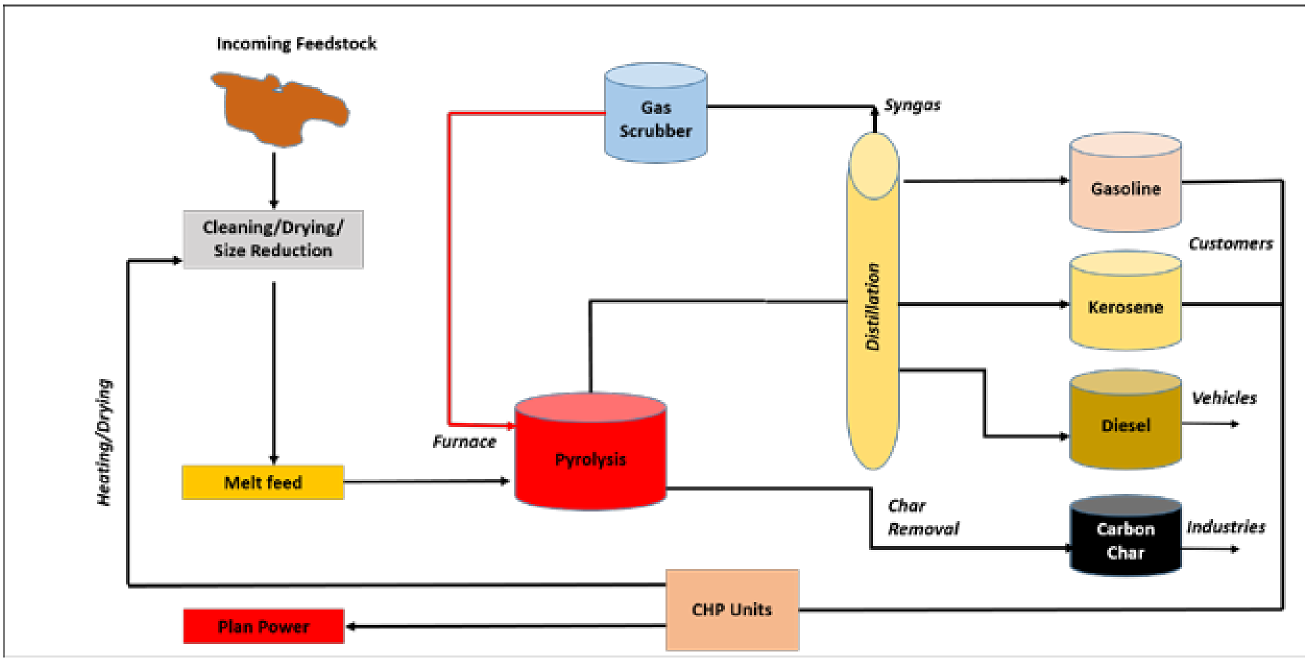


Figure: Plastic to Fuel

> **CASE STUDY: GOA- PLASTIC TO LIQUID RDF**
>
> M K Aromatics has planned to set-up a plant in Goa which would use environmental friendly system for processing plastic waste into hydrocarbons/ crude oil. The plant would use all types of plastics for production of oil in their process. The expected output ratio is going to vary with the type of plastics being used. For High quality plastics such as Milk packets etc. the yield is expected to be 80% however, yield for other low quality plastics output is expected around 60%.

waste into the secondary chamber where these gases are combusted in the presence of excess air. The inflammable gases are ignited with high voltage spark. The secondary chamber temperature is maintained at 10500 °C. The hydrocarbon, CO and hydrogen are combusted into safe carbon dioxide and water.

The process conditions are maintained such that it eliminates the possibility of formation of toxic dioxins and furans molecules (in case of chlorinated waste). The conversion of organic waste into non-toxic gases (CO_2, H_2O) is more than 99%. The extreme conditions of plasma kill stable bacteria such as bacillus stereo-thermophilus and bacillus subtilis immediately.

3.3.3.3 Plastic to Road Construction

The implementation of plastics in roads opens a new option for recycling post- consumer plastics. Plastic roads are made entirely of plastic or of composites of plastic with other materials.

The types of plastic that can be used for construction of roads are Polystyrene (PS) (Hard packaging, cartons, plates, vending cups etc.); Polypropylene (PP) (ketchup bottles, yogurt cups etc.); Polyethylene (PE) (both high and low density) (plastic bags, water bottle, shampoo bottle etc.). Please note that Poly

Vinyl Chloride (PVC) sheets or Flux sheets should not be used.

a) Methodology

The waste plastic has to be collected, segregated, cleaned and then shredded as shown in Figure below. The shredded waste plastic shall pass through 4.75 mm sieve and be retained on 1 mm.
This also indicates indirectly that the size of the shredded plastic should normally be 2-3 mm for better spread and coating the aggregate.

• *Types of Bitumen*

The three classifications of bitumen used in the construction of roads are mentioned below:
Bitumen 80/100: The characteristics of this grade confirm to that of S 90grade of IS-73-1992. This is the softest of all grades available in India. This is suitable for low volume roads and is still widely used in the country.

Bitumen 60/70: This grade is harder than 80/100 and can withstand higher traffic loads. The characteristics of this grade confirm to that of S 65 grade of IS – 73-1992. It is presently used mainly in construction of National Highways & State Highways.

Bitumen 30/40: This is the hardest of all the grades and can withstand very heavy traffic loads. The characteristics of this grade confirm to that of S 35 grade of IS-73-1992. Bitumen 30/40 is used in specialized applications like airport runways and also in very heavy traffic volume roads in coastal cities of the country.
The Bitumen to Plastic ratio shall be 10:1.

b) Plastics as a 'binder'

Waste plastic is shredded into required size and mixed with hot stone (150 to 170 °C) with uniform mixing. When heated to around 150 to 170 °C, plastic melts and spreads over the stone aggregate in its molten state, giving a thin coating at the surface and acting as a binder. The points to note here are:

- Plastics cannot be melted separately to use for coating. On contact with the surface of the hot stone

Step 1- Segregation

Step 2- Cleaning

Step 3- Shredding

Figure: Steps to shred plastic waste for recycling purpose the plastic gel softens and coats over the aggregate. It is important to note that the size of the shredded plastic should be less than the surface area of the aggregate to get uniform coating, otherwise the binding will not be effective.

- The waste plastic when heated to temperature more than 250 °C may decompose producing gaseous products which results in air pollution, hence the temperature during heating shall be maintained between 150 to 170 °C. It is to be ensured that plastic is boiling and not burning.

• *Interaction between Plastic Aggregate and Bitumen*

When the aggregate temperature is around 150 to 170 °C the coated plastic is in a molten state and over this, hot bitumen at 160 °C is added. The added bitumen spreads over the aggregate. At this temperature both the coated plastic and bitumen are in the liquid state, capable of easy diffusion at the interphase. This process is further helped by the increase in the contact area (increased surface area).

Waste polymers namely PE, PP and PS are hydrocarbons with long chains. The bitumen is a complex mixture of asphaltenes and maltenes which are also long chain hydro carbon. When bitumen is mixed with plastic coated aggregate a portion of bitumen diffuses through the plastic layer and binds with aggregate. The plastic layer has already bonded strongly with aggregate. During this process three dimensional internal cross linked network structure results between polymer molecules and bitumen constitutes.

Therefore the bond becomes stronger and the removal of bonded bitumen becomes difficult. Below figure illustrates the plastic aggregate bitumen interaction for the plastic waste coated aggregate bitumen mix.

• *Types of Process*

The two processes for manufacturing bituminous mixes using waste plastic are dry and wet process. In the dry process, the processed waste plastic is added after shredding into the hot aggregates and is recommended for isolated works; while in the wet process, processed waste plastic in the form of powder is added in the hot bitumen.

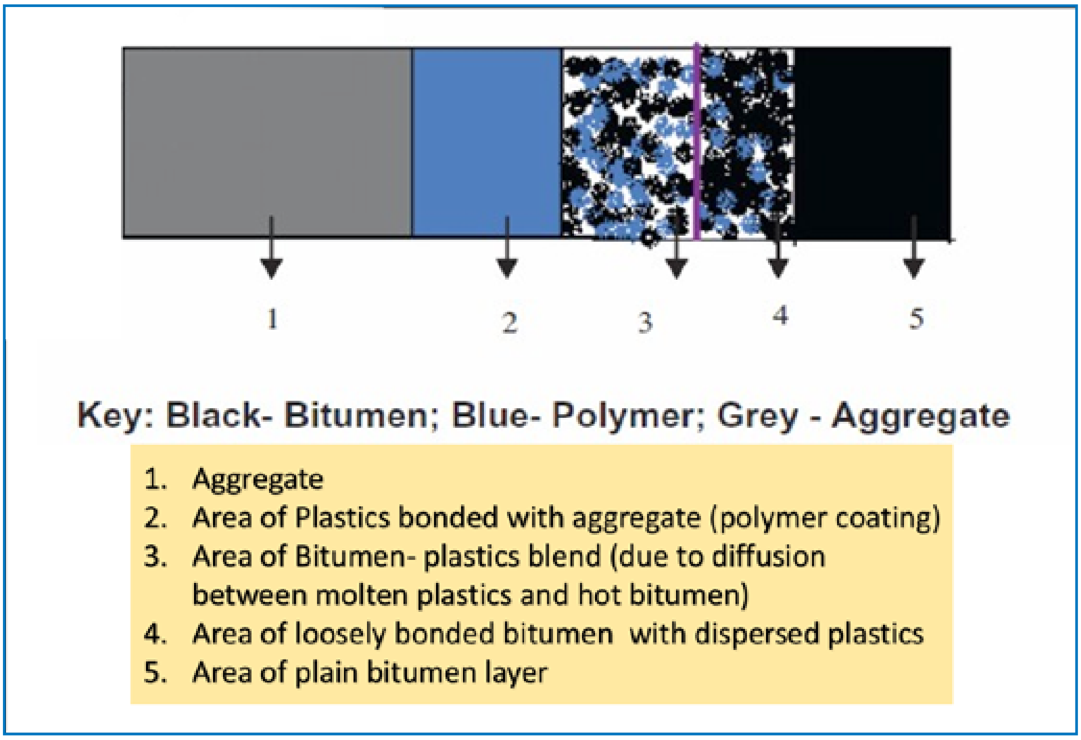


Figure: Bitumen and Plastic Aggregate

i. Mini Hot Mix Plant

The stone aggregate mix (as per specification) is transferred to the mix cylinder where it is heated to 165 °C (as per the IRC specification) and then it is transferred to the mixing puddler.

Figure: Mini Hot Mix Plant

The temperature can be monitored using IR thermometer, while transferring the hot aggregate into the puddler, calculated quantity of shredded plastics is sprayed over the hot aggregate within 30 seconds.

Figure: Mixing of Plastic with Hot Aggregate

The sprayed plastic films melts and gets coated over the aggregate thus forming an oily coating. Similarly, the bitumen is to be heated to a maximum of 160 °C (HRS Specification) in a separate chamber and kept ready (The temperature should be monitored to have good binding and to prevent weak bonding).

At the mixing puddler, the hot bitumen is added over the plastic coated aggregate and the resulted mix is used for road construction as shown in figure. The road laying temperature is between 110°C to 120°C. The roller used is a one with 8-ton capacity.

ii. Central Mixing Plant (CMP)

The Central Mixing Plant technique includes three material types:

Materials I– The hoppers are filled with necessary ggregates as per the mix formula

Materials II– Plastic films (thickness not more than 60microns) to be cut to a size less than 4 X 4 mm. It should not exceed this size.
Materials III– Bitumen of type 60/70 or 80/100 to be used

In Central Mixing, the stone is heated and at the same time the plastics films get melted over the heated stone and gets coated. Slowly the plastics coated aggregate moves forward where this polymer coated aggregate mix is mixed with bitumen. Overall the process consists the following steps:

Figure: Mixing of Bitumen with plastic coated aggregate

1. The aggregate materials are transferred to the cylinder through the conveyer belt.

2. The shredded plastic is sprayed over the aggregate while it is moving in the conveyer belt.

- The spraying is done by manual labors standing up on both side of the conveyer belt of the central mixing plant. While one person adds the shredded plastics on the conveyer belt, in the meantime another person keeps another bucket full of plastics ready so that the addition of plastics is continuous and done quantitatively.

- The amount of plastic to be added is calculated as follows:
  - In the CMP, at the control room the addition of bitumen is monitored.
  - The amount of bitumen sprayed per minute inside the cylinder is to be checked. For example, If the bitumen quantity per minute is 10Kg, the plastic need to be added is 1Kg. (i.e. a bucket can be used which can hold 1 Kg at a time).
  - Hence, the shredded plastics taken in the bucket are sprayed with a speed of 1Kg/min.

- As the plastic is added over the aggregate, the mix (aggregate and plastics) moves into the cylinder.

3. The polymer coated aggregate bitumen mix is then transferred to the dipper.

Salient features/ Advantages of CMP Process

1. Easy process without any new machinery or industry involvement

2. Use of lesser percentage of bitumen and thus savings on bitumen

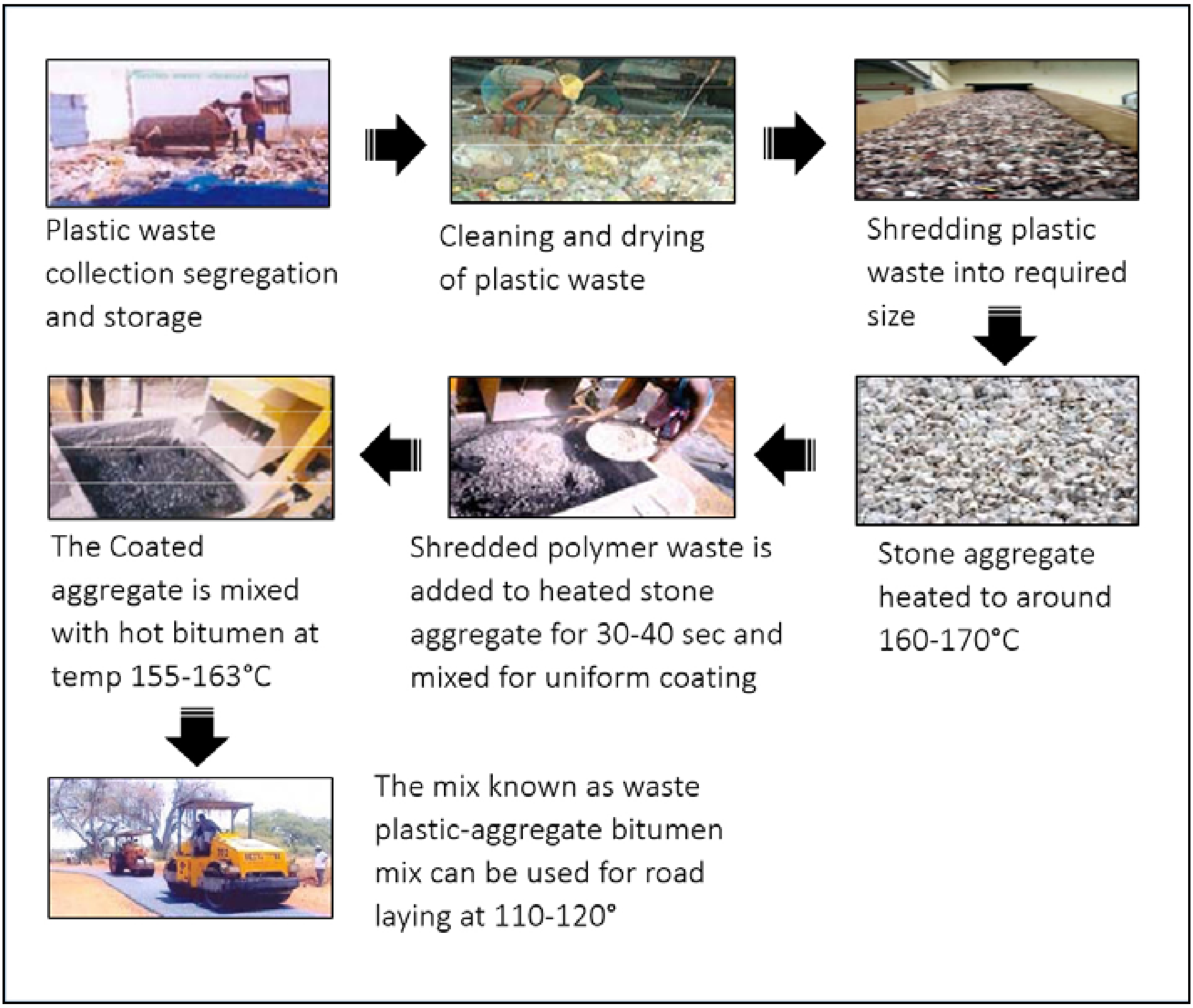
3. No evolution of any toxic gases like dioxin

4. Mixing of the plastics over the aggregate is uniform and better distribution takes place in Central Mixing Plant

5. The coating is better when the mixing of bitumen is being carried out:

a. Inside the Cylinder
b. During loading in the dipper.
c. During transferring the mix in the paver
d. During the spreading of the mix by the paver

• **Flowchart of Plastic Bitumen Road process**



• **Specification for different types of Plastic Bitumen Road**

The key specification for the different types of plastic bitumen road (optimum quantity of polymer 10% by weight of bitumen) is shown in the table below.

Table: Specification for the different types of plastic Bitumen road

Type of Pavement	Aggregates	Bitumen	Polymer	IRC
SDBC 40mm thick-10m^2	13.2mm-0.10m^3 11.8mm-0.16m^3 6.7mm -0.16m^3 2.8mm -0.18m^3	34.20kgs	3.8kgs	508
SDBC 25mm thick -10m^2	11.2mm -0.10m^3 6.7mm -0.16m^3 2.8mm&below-0.11m^3	21.6kgs	2.4kgs	508
Bituminous Concrete 40mm thick-10m^2	26.5-9.5mm -0.40m^3 9.5-2.36mm -0.22m^3 18kgs-cement/hydrates lime/rock dust	38.7kgs	4.3kgs	509
Bituminous Concrete 25mm thick-10m^2	19-9.5mm -0.25m^3 9.5-2.36mm-0.14m^3	24.3kgs	2.7kgs	509
Open grade premix carpet -10m^2	(22.4-11.2mm)13.2mm-0.18m^3 (13.2-5.6mm)11.2mm-0.09m^3	13.14kgs	1.46kgs	511
Premix carpet with seal coat Type A-10m^2	13.2mm -0.18m^3 11.2mm -0.09m^3 6.7mm -0.09m^3	13.14kgs	1.46kgs	511
Premix carpet Type B-10m^2	13.2mm -0.18m^3 11.2mm -0.09m	13.14kgs	1.46kgs	511
Seal Coat Type B	Clean good sand-0.06m^3	6.6kgs	0.25kgs	511
Surface dressing Single coat/First coat-10m^2	13.2mm -0.15m^3	16.2kgs	1.8KGS	---
Bituminous Macadam 75mm thick -10m^2	(45-22.4mm -0.63m^3 (22.4-11.2mm) -0.16m^3 (11.2-2.8mm) - 0.25m^3	52.2kgs	5.8kgs	504
Bituminous Macadam 50mm thick -10m^2	(26.5-11.2mm)-0.42m^3 (11.2-2.8mm) -0.10m^3 2.8mm -0.18m^3	34.2kgs	3.8kgs	504
Dense Bituminous Macadam 75mm thick -10m^2	(37.5-13.2mm) -0.35m^3 13.2-2.36mm) -0.45m^3 2.36mm& below -0.20m^3 36kgs –rock dust	62.1kgs	6.9kgs	507
Dense Bituminous Macadam 50mm thick -10m^2	(26.5-13.2mm) -0.35m^3 (13.2-2.36mm) -0.21m^3 2.36mm& below -0.14m^3 24kgs cement/rock dust	41.4kgs	4.6kgs	507

c) Performance Evaluation of Polymer Coated Bitumen Roads

The Central Pollution Control Board has prepared a performance evaluation report (Programme Objective Series: PROBES/122/2008-2009) titled Performance Evaluation of Polymer Coated Bitumen Built Roads to evaluate the performance of certain roads

Consolidated test results

Monitoring of test roads were carried out using structural evaluation, functional evaluation and conditional evaluation studies.

The results obtained for these roads mentioned in the table below helped to conclude that these roads are performing very well in spite of their age. Under the similar conditions most of the bitumen roads are not performing well at all. These roads have not developed even small cracking and a pothole. The roads were distributed over the different localities of Tamil Nadu exposed to various environmental conditions like temperature, rainfall, etc., yet roads are performing well.

Table: Consolidated Test Results

Road	Year laid	Unevenness (mm /km)/ Roughness	Skid number / Resistance	Sand Texture Depth(mm)	Field Density	Rebound Deflection (mm)/ Benkelman Beam
Jambulingam Street	2002	2700	41	0.63	2.55	0.85
Veerabadhra Street	2003	3785	45	0.70	2.62	0.60
Vandiyur road,	2004	3005	41	0.66	2.75	0.84
Vilachery Road, MDU	2005	3891	45	0.50	2.89	0.86
Canteen Road, TCE	2006	3100	45	0.65	2.86	0.86
Plain Bitumen Road	2002	5200	76	0.83	2.33	1.55
Tolerance Value*	------	4000	<65	.6-.8	2.86	0.5-1

1. Unevenness / Roughness; Source IRC: SP: 16-2004
2. Skid Resistance/ Skid Number; Standardized in UK under BS:812-1967
3. Sand Texture Depth; BS 598 part 105(1990)
4. Rebound Deflection / Benkelman Beam; IRC:81-1997
5. Field Density; Highway Engineering by S. K. Khanna, C.E.G. Justo; New Chand & Bros, Roorkee (U.A); Eighth edition ;2001

d) Advantages of Plastic Bitumen Road

- Presence of plastic increases the binding capacity better bonding of the mixture, making the roads more resistant to external conditions such as extreme heat (UV radiation), etc., and makes roads stronger with increased Marshall Stability Value
- Bitumen film is often stripped off the aggregates because of the penetration of water, which results in pothole formation. This is accelerated during the movement of vehicle. When polymer is coated over aggregate, the coating reduces its affinity for water due to non-wetting nature of the polymer and this resists the penetration of water, thereby reducing pothole formation during rains
- Making roads with plastic mixture reduces the cost and frequency of maintenance.
- The cost incurred in construction of a Bitumen-plastic road is significantly lesser than that of an only Bitumen road
- Salt deposition on the pores of stone which results in road degradation, is also prevented
- Consumption of bitumen decreases by around 10%. For 1km x 3.75m road, 1 tonne of plastic (10 lakh carry bags) is used and 1 tonne of bitumen is saved [14].

e) Cost Comparison between Plain bitumen road and Plastic Bitumen Road*

S No	Material Needed	Plain Bitumen Process	Plastic Bitumen road
1	Road Construction Cost	Rs. 21.00 lakhs	Rs. 18.90 lakhs
2	Maintenance Cost @ Rs. / km per year	Rs. 14,000 per km per year for rural roads. Thus for five years Rs. 70,000	No Maintenance cost for a min five years Maintenance not needed up to 10 years
3	Road Renewal Cost	Roads renewed after 5 years costing Rs. 3.5 lakhs	Nil
4	Total Cost for min. service of five years	Rs. 25.2 lakhs	Rs. 18.9 lakhs
5	Use of Waste Plastics	Nil	One Tonne per Km
6	Total Cost Saved	Nil	Rs. 6.3 lakhs

Cost Comparison implies Rs. 6.3 lakhs can be saved when constructing plastic bitumen road of 1 km length by 3.75 m width.

*The data has been compiled from Padma Shri. Dr. R Vasudevan who is also called as the 'Plastic Man of India'.

14 Source: http://earthuntouched.com/plastic-roads-revolutionary-idea/

CASE STUDY: UTILIZATION OF PLASTIC WASTE IN ROAD CONSTRUCTION IN BENGALURU

(Bruhat Bengaluru Mahanagara Palika)

Bruhat Bengaluru Mahanagara Palika (BBMP) has worked with a Bangalore based company, KK Plastic Waste Management Ltd. in providing innovative solution by reusing non-recyclable plastics in construction of roads. The technology has been patented and certified by the Centre for Transportation Engineering (CTE) and the Central Road Research Institute (CRRI). Since 2002, The Company has been successful in laying 3000 Km of road length successfully in Bangalore city by using 12,000 Tonnes of the plastic waste collected from city's garbage. A Memorandum of Understanding (MoU) was signed with BBMP since 2004-2005 to till date for collecting plastic waste from city's garbage and mixing KK Poly Blend in Bitumen while constructing roads at a rate of Rs. 27/Kg. The manufacturing units with a potential of 20 tonnes per day are located in:

1. Yelchenahalli: Kanakpura Road
2. Anjanapur, Kanakpura Road

BBMP also helped in establishing the network with the bulk generators for collecting the plastic waste from the source of its generation within the city. Following are the roads being laid in recent time:
2018

Location	Road Length in Km	Period of Laying
Outer Ring Road of Bangalore	14	2008-09
Bangalore University Road	8	2013-2014
Under PMGYS in Karnataka	80	2014-2015
Major Roads in Bangalore	20	2017-2018

First 100% recycled road of 500 meters trial run stretch has been laid by KK Plastic Waste Management Ltd. for Karnataka State Highway Improvement Project under World Bank Funding. In the same road, 100% of scarified aggregates and 2% bitumen bas been reused out of scarified materials.

3.3.3.4 Plastic to Toilet (Plastone)[15]/ Pavement Blocks

According to the research conducted by Dr. R.Vasudevan, Dr. A. Ramalinga Chandra Sekar and Mr B. Sundarakannan from Thiagarajar College of Engineering, Madurai, Plastone is a material prepared using waste plastics available in the solid waste of the particular area which can be segregated and used as binder with the stone aggregate. This prefabricated Plastone can be used in the construction of structure of the Toilet Blocks (Individual Household Latrines) and is an effective substitute for bricks and cement blocks. This process can also be done in situ and no external industry is involved. This process results in not only in the reduction of the cost of construction of IHHL, but also in the easy disposal of solid waste available in the village. In a nut shell the research aim is to provide the technology of using Plastone in the construction of toilets at a cheaper cost and as well as a method for the easily disposal of waste plastics.

Novelty involved in the Product

- A new technique using waste plastics as a binder – new technique
- Structural blocks manufactured using solid waste materials and waste plastics
- First technology to utilize multi layered films of waste plastics
- Special properties of Plastone block with high compression strengths, malleability and ductility

Utility:

- Construction of IHHL at low cost using Plastone and achieving hygienic sanitation
- Solution for easy disposal of waste plastics

Scalability:

- Plastone, the product outcome has been very handy and important structural material which solves the problem of disposal of waste plastics
- Plastone can consume all filmy waste plastics both mono layered and multi layered packaging covers
- Plastone blocks are made without using bitumen, sand, cement and water, instead is made up of waste plastics and other waste materials only.

Cost Analysis:

A comparative cost analysis between the toilet structures constructed using traditional method and using Plastone blocks is mentioned below. (Assuming for construction of 4ft X 4ft X 7ft – Toilet structure)

- Using Plastone Block – Rs 7556.00
- Total number of Plastone blocks required of size 2ftX 1ft for the construction of toilet structure is 49 blocks
- Amount of waste plastics required is 156.00 Kgs
- Amount of Aggregate required is 294.00 Kgs

S. No	Type of Material	Amount Required in Kg	Cost in Rs	Total in Rs
1.	Waste Plastics	156	156 X 8 = 1248	1248.00
2.	Aggregate	294	294 X 1= 294	294.00
3.	Energy	2	2 X 57 = 114	114.00
4.	Labour	NA	400 X 3 = 1200	1200.00
5.	Fixing Frame	NA	2700	2700.00
6.	Sheet Laying and Sheet cost	NA	2000	2000.00
Total				7556.00

15 Source: Research Study by Dr. R. Vasudevan, Dr. A. Ramalinga Chandra Sekar and Mr B. Sundarakannan from Thiagarajar College of Engineering (TCE), Madurai on PLASTONE BLOCK – A PRECAST STRUCTURE MADE WITH WASTE PLASTICS AND STONE AGGREGATE AND ITS USE IN TOILET CONSTRUCTION

Figure: Toilet Blocks made of Plastic Waste

- **Using traditional method (Cement Wall Structure):**

S. No	Type of Expenses	Total in Rs
1.	Earth work and Plain Concrete Cement (PCC) structure	3000.00
2.	Brick Work	4000.00
3.	Brick Work for 4.5 ft. and 7 ft. height	9000.00
4.	Plastering all over	3000.00
5.	Sheet laying and sheet cost	2000.00
6.	Cement and Sand	6000.00
Total		27000.00

Thus, the cost of IHHL construction with Plastone structures around 30% of the cost of cement wall structure, when compared with traditional methods.

Plastic to Pavement Blocks

In addition to the Toilet blocks, the 'Plastone block technology' can be used for construction of Pavement blocks. The Plastone blocks are made from mixture of waste plastics and stones and have been found to be five times stronger than the cement concrete block and is able to withstand more pressure and resist percolation of water. It has many advantages over the conventional blocks made of cement. Each Plastone block consumes 300 plastic carry bags and four to six PET bottles. It weighs light and has high transverse strength. These blocks can be used for flooring especially outdoor, in raising compound walls and lining of canals

CASE STUDY: **HYDERABAD- USE OF PLASTIC PAVEMENT BLOCK**

India's first dog park is not just a haven for dog lovers, but also a glimmer of hope for environmentalists fighting for a plastic-free world. In a first, the 4,000 sq. ft. pavement right outside the park has been constructed out of 1,500 recycled plastic tiles. Installed by GHMC and Hyderabad-based start-up Bamboo House India, these tiles are an eco-friendly alternative that offers a practical solution to the growing menace of plastic.

"Urban cities today are plagued with the problem of waste-management and as social entrepreneurs we consider it as an opportunity to produce sustainable yet profitable products," says Prashant Lingam, co-founder Bamboo House India. These tiles are a smart investment option for the government as they do not have to be replaced every six months thus saving a lot of money. These tiles are strong, long-lasting and comparatively cheap too, he points out. Currently installed on a pilot basis, each tile weighs up to 300 grams and is made out of 600 polybags. Besides being fire-proof and damage-free, these have been designed for percolation of water and thereby ensure better ground water table recharge.

GHMC West Zone Commissioner Harichandana says the civic body had been looking for solutions to deal with waste in general and wants very little trash to end up in its dumpyards. With these tiles we are not only getting a cost cut, but also ensuring that our environment is not negatively affected. This project is picking up and we are soon going to see several pavements like these across Hyderabad," she says. The figure shows one such recycled footpath.

Interestingly, this is not the only eco-friendly installation by Bamboo House India. Only two months ago, the parking shelter at Miyapur Metro Station was replaced by a unique house made completely out of recycled plastic waste. But why chose plastic over conventional steel shelters? "Because they are cheaper and cooler," avers Prashant. Bamboo House India produced and installed one plastic house for just Rs 1.5 lakh whereas a regular steel shelter would have cost twice. And because they used 'trash' like tetra packs, bottle caps and poly bags as raw materials, they ended up producing a heat-proof, water- proof, fire-proof and damage-free house at a minimum cost.

Not only this, Hyderabad has made Recycle Bins out of Plastic Pet Bottles, Plastic Bags, Shampoo Bottles & Toothpaste Packets. Each Bin consists of 30kgs of Plastic.
In total, there are 775 no of bins installed in one zone and 23,500 Kgs of Total Amount of Plastic Waste has been used.

3.3.3.5 Recycling of multilayered plastic

As per the CPCB and Plastic Waste Management Rules 2016, 'multi layered packaging means any material used or to be used for packaging and having at least one layer of plastic as the main ingredients in combination with one or more layers of materials such as paper, paper board, polymeric materials, metalized layers or aluminum foil, either in the form of a laminate or co-extruded structure.

Fruit juices and wines can be kept for extended periods of time at room temperature in containers made from paper, aluminum foil and polyethylene film. Laminated foil with paper on the inside is used for packaging tea and sweets. This kind of foil is three times as waterproof as standard foil even in hot climates: the paper absorbs moisture while the foil itself protects the contents against other negative elements. Most companies prefer multi layered packaging because it is light, reduces shipping volume, doesn't take up much space on a shelf, and is graphics friendly. Multi layered packaging waste has found mention in the Plastic Waste Management Rules, 2016 and its amendment in 2018.

- No one shall manufacture multi layered packaging unless they obtain a registration from the State Pollution Control Board
- Manufacture and use of multi layered plastic which is non- recyclable or non-energy recoverable or with no alternate fuel, should be phased out in two years' time
- Extended Producer Responsibility: Primary responsibility for collection of used multilayered plastic sachet or pouches or packaging is of Producers, Importers and Brand owners who introduce the products containing multilayered plastic in the market

Tertiary Recycling is most preferred option till the industry finds an alternative to Multi layered packaging since separating the individual layers is difficult and costly. Pyrolysis and gasification are two key technologies currently used for tertiary recycling of multi-layered packaging waste. If Tertiary recycling not possible, Quaternary Recycling, i.e. the process for recovering energy from waste plastics by incineration may also be considered to recycle multi-layered plastics.

3.3.3.6 Styrofoam and Tetra Pak

a) Styrofoam (Extruded polystyrene foam)

Plastic with recycling symbol of #6, Styrofoam is the trademarked name of Expanded Polystyrene (EPS). It is commonly used in food, insulating materials, and shipping packaging. EPS is cheap to produce, lightweight, and recyclable, yet most Materials Recovery Facilities still do not accept it as part of the recycling program and is impossible to degrade naturally over time, making it a big problem for landfills[16].

Recycling of Styrofoam:

Recyclers have found ways to compact the material to a more manageable size. Balers take foam packaging and compress it, reducing the bulk somewhat. Another method is to use limonene, a natural solvent made from orange peels. Limonene dissolves and concentrates EPS and can itself be reused. The chemical causes the EPS foam to "melt" without heat, reducing it to 5% of its original size. Thermal compaction uses heat to reduce chopped EPS to a concentrated brick that's easier to ship.
When it is burned in municipal incinerators, polystyrene yields nothing but carbon dioxide and water vapor. It's a good fuel for waste-to-energy plants that capture the heat and turn it to useful purposes.

Benefits of recycling Styrofoam:

- Recycled EPS product that looks like wood and can be used for park benches and fence posts. The material costs less than hardwood and can be used instead of woods such as mahogany and teak, which are harvested from rainforests.

16 Source: https://science.howstuffworks.com/environmental/green-science/polystyrene-recycling1.htm

- Making polystyrene requires petroleum, which is a non-renewable resource. So, recycling polystyrene reduces the amount of oil needed for the manufacturing process.
- Recycled EPS would lead to reduction of litter both on land and in the sea
- Recycling consumer polystyrene also prevents the material from being burned in backyard fires. Polystyrene can produce toxic chemicals when burned unless efficient incinerators are used.

b) Tetra Pak

It is multinational food packaging and processing company of Swedish origin. The company offers packaging, filling machines and processing for dairy, beverages, cheese, ice-cream and prepared food,

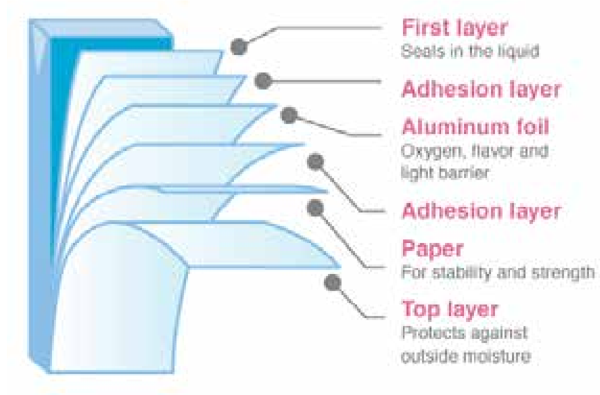
Snapshot of countries that have introduced regulations on Styrofoam products

The table[17] below highlights a snapshot of few countries that have introduced regulations on Styrofoam products:

Area	Country	Year	Level	Policy	Features
Asia	Sri Lanka	2017	National	Ban-entered into force	Type: Ban on the import, sale, and use of polyethylene bags <20μ and Styrofoam containers (Sri Lanka bans plastic, 2017; Jayasekara, 2012)
	Indonesia	2016	Local – Bandung	Ban-entered into force	Type: Ban on the use of Styrofoam in the city of Bandung (Hong, 2016).
	Philippines	2011	Local – Muntinlupa	Ban-entered into force	Type: Ban on the use of plastic bags on dry goods, regulations on their use for wet goods in the city of Muntinlupa & Ban on the use of Styrofoam and styropor (Earth justice, 2015).
Central & South America	Belize	2018	National	Ban- approved	Type: Ban on single-use plastic shopping bags, Styrofoam, and plastic food utensils (Government of Belize Press Office, 2018).
	Antigua and Barbuda	2017	National	Ban-entered into force	Type: Ban on Styrofoam with an implementation plan of three stages. Ban on food service containers since 2017, from 2018 onwards ban on plastic utensils (e.g. spoons, straws, food trays, etc.) and ban on importation and use of Styrofoam coolers (Nice, Ltd, 2017).
	Guatemala	2017	Local – San Pedro La Laguna and other cities	Ban-entered into force	Type: Ban on plastic bags and Styrofoam containers in San Pedro La Laguna. Cantel, Quetzaltenango and San Juan Sacatepéquez have introduced similar laws (Chiyal, 2017).
North America	Canada	2018	Local- Montreal	Ban-entered into effect	Type: Ban on plastic bags <50μ in Montreal (Quebec) (Fundira, 2016).
	United States of America	2015	Local- New York City, New York	Ban-entered into force	Type: Ban on single-use Styrofoam containers instituted in New York City. The ban was challenged by a coalition of recycling firms and plastics manufacturers who claimed the material is recyclable. The ban was lifted in 2015 and reintroduced in 2017 (Alexander, 2017).
Oceania	Marshall Islands	2017	National	Ban-entered into force	Type: Ban on importation, manufacture and use of single-use plastic carrier bags. Ban on Styrofoam and plastic cups, plates and packages (SPREP, 2018; Styrofoam and Plastic Products Prohibition Act, 2016).

17 Source: UN Environment: Single Use Plastics- A Roadmap for Sustainability including distribution tools like accumulators, cap applicators, conveyors, crate packers, film wrappers, line controllers and straw applicators.

It has 6 layers of packaging. Tetra Pak was founded by Ruben Rausing and built on Erik Wallenberg's innovation, a tetrahedron shaped plastic-coated paper carton, from which the company name was derived. Tetra Pak products have been identified as solid waste problem by many NGOs and environmental groups. Unlike aluminum cans or glass bottles, it cannot be recycled in municipal recycling facilities. However, since aseptic packages contain different layers of plastic and aluminium in addition to raw paper, they cannot be recycled as "normal" paper waste, but need to go to special recycling units for separation of the different materials, or if not recycled, can end up in landfills[18].



Products of Tetra Pak can be handled and recycled just like multi-layered plastics.

CASE STUDY: **GO GREEN INITIATIVE OF TETRA PAK**

Tetra Pak India has come up with 'Go Green' initiative thereby encouraging recycling of cartons. It has partnered with McCann Health India for its campaign 'Cartons le aao, classroom banao' (bring cartons and build a classroom), which encourages consumers to adopt green practices by depositing used paper-based Tetra Pak cartons for recycling at collection centres. Such cartons can be used to make desks, notepads, exam pads and even roofing sheets for the less privileged. The initiative is in line with its efforts to raise awareness and encourage recycling of used cartons and a part of its on-going flagship programme 'Go green with Tetra Pak.'

Since the beginning of the Go green campaign in 2010, 1.8 million cartons have already been collected and recycled and 250 school desks have been provided to schools for the lesser privileged through this campaign. The campaign is a multi-city one and the first leg in Mumbai has been undertaken in collaboration with retail chains Reliance Fresh, Reliance Smart and Sahakari Bhandar and with NGO RUR Greenlife, a Mumbai-based environment organisation at the forefront of promoting recycling.

To take the campaign message to Mumbaikars across the city, Tetra Pak has also tied up with the Dabbawala association as part of the campaign.

Source: https://bestmediainfo.com/2017/04/tetra-pak-india-continues-go-green-initiative-encourages-recycling-of-cartons/

18 Source: https://en.wikipedia.org/wiki/Tetra_Pak#Environment

3.3.3.7 Applications of Recycled Plastics

1 PETE	PETE or PET	PET- Polyethylene Terephthalate used for many bottles application because they are inexpensive, lightweight, and shatter- resistant. (RECYCLED PRODUCTS: Mineral/ Drinking Water Bottles, Cosmetic Bottles)
2 HDPE	HDPE	HDPE- High Density Polyethylene used for in bottles, carry bags, milk pouches, recycle bins, etc. (RECYCLED PRODUCTS: Tubes, sewer pipes, pallets, boxes, buckets, toys, bottles for detergents, construction, cable insulation, packaging of food products etc.)
3 PVC	PVC	PVC- Polyvinyl Chloride used for pipes and fittings, Tarpaulins, Medical Apps., etc. (RECYCLED PRODUCTS: Sewer Pipes, Window frames, Construction, Flooring, Wallpaper, Bottles, Car Interiors, Medical products, Planks, etc.)
4 LDPE	LDPE	LDPE- Low Density Polyethylene used in Plastic bags, various containers, dispensing bottles, wash bottles, tubing, etc. (RECYCLED PRODUCTS: Flexible packaging, bin liners, carrier bags, tubes, agricultural mulch film, agricultural sheet, construction film, cling-film, heavy duty sacks, etc.)
5 PP	PP	PP- Polypropylene used in Auto parts, Industrial Fibers, Food containers, etc. (RECYCLED PRODUCTS: Pipes, pallets, boxes, furniture, car parts, pots of yoghurt, buckets, butter, margarine, fibers, milk crates, etc.)
6 PS	PS	PS- Polystyrene is used in food service packaging, disposable cups, tray pitchers, refrigerators, liners, etc. It may also be used as cushioning materials for fresh produce, electronic or appliance industries, etc. (RECYCLED PRODUCTS: Clothes Hangers, Park Benches, Flower Pots, Toys, Spoons, Cutlery, Picture Frames, Seeding containers, etc.)
7 Other	Others	Others (usually, Mixed Plastic Waste, used in Thermoset Plastics, Multilayer and laminates, Bakelite, Polycarbonate, etc.) (RECYCLED PRODUCTS: CDs, Pallets, Floors, Roofs, Furniture, Sheeting, Benches, Shoe soles, etc.)

Figure: Applications of Recycled Plastic

CASE STUDY: **CONVERSION OF PET BOTTLE WASTE INTO TEXTILE PRODUCTS**

A Petro- Chemical company has taken an initiative to collect the PET bottle waste from all over India and convert it into textile products. It has tied up with 150 vendors in India to provide PET bottle bales for processing into textile products.

The company is installing RVM (Reverse Vending Machines) at various locations such as Malls, Exhibition Centres, School/ Colleges and Temples/ Pilgrimage Places, for collection of PET bottle waste and creating awareness among citizens to use the PET bottles responsibly. These collected bottles are recycled and used to make fabrics for bags, T-shirts and garments in composition with natural fibres like cotton, wool etc.

The company uses 4 R model which includes the concept of 'Replace' along with the existing 3R model (Reduce, Reuse and Recycle). It has replaced natural raw materials with used PET bottles and for every 8000 PET bottles recycled, one full barrel of Oil is saved.

The wet colouring process in the product of Polyester staple fibre into dry one with no Pollution. Elimination of wet dyeing from process also eliminates all the associated pollution. The process of using dry dyeing is an advantage to environment.

Henceforth, every bag or T shirt made from PET bottles:
1. Reduces the usage of water by 1400 Litres
2. Redeems 8 waste PET bottle from the land-fill
3. Reduces pesticide usage by over 50%
4. Reduces carbon foot-print by 32%

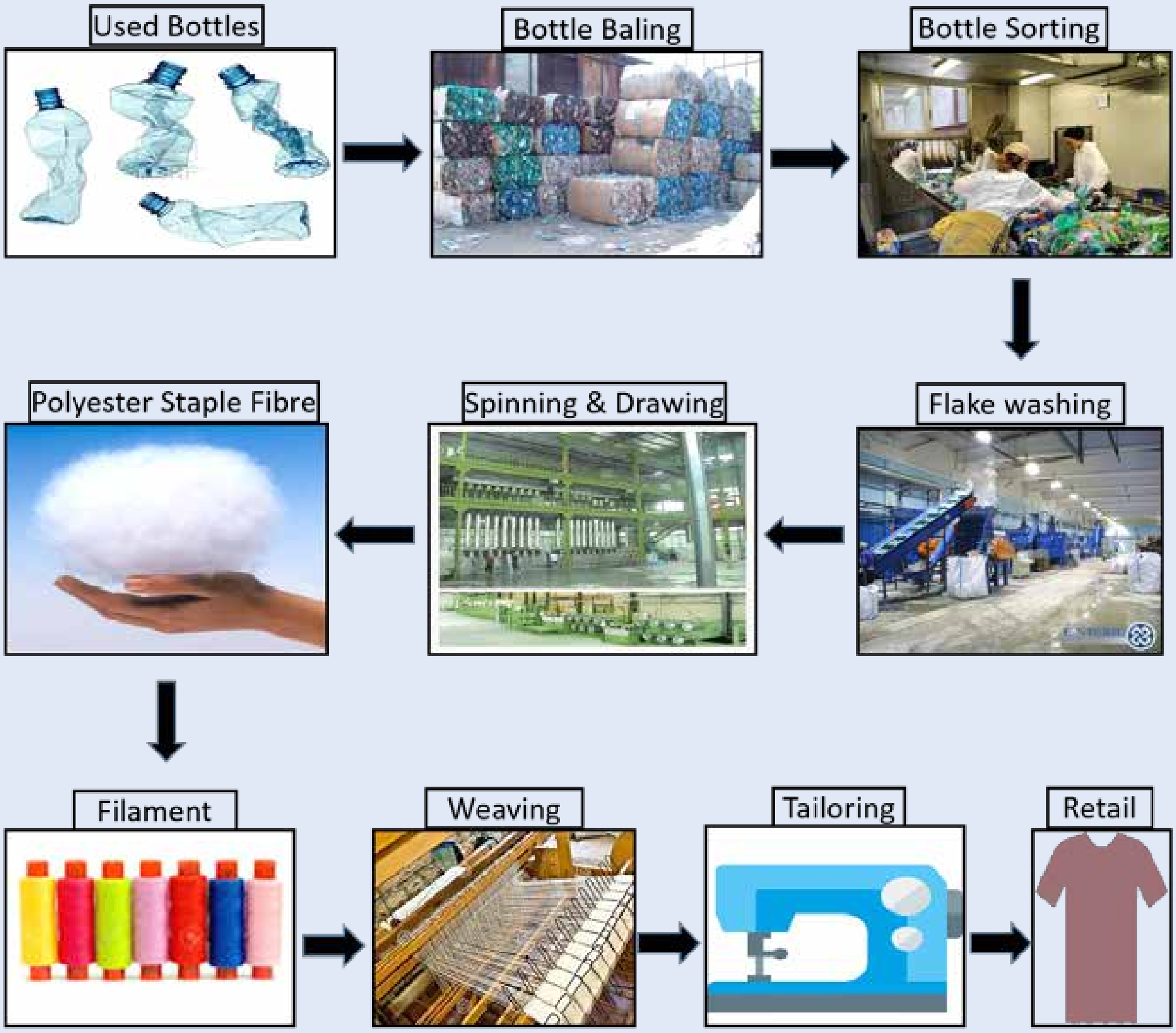
This eco-friendly process of conversion of PET bottles to bags/textile products is based on zero waste concept, uses renewable energy, prevents sewage pollution, reduces consumption of bags and creates green environment.

Reverse Vending Machine (RVM):

Machine specification

- Dimension in Inch:72" (H) x 38" (W) x 32" (D)
- Dimension in Ft: 6 Ft (Height) x 3.1 Ft (Width) x 2.66 Ft (Breath)
- External 17" Led Screen for coupon management and branding.
- Dual cylinder hydraulic compression.
- 220 V Single Phase Motor, 50 HZ, 1.5 kW
- Internal coupon printer.
- Collection bin with capacity to collect 15kg of crushed plastic
- Sensors to detect bottles with auto stop functionality
- Wi-Fi/3G network operations with remote software access.
- Galvanized sheets with carbon steel load bearing components

PET bottle recycling system:



This case study is created based on the information shared by 'Reliance Industries Limited'. Similar model may be adopted and replicated by other companies.

3.3.4 Recovery

Another alternative is recovering the energy stored in residual material. That means turning waste into fuel for manufacturing processes or equipment designed to produce energy. Various mechanical, biological and caloric systems and technologies can convert, reprocess or break up wastes into new materials or energy.

3.3.4.1 Plastic to Alternate Fuel

(Co-processing of Plastic Waste as Alternate Fuel and Raw Material (AFR) in cement Kilns and Power Plants)

Co-processing refers to use of waste materials in industrial processes such as cement and power stations or any other large combustion plants. Co-processing indicate substitution of primary fuel and raw material by waste, and/or material from waste. Waste material such as plastic waste used for co-processing are referred to as alternative fuels and raw material (AFR). Co-processing of plastic waste offers advantages for cement industry as well as for the Municipal Authorities responsible for waste management. On other hand, cement producers or power plants can save fossil fuel and raw material consumption, contributing more eco-efficient production. In addition, one of the advantages of recovery method is to eliminate the need to invest on other plastic waste practices and to secure land filling. The schematic flow diagram of the process is shown in Figure below and protocol for Co-Processing of Plastic Waste is given in the table below:

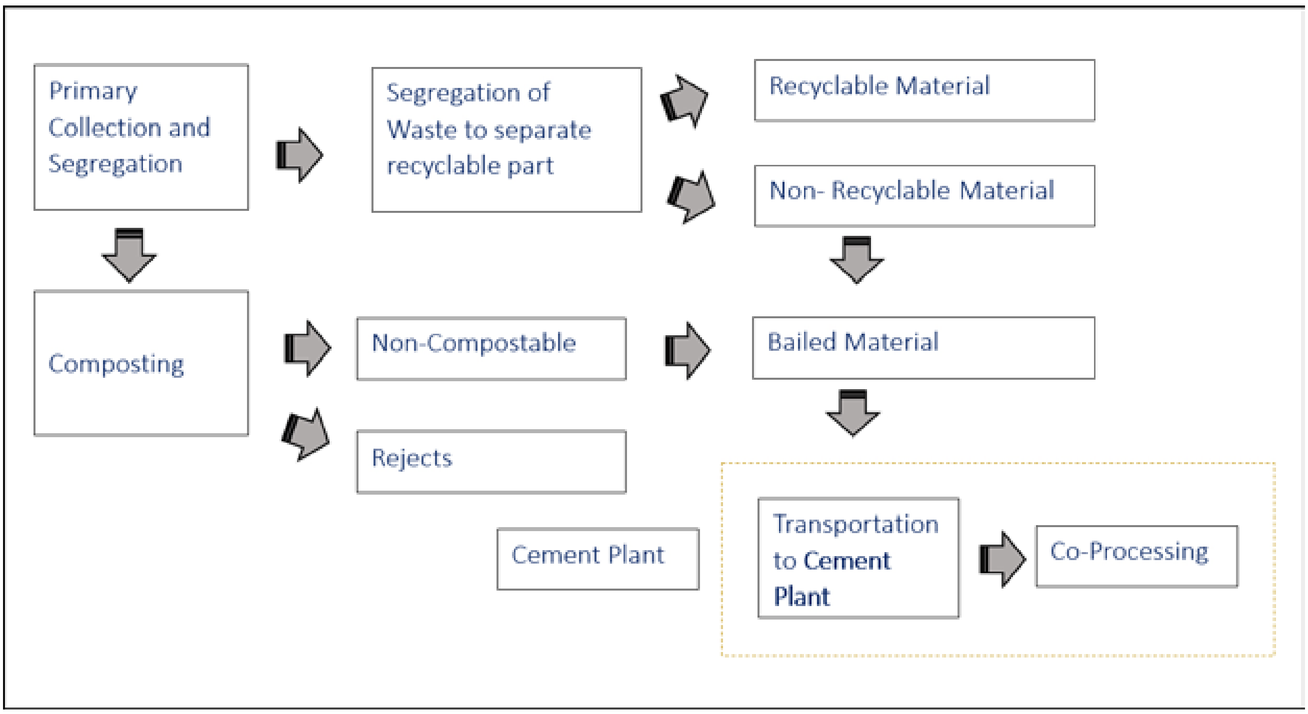


Figure: Co-Processing of Plastic Waste

Protocol for Co-processing of plastic waste

Sl. No	Item	Description	Action to be taken by
1	Collection of plastic waste	Concerned Municipal Authority should create a system for collection of plastics waste through Public Private Partnership (PPP) mode or any other feasible method.	Municipal Corporation, Nagar Nigam, Nagar Parishad & Cantonment Boards
2	Segregation & Pre-processing of plastics waste	Collected plastics can be reprocessed/sorted into recyclable and non-recyclable fractions. The Non-recyclable plastics waste will be transported to nearest cement kilns and power plants for co-processing by concerned Municipal Authority in consultation with concerned State Pollution Control Board (SPCB)/ Pollution Control Committee (PCC).	Municipal Corporation, Nagar Nigam, Nagar Parishad & Cantonment Boards
3	Identification of cement factory	Mapping of cement kilns and power plant for accepting co-processing of plastic waste in same State or neighboring State. An agreement shall be signed between Municipal Corporations and Cement kilns.	State Pollution Control Boards & Pollution Control
4	Modification for feeding plastic waste (PW) in cement kilns	Cement Industry/power plant to set-up storage facility, shredder, conveyor-belt, hopper, winch-machine and double-flap damper.	Concerned Cement Industries/ power plant
5	Setting-up of laboratory for plastics waste analysis	Cement industry/power plant shall set-up a lab facility to analyze plastics waste before sending for co-processing. The instrumentation include Thermo-Gravimetric Analyzer, Bomb- Calorimeter and C, H, N & S Analyzer.	Concerned Cement Industries/ power plant
6	Monitoring of emission by cement industry/ SPCBs	Cement Industry/power plant shall monitor the emission in respect of routine parameters and hazardous air pollutants (HAPs)	Concerned Cement Industry , Power Plant and SPCBs/ PCCs
7	Forwarding progress Report to CPCB	Quarterly progress report of Co-processing of plastic waste shall be forwarded to CPCB.	SPCBs/PCCs and Cement Industries/ Power Plant

CASE STUDY: **PLASTIC TO ALTERNATE FUEL**

(Co-Processing of Plastics Waste in Cement Kiln- ACC Cement Limited (Gagal Cement Works)

Company Details:

ACC Limited is India's foremost manufacturer of cement and concrete. ACC's operations are spread throughout the country with 16 modern cement factories, more than 40 Ready mix concrete plants. Since inception in 1936, the company has been a trendsetter and IMPORTANT benchmark for the cement industry in many areas of cement and concrete technology. ACC has a unique track record of innovative research, product development and specialized consultancy services. The company's various manufacturing units are backed by a central technology support services center - the only one of its kind in the Indian cement industry. Gagal Cement Works is one of cement plants in ACC Group.

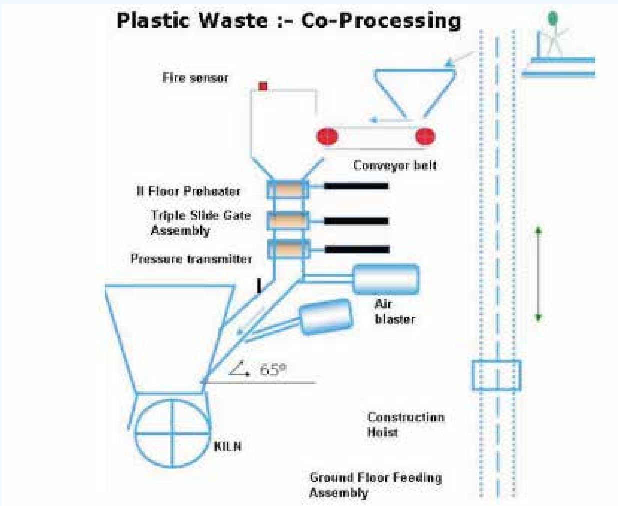
Green Soldiers from Gagal Cement works launched first project titled 'Making Gagal Plastic Free'. Segregation is the essence of effective waste management and hence, a workshop was organized for the stakeholders. All colony and local village residents were invited for a discussion on the strategy. Green Soldiers team was trained on the ways to segregate the plastic waste. The Green Soldiers team collected about 53 Tonnes of plastic waste, which was successfully co-processed in Gagal cement kiln.

Project Details:

The plastic waste collected from the villages, colony and plant premises were weighed at the weighbridge each week after the collection drive. The drive started with collection of 50 kgs/week, which is presently recording approximately 2 Tonnes of collection per week. This gave a clear indication that the stakeholders were increasingly becoming more aware about segregation and concerned about their environment.

Result of the Project and Replication Potential:

- Co-processing of waste at cement kiln is the best disposal option than conventional options of landfilling and incineration. It also substitutes fossil fuel.
- The initiative can be replicated across other industries and companies countrywide, as well as at a global level. The beauty of the initiative is that, keeping the ideas intact, the projects can easily be moulded to suit the climate, topography and biodiversity of any area across the world. Our natural resources are getting scarce by the minute and alternate fuels such as bio-charcoal / plastic are an excellent way to alleviate this paucity of non-renewable energy sources



3.3.4.2 Waste Incineration

Waste incineration, or controlled burning, is typically considered as a disposal method, because it is usually applied as a method of reducing the volume of miscellaneous municipal waste. However, incineration of plastics can also be seen as recovery method, as plastics could replace the application of other oil based fuels.

Material	Heat Capacity MJ/kg	Material	Heat Capacity MJ/kg
PVC	18	Heavy fuel oil	41
PE	27	Coal	26
PET	46	Natural gas	36
PS	41	Milled peat	10
ABS	35	Paper	17

Table: Heat capacity of plastics and some other materials

4. Way Forward

4.1 Ten step Roadmap for Governments[19]

Given the broad range of possible actions to curb single-use plastics and their mixed impact, UN Environment has drawn up a 10-step roadmap for governments that are looking to adopt similar measures or improve on current ones. The steps are based on the experiences of 60 countries around the globe:

1. **Target the most problematic single-use plastics** by conducting a baseline assessment to identify the most problematic single-use plastics, as well as the current causes, extent and impacts of their mismanagement.
2. **Consider the best actions to tackle the problem** (e.g. through regulatory, economic, awareness, voluntary actions), given the country's socio-economic standing and considering their appropriateness in addressing the specific problems identified.
3. **Assess the potential social, economic and environmental impacts** (positive and negative) of the preferred short-listed instruments/actions, by considering how will the poor be affected, or what impact will the preferred course of action have on different sectors and industries.
4. **Identify and engage key stakeholder groups –** retailers, consumers, industry representatives, local government, manufacturers, civil society, environmental groups, and tourism associations – to ensure broad buy-in. Evidence-based studies are also necessary to defeat opposition from the plastics industry.
5. **Raise public awareness about the harm caused by single-used plastics**, by clearly explaining the decision and any punitive measures that will follow.
6. **Promote alternatives.** Before the ban or levy comes into force, the availability of alternatives need to be assessed, hence the government may:
   - Ensure that the preconditions for their uptake in the market are in place.
   - Provide economic incentives to encourage the uptake of eco-friendly and fit-for-purpose alternatives that do not cause more harm.
   - Support can include tax rebates, research and development funds, technology incubation, public-private partnerships, and support to projects that recycle single-use items and turn waste into a resource that can be used again.
   - Reduce or abolish taxes on the import of materials used to make alternatives.
7. **Provide incentives to industry** by introducing tax rebates or other conditions to support its transition. Governments will face resistance from the plastics industry, including importers and distributors of plastic packaging. Give them time to adapt.
8. **Use revenues** collected from taxes or levies on single-use plastics to maximize the public good, thereby supporting environmental projects or boosting local recycling with the funds and creating jobs in the plastic recycling sector with seed funding.
9. **Enforce** the measure chosen effectively, by making sure that there is clear allocation of roles and responsibilities.
10. **Monitor and adjust** the chosen measure if necessary and update the public on progress.

19 Source: UN Environment: Single Use Plastics- A Roadmap for Sustainability

4.2 Adoption of 'Circular Economy'

A circular economy[20] aims to eliminate waste, not just from recycling processes, but throughout the lifecycles of products and packaging. A circular economy aims to maximize value and eliminate waste by improving the design of materials, products and business models.

A circular economy goes beyond recycling. The goal is not just to design for better end-of-life recovery, but to minimize the use of raw materials and energy through a restorative system.

In a circular economy, the value of products and materials is maintained for as long as possible. Waste is minimized and resources are kept within the economy when a product has reached the end of its life, to be used again to create further value.

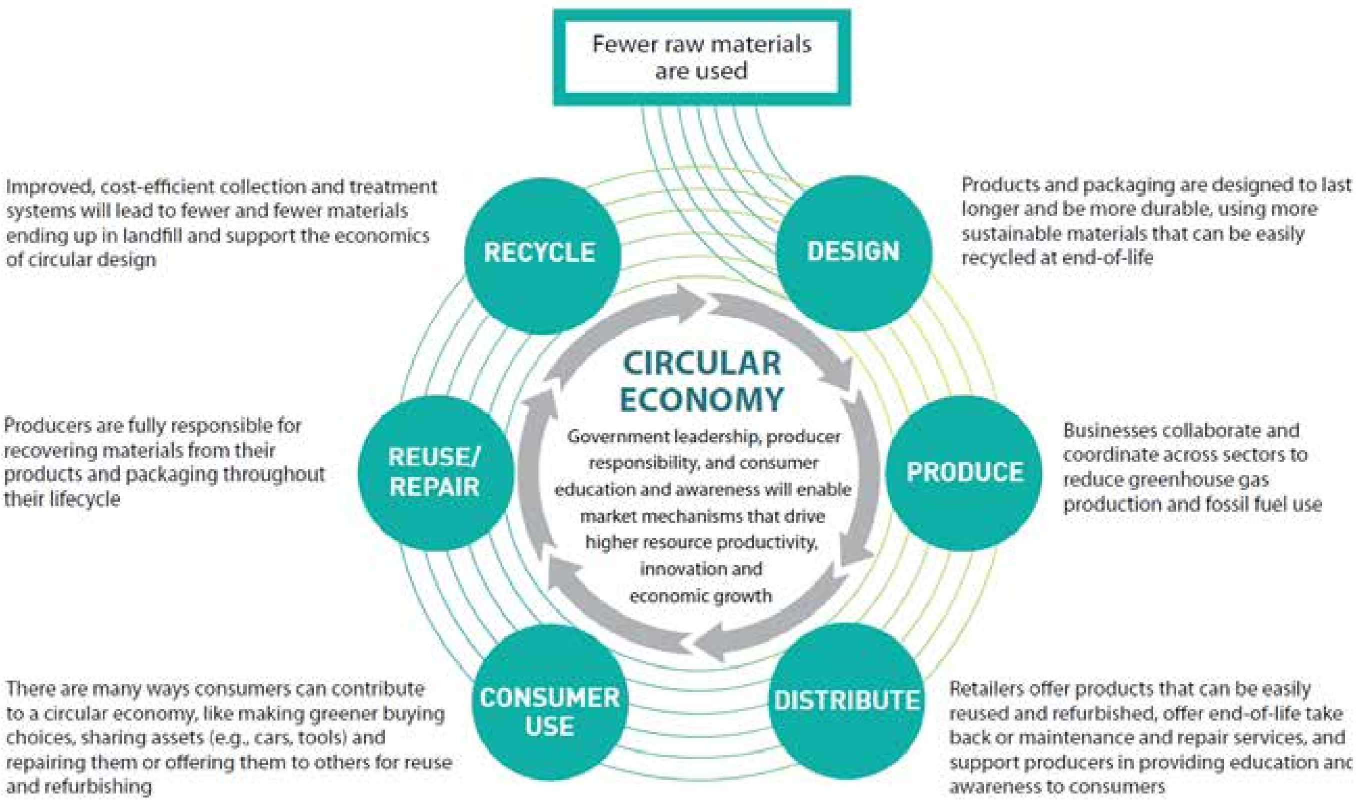


Figure: Overview of 'Circular Economy'

20 *Source: 2017 strategy for a waste-free Ontario. Building the circular economy. https://www.ontario.ca/page/strategy-waste-free-ontario-building-circular-economy*

4.3 Extended Producer's Responsibilities (EPR)

In addition to the responsibilities of Producer's, Plastic Waste Management Rules, 2016 defines the Extended Producer's Responsibility (EPR), as responsibility of a producer for the environmentally sound management of the product until the end of its life.

Rule 9 of the Plastic Waste Management Rules, 2016 (PWMR, 2016), sets out modalities for implementation of EPR under the ambit of the rules. The producers are required to set out modalities for waste collection system based on Extended Producers Responsibility and involving State Urban Development Departments, either individually or collectively, through their own distribution channel or through the local body concerned.

In this regard, below mentioned models suggesting producers' responsibilities may be considered to improve recycling:

Model-1:

State/ ULB to introduce 'Buy back Depository Mechanism' with a predefined buy back price printed on plastic products, so that consumers will receive a specified amount while returning the used products. The manufacturers/ producers of these plastic products need to set up collection centres with reverse vending or crushing machines and recycling units of adequate capacity to collect such used plastic products/packaging and recycle these. This model not only incentivises consumers to not litter plastic products/ packaging post consumption but also encourages retailers/producers to recycle more.

Following are some of the ways in which this model may be implemented:

- The 'Deposit Return schemes' operating in Germany, England, etc. suggest a model wherein the consumer has to pay an additional deposit as part of the price of the product, and deposit is returned to the consumer on return of the product to the retailer.

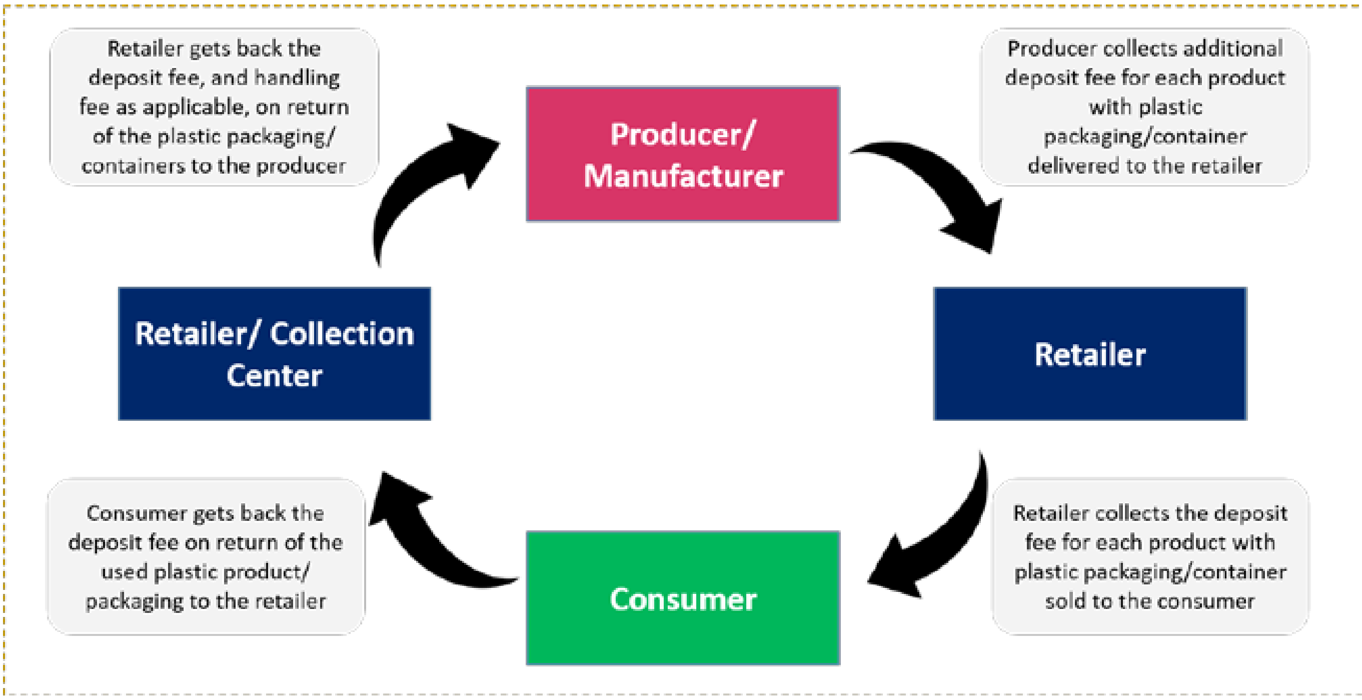


Figure: Model-1 of EPR

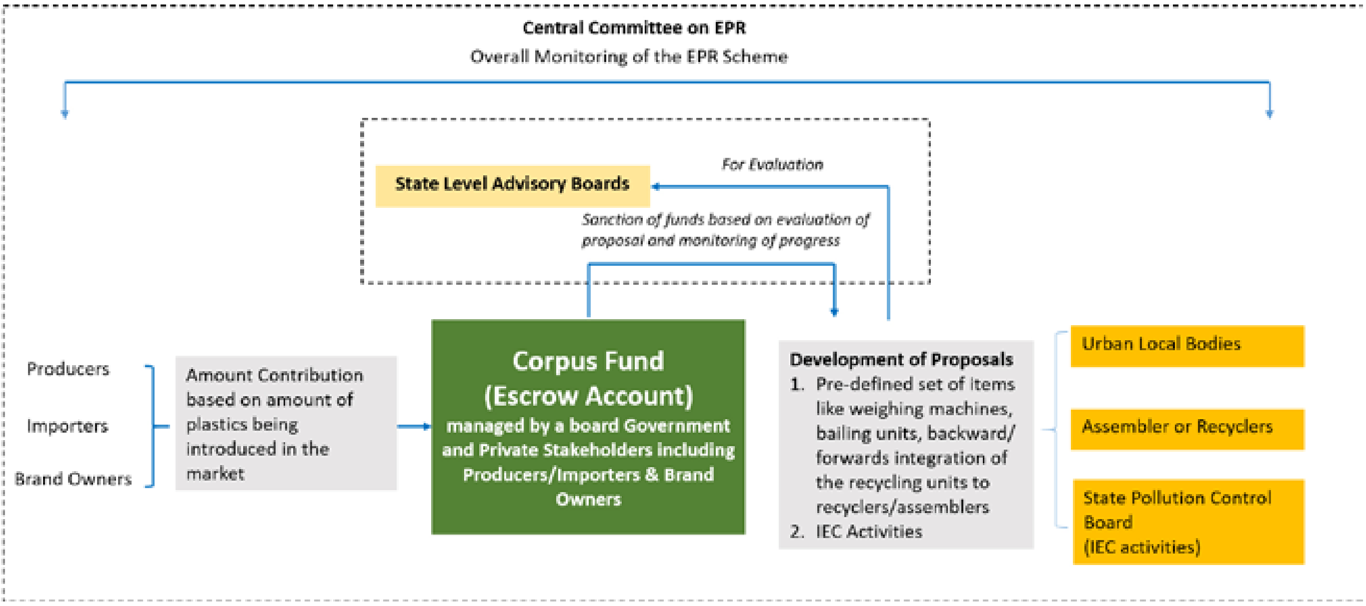


Figure: Model-2 of EPR

- The consumers may also use the "reverse vending machines" which weigh and scan the plastic product to match against a list of acceptable shapes and sizes. If it matches the list, the product would go down a chute for either recycling or shredding, and the machine hands the consumer a voucher to be encashed at any of the store. The machines could be located at strategic places, such as malls, hotels, multiplexes, shops, public places, etc. to make these easily accessible by citizens and encourage them to use the same.
- As a part of EPR, the producers can sign agreements with the retailers to return the plastic product/ packaging, as received from the consumer for recycling purpose. The barcode on these products/ packaging may be used for tracking.

Model-2:

A national Framework on EPR is proposed where the producers/importers/brand owner is required to contribute to the EPR corpus fund at the central level. This may be an escrow account managed by a Board where government, private and other stakeholders including producers/importer/brand owner can become members. The amount to be contributed by each of the producers/ importer/ brand owner will be decided based on the amount of plastic being introduced into the market by the producers/ importer/ brand owner. Under the National Framework of EPR, funding will be provided to 3 entities, one is the ULB, second is the assembler/recycler and the third is through SPCB for conducting IEC Activities.

- A committee will be constituted at the central level for overall monitoring the implementation of the EPR.
- The State Level Advisory Boards (SLABs) constituted under the Solid Waste Management Rules 2016 at the state level will manage the process of appraising the proposals submitted by the ULBs and disbursement of funds to the ULBs, recyclers and for IEC activity.
- Representative of producers/ importer/ brand owner to be part of SLABs.

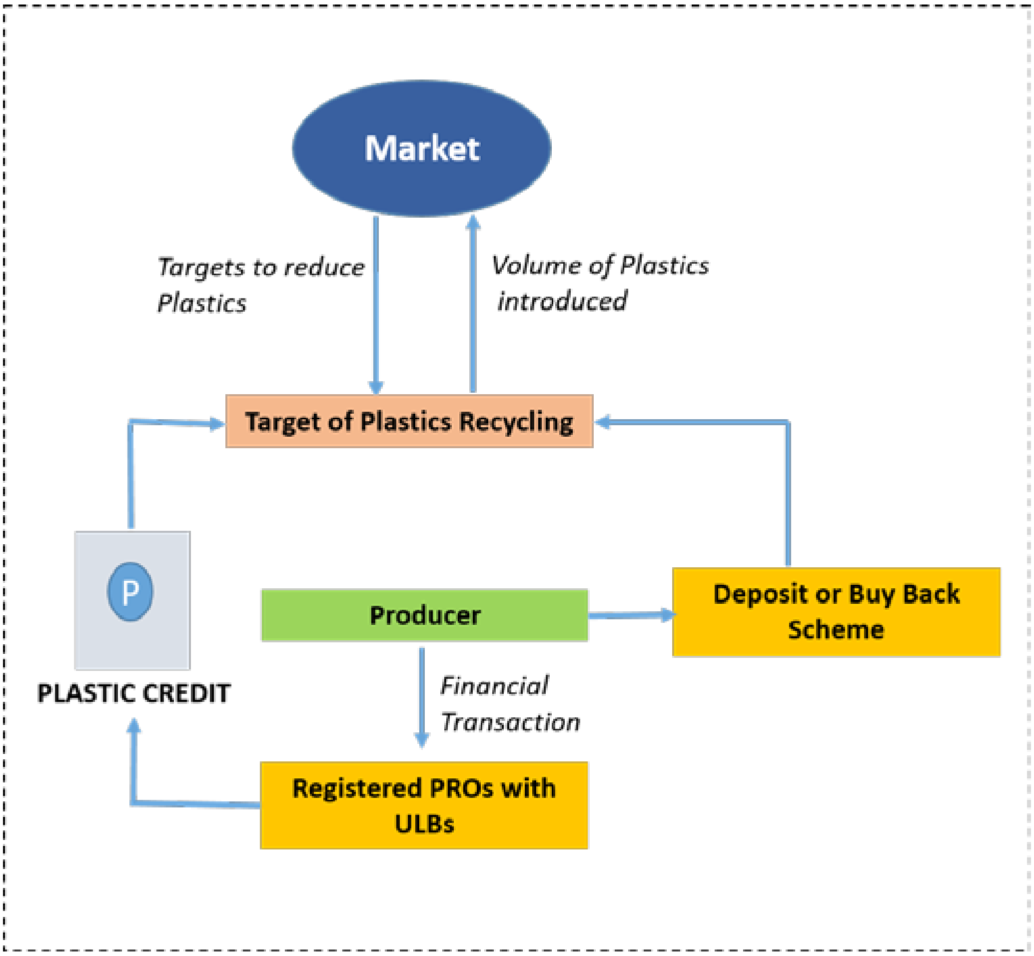


Figure: Model-3 of EPR

- The proposal of ULBs will be compulsorily for the management of plastic waste
- Funds will be provided for a pre-defined set of items like weighing machines, bailing units, backward/ forwards integration of the recycling units to recyclers/assemblers.
- Funds can be allocated by SLABs to the SPCB for the IEC activities. SPCBs can appoint selected agencies for conducting these activities. A systematic implementation schedule can be prepared by SPCB and based on the schedule they can conduct IEC Activities.
- A monitoring mechanism will be established for timely implementation of projects/ allotment of pre-defined items to recyclers/assemblers.

Model-3:

The basic framework of the system will perform as follows:

- Targets will be assigned to producers based on the plastic put out by them in the market
- Producers will not be required to recycle their own plastics, but will be required to ensure that an equivalent amount of plastic is being recycled/ reused
- An instrument called 'Plastic Credit' is proposed to be introduced which is and will be evidence of recycling or recovery.
- Plastic Credit will be issued by accredited processors in exchange of financial transactions to producers (or PROs)
- The funds generated by the processors will

- incentivize the collection and segregation systems (through ULBs) and the recycling industries to increase capacity and capability to ensure environmentally sound end of life management of plastic waste
- Producers will be at liberty to engage individually (through buy back or deposit refund schemes) or collectively (through registered PROs) will the ULBS, processors and the inform sector
- They system aims to create a marketplace for plastic credits which can be traded

PLASTIC CREDIT

- A producer is not required to recycle their own packaging, but to ensure that an equivalent amount of packaging waste has been recovered and recycled to meet their obligation.
- Producers are mandated to acquire evidence of recycling or recovery {Plastic Credit} from properly accredited processors (recyclers, W2E, plant operators, cement co-processors, users utilizing plastic in road) or exporters
- Producers and processors/ exporters may exchange plastic credits for a financial transaction at a price and other terms as negotiated between them.
- The producers can exchange credits from processors that have been specifically accredited for this purpose by CPCB. The accredited processors therefore receive additional funding for every tonne of packaging waste they reprocess and have an incentive to acquire further tonnage, thereby driving up recovery rates
- The system is designed to ensure funding may be directed to remove bottlenecks in the material recovery chain through market corrections. Market would correct itself and guide funding to sources such as material collection, sorting, reprocessing or supporting end use markets. Hence, businesses will have incentive to support long term investments to support their efforts.

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Annexure

I. Ban on 'one time use' and 'throwaway' Plastics in Tamil Nadu

ABSTRACT

Environment – 110 Announcement of the Hon'ble Chief Minister on the floor of the Assembly on 05.06.2018 regarding ban on one-time use and throwaway plastics irrespective of thickness with effect from 01.01.2019 under Environment (Protection) Act, 1986 – Notification – Orders - Issued.

Environment and Forests (EC.2) Department

G.O. (Ms) No.84

Dated:25.06.2018
விளம்பி, ஆனி–11,
திருவள்ளுவர் ஆண்டு -2049

=====

ORDER :

The Hon'ble Chief Minister on 05.06.2018, on the floor of the Legislative Assembly, with a view to make Tamil Nadu Plastic Free, has announced, ban on 'one time use and throwaway plastics', irrespective of thickness, with effect from 1st January, 2019 under the provisions of the Environment (Protection) Act, 1986.

2. Accordingly, the following Notification will be published in the TamilNadu Government Gazette:-

NOTIFICATION

WHEREAS, plastic carry bags and other plastic items used in daily life cause short term and long term environmental damage and health hazard;

AND WHEREAS, Article 48-A of the Constitution of India, inter alia, envisages that the State shall endeavour to protect and improve the environment;

AND WHEREAS, it has come to the knowledge of the Government that, the use of 'use and throwaway plastics' such as plastic carry bags, plastic sheets used for food wrapping, spreading on dining table etc., plastic plates, plastic coated tea cups and plastic tumbler, water pouches and packets, plastic straw and plastic flags are causing serious environmental hazards and health problems amongst human beings as well as plants and animals;

AND WHEREAS, it is observed that the plastic wastes are also causing blockage of sewers and drains apart from resulting in pollution of water bodies;

AND WHEREAS, with a view to prevent the recurrence of such problems, the State Government have decided to issue the following directions imposing ban on manufacture, storage, supply, sale and use of 'use and throwaway plastics', such as,

..2..

plastic sheets used for food wrapping, spreading on dining table etc., plastic plates, plastic coated tea cups and plastic tumbler, water pouches and packets, plastic straw, plastic carry bag and plastic flags irrespective of thickness.

NOW, THEREFORE, in exercise of the powers conferred under section 5 of the Environment (Protection) Act, 1986 (Central Act 29 of 1986) read with Government of India, Ministry of Environment and Forests Notification No.S.O.152(E), dated: 10th February, 1988, the Governor of Tamil Nadu hereby issues the following directions:-

2. This Notification will come into force on the 1st January, 2019:

THE DIRECTIONS

1.(a) No industry or person shall manufacture, store, supply, transport, sale or distribute, 'use and throwaway plastics'.

(b) No person including shopkeeper, vendor, wholesaler, retailer, trader, hawker or salesmen shall use, 'use and throwaway plastics':

Provided that the plastic used for the following purposes are exempted:-

(a) The plastic carry bags manufactured exclusively for export purpose against any export order in a plastic industry located in Special Economic Zone (SEZ) and Export Oriented Units (EOU).

(b) The plastic bags which constitute or form an integral part of packaging in which goods are sealed prior to use at manufacturing/processing units.

(c) The plastic bags and sheets used in Forestry and Horticulture nurseries against the orders from the Government Departments.

(d) The plastic used for packing of milk and milk products (dairy products), oil, medicine and medical equipments.

(e) Carry bags made from compostable plastics bearing a label "compostable" and conforming to the Indian Standard: IS or ISO 17088:2008 titled as Specifications for "Compostable Plastics".

2.(a) The Commissioners, in respect of the Municipal Corporations and the District Collectors, in respect of the local areas other than Municipal Corporations shall ensure prevention of storage, supply, transport, sale, distribution and use of the above said plastic items;

(b) District Environmental Engineers shall ensure prevention of manufacturing of the above said plastic items

Explanation 1 - **"Plastic"** means material which contains as an essential ingredient a high polymer such as polyethylene terephthalate, high density polyethylene, Vinyl, low

..3..

density polyethylene, polypropylene, polystyrene resins, multi-materials like acrylonitrile butadiene styrene, polyphenylene oxide, polycarbonate, Polybutylene terephthalate.

Explanation 2 – **"use and throwaway plastic"** means items such as plastic carry bags or plastic flags, plastic sheets used for food wrapping, spreading on dining table etc. plastic plates, plastic coated tea cups and plastic tumbler, water pouches and packets, plastic straw irrespective of thickness.

Explanation 3 – **"plastic sheet"** means sheet made of plastic.

Explanation 4 – **"Carry bag"** means bag made from plastic material, used for the purpose of carrying or dispensing commodities which have a self carrying feature but do not include bag that constitute or form an integral part of the packaging in which goods are sealed prior to use.

Explanation 5 – The word **"compostable plastic"** means plastic that undergoes degradation by biological processes during composting to yield Carbon di-oxide, water, inorganic compounds and biomass at a rate consistent with other known compostable materials, excluding conventional petro-based plastics, and does not leave visible, distinguishable or toxic residue.

(BY ORDER OF THE GOVERNOR)

Md. NASIMUDDIN
PRINCIPAL SECRETARY TO GOVERNMENT

To
The Works Manager, Government Central Press, Chennai-79.
(for publication of the notification in the Extra-ordinary Gazette on 27th June 2018 and to send 50 copies to Government),
All Additional Chief Secretaries/Principal Secretaries/
Secretaries to Government, Secretariat, Chennai-9.
All District Collectors/ All District Judges/ All Chief Judicial Magistrates.
All Departments of Secretariat.Chennai-9.
The Director of Environment, Chennai-15.
The Chairman, Tamil Nadu Pollution Control Board, Chennai-32.

Copy to:-
The Hon'ble Chief Minister office, Chennai-600 009.
The Private Secretary to the Principal Secretary to Government,
Environment and Forests Department, Chennai- 600 009.
The Private Secretary to the Principal Secretary to Government, Law Department, Chennai- 600 009.
The Personal Assistant to Hon'ble Minister (Environment), Chennai-600 009.
Stock File/Spare Copy.

// FORWARDED: BY ORDER //

15/6/18
Section Officer.

II. Ban on use of plastic carry bags in Himachal Pradesh

(Authoritative English text of this Department Notification No. STE-F (9)-1/2018 dated 06.07.2018 as required under clause (3) of article 348 of the Constitution of India)

Government of Himachal Pradesh
Department of Environment, Science & Technology

No. STE-F (9)-1/2018 Dated: Shimla-2 the 6th July, 2018

NOTIFICATION

WHEREAS, the Governor of Himachal Pradesh vide this Department's Notification No. STE-F (4)-2/2008, dated 07th July, 2009 and Notification No. STE-F(4)-2/2008-II, dated 19th March, 2011, with an objective to improve plastic waste management system, under the **Himachal Pradesh Non- Biodegradable Garbage (Control) Act, 1995,** imposed ban on use of plastic carry bags (irrespective of their sizes and thickness) and plastic items having one time use such as disposable plastic cups, glasses and plates which are made up of non –biodegradable material as listed in the Schedule appended to the **Himachal Pradesh Non-Biodegradable Garbage (Control) Act, 1995** and littering of non-biodegradable waste in the State;

AND WHEREAS, it has come to the notice of the Government that despite complete ban on polythene carry bags (irrespective of their sizes and thickness) and plastic items having one time use such as disposable plastic cups, glasses and plates vide aforesaid notification, thermocol cups, plates, glasses and spoons are still in use. Therefore, the State Government has not achieved the expected results;

NOW, THERFORE, the Governor of Himachal Pradesh, in continuation of the Notification No. STE –F (4) – 2/2008 dated 07th July, 2009, 13th August, 2009 and Notification No. STE-F(4)-2/2008-II, dated 19th March, 2011 and in exercise of the powers conferred under sub section (1) of section 3-A of the Non- Biodegradable Garbage (Control) Act,1995, is pleased to issue directions that no person including shopkeepers, vendors, wholesalers, retailers, hawkers, rehriwala etc. shall use "Thermocols Cutlery" i.e. cups, plates, glasses, spoons or any other item used for serving and consuming food in any form manufactured from non-biodegradable material as listed in the Schedule appended to the **Himachal Pradesh Non- Biodegradable Garbage (Control) Act, 1995.**

Any person, institution/commercial establishment (educational institution, offices, hotels, shops, restaurants, sweetshops, dhabas, religious institution, industrial establishments, banquet halls etc.) causing breach of the aforesaid prohibition shall be liable for the penalties as per the provisions contained in the Act *ibid*.

The Governor, Himachal Pradesh, is further pleased to order that the officers/ officials already authorized vide notification no. STE- F(4) -2/ 2008 dated 07-07-2009 for entry and inspection under section 7(A) and to compound any offence as per provision of section 11 of the Act *ibid*, while compounding the offences committed under the Act *ibid* shall specify the sum for compounding as per the following criteria:-

Sr. No. (A)	*Quantity of Prohibited material i.e. Thermocol cutlery*	*Amount (Rs.)*
1.	Upto 100 gms	500/-
2.	101-500 gms	1500/-
3.	501gms – 1.00 kgs.	3000/-
4.	Above 1 kgs to 5 kgs.	10,000/-
5.	Above 5 kgs to 10 kgs.	20,000/-
6.	More than 10 kgs.	25,000/-
(B)	Littering of "Thermocols Cutlery" like cups, plates, glasses, etc. waste by any institution/ commercial establishment (educational institution, offices, hotels, shops, restaurants, sweet shops, dhabas, temple complexes, industrial establishments, banquet halls, etc.,) with in its premises and on roads, streets, hill slopes, drains, forest areas, public parks, all public places etc.	5000/-
(C)	Littering of "Thermocols Cutlery" like cups, plates, glasses, etc. waste by individuals in the premises of any private or commercial establishments (educational institutions, offices, hotels, shops, restaurants, sweetshops, dhabas, temple complexes, industrial establishments, banquet halls, etc.,) with in its premises and on roads, streets, hill slopes, drains, forest areas, public parks, all public places etc.	1000/-

The ban on the thermocol cutleries will be made effective after 3 months of the date of publication of this notification in the Rajpatra (e-Gazette), Himachal Pradesh in the entire State of Himachal Pradesh in the public interest, so that the manufacturers, stockiest, shopkeepers may dispose off their stocks and no financial loss is caused to them .

By order

(Tarun Kapoor)
Addl. Chief Secretary (Env. Sci. & Technology) to the
Government of Himachal Pradesh.

Endst. No. As above. Dated: Shimla-2, the 6th July, 2018

Copy forwarded for information and necessary action to:-

1. The Secretary to the Governor, Himachal Pradesh Shimla-2.
2. The Pr. Secretary to the Chief Minister, H.P. Shimla.
3. The Private Secretaries to all the Cabinet Ministers Government of H.P. Shimla-2.
4. The Private Secretary to the Chief Secretary to the Government of Himachal Pradesh.
5. All the Administrative Secretaries to the Govt. of Himachal Pradesh.
6. All Heads of the Departments of H.P.
7. All the Divisional Commissioner in H.P
8. All the Deputy Commissioners in H.P.
9. The Commissioner (Municipal Corporation) Shimla /Dharamshala.
10. The Director (Env.S&T)H.P, U.S. Club Shimla-171001.
11. The Member Secretary, HP State Council for Science, Technology & Environment, Block No. 34, SDA Complex Kasumpati Shimla-9
12. The Member Secretary, HP State Pollution Control Board, Paryavaran Bhawan, Phase-III, New Shimla-9.
13. The Controller, Printing and Stationary, H.P. Government Press, Shimla-5 for publishing in the Rajpatra.
14. Guard file.

06/7/18

(D.C.Rana)

Special Secretary (Env. Sci. & Technology)to the
Government of Himachal Pradesh
Ph. No. 0177-2626212
Email:dc.rana04@nic.in

III. Ban on manufacturing and use of 'Thermocol Cutlery' in Himachal Pradesh

Government of Himachal Pradesh
Department of Environment, Science & Technology

No. STE-F (9)-1/2018 Dated: Shimla-2 the **31st August, 2018**

NOTIFICATION

WHEREAS, the Government of Himachal Pradesh vide this department Notification of even number dated 06th July, 2018 has imposed the ban on the manufacturing and on the use of "Thermocol Cutlery" i.e. cups, plates, glasses, spoons or any other item used for serving and consuming food in any form manufactured from non-biodegradable material as listed in the Schedule appended to the **Himachal Pradesh Non- Biodegradable Garbage (Control) Act, 1995;**

AND WHEREAS, after issue of this Notification which stipulates ban on Manufacturing of "Thermocol Cutlery", the Manufacturers have represented to the State Government i.e Environment Science and Technology Department to allow permission of manufacturing the "Thermocol Cutlery" items in their already established Industries in the State of Himachal Pradesh with the view that employees (80% of these are Himachalis) do not lose their jobs apart from loss of revenue in Crores to the State exchequer,

NOW THEREFORE, keeping in view of the submissions of the Manufacturers of the Thermocol Cutlery, the Governor Himachal Pradesh is pleased to accord approval that all the Manufacturers of "Thermocol Cutlery" in Himachal Pradesh may be allowed to continue the manufacturing of the Thermocol Cutlery in their already established Units with the condition of its sale outside the State of Himachal Pradesh. There will be complete ban on sale of "Thermocol Cutlery" by them in Himachal Pradesh. Therefore, in partial modification of this department's notification dated 06th July, 2018 the word "Manufacturers" appearing in the last paragraph of the said notification is now hereby deleted. This notification will be made effective from the date of publication of this notification in the Rajpatra (e-Gazette), Himachal Pradesh in the entire State of Himachal Pradesh in the public interest.

By order

Tarun Kapoor
Addl. Chief Secretary (Env. Sci. & Technology) to the Government of Himachal Pradesh.

P. A. Cell
DHE
04 SEP 2018
Shri Banyal ji
General
05/9/18

Continue to next page

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Endst. No. STE-F (9)-1/2018 Dated: Shimla-2, the **31st August, 2018**

Copy forwarded for information and necessary action to:-

1. The ACS-cum- Pr. Secretary to the Chief Minister, H.P. Shimla.
2. The Private Secretaries to all the Ministers, Himachal Pradesh.
3. The Private Secretary to the Chief Secretary Government of Himachal Pradesh.
4. All the Administrative Secretaries to the Govt. of Himachal Pradesh.
5. All the Heads of the Departments of H.P.
6. All the Divisional Commissioner in H.P
7. All the Deputy Commissioners in H.P.
8. The Commissioner (Municipal Corporation) Shimla /Dharamshala.
9. The Director (Env.S&T) H.P, U.S. Club Shimla-171001.
10. The Member Secretary, HP State Council for Science, Technology & Environment, Block No. 34, SDA Complex Kasumpati Shimla-9.
11. The Member Secretary, HP State Pollution Control Board, Paryavaran Bhawan, Phase-III, New Shimla-9.
12. The Controller, Printing and Stationary, H.P. Government Press, Shimla-5 for publishing in the Rajpatra.
13. Guard file.

(Sat Pal Dhiman) 31-8-2018
Joint Secretary (Env.Scie. & Tech.) to the
Government of Himachal Pradesh.
email: jointsecyforest05@gmail.com
Ph. No.0177-2621874

DHE, H.P. Shimla-I

Endst No. EDN-H [21] F-[7] 92/2011 - Sc. Envi.Science, Dt 7/9/18

copy forwarded for information & further necessary action to:

1) All Principals Govt. Degree colleges in H.P.
2) All Dy. Directors Higher Education in H.P.
3. All Principals Govt Sr. Sec. Schools in H.P.
4. All Headmasters Govt High Schools in H.P.
5. All Branch Supdts DHE, H.P. Shimla-
6. I.O. (I.T Cell) DHE, H.P. with the request to upload the Notification in the Deptt Website.

Science Consultant
Directorate of Hr. Edu.
H.P. Shimla-I

IV. Ban on sale and use of disposable items made from Styrofoam in Sikkim

GOVERNMENT OF SIKKIM
HOME DEPARTMENT
GANGTOK, SIKKIM

No.26/Home/2016 Dated 19/05/2016

NOTIFICATION

Whereas the Government has been initiating various measures to manage the waste and maintain a clean environment, it has been found that a lot of disposable styrofoam items are being rampantly used not only in the bazaar areas but also in the rural areas. The result is that a huge quantity of municipal waste is created in the form of used Styrofoam and other disposable products. These products are environmentally hazardous and occupy a huge space in our landfill. It is also not healthy to eat especially hot items in the styrofoam containers.

Therefore, the government is pleased to ban the sale and use of disposable items, such as cups, plates, spoons, containers etc made from Styrofoam throughout the State with immediate effect.

By order and in the name of the Governor.

(Alok K. Shrivastava, IAS)
Chief Secretary
Government of Sikkim
File No.GOS/RMDD/2015-16/157/SAN

V. Government order for the Use of Plastics in Road construction.

The Ministry of Road Transport & Highways, Government of India has made it mandatory for road developers to use waste plastic along with bituminous mixes for road construction to overcome the problem of disposal of plastic waste in India's urban centres.

The road developers will now have to use waste plastic along with hot mixes for constructing bitumen roads within 50 km of periphery of any city that has a population of over 5 lakh.

In case of non-availability of waste plastic the developer has to seek ministry's approval for constructing bitumen only roads. The Government Order dated 9th November 2015, is placed below:

Government of India
Ministry of Road Transport & Highways

Parivahan Bhawan
1, Parliament Street,
New Delhi- 110001.
Dated the 09th November, 15

No. RW-NH- 33044/24/2015-S&R (R)

To

1. The Chief Secretaries of all State Governments/Union Territories
2. The Principal Secretaries /Secretaries of all States/U.Ts. Public Works Department dealing with National Highways, other Centrally Sponsored Schemes and State Schemes.
3. The Engineers-in-Chief and Chief Engineers of Public Works Departments of States/U.Ts dealing with National Highways, other Centrally Sponsored Schemes and State Schemes.
4. The Chairman, National Highways Authority of India, G-5&6, Sector-10, Dwarka, New Delhi-110 075
5. Managing Director, NHIDCL, Room No 101, Parivahan Bhavan, 1.Parliament Street, New Delhi. 110001
6. Director General (Border Roads), Seema Sadak Bhawan, Ring Road, New Delhi-110 010.

Sub: Use of plastic waste in bituminous mixes in construction of National Highways

With the rapid urbanization, a large quantum of plastic waste is being generated. Safe disposal of the plastic waste is a serious environmental problem. Studies have revealed that use of waste plastic improves the desirable properties of bituminous mixes leading to improved longevity and pavement performance. The Indian Roads Congress (IRC) has already published IRC: SP: 98-2013 "Guidelines for the use of waste plastic in hot bituminous mixes (dry process) in wearing coats". However, this technology continues to receive lukewarm response by the Project Engineers, Designers as also the Consultants. Its adoption needs to be encouraged.

2. Therefore, the Ministry has decided to encourage use of plastic waste in the hot mix bituminous wearing coat. Accordingly it is decided that;

a) Bituminous mix with waste plastic shall be the default mode for periodic renewal with hot mixes within 50 kms periphery of urban area having population more than 5 lakhs. Any relaxation on ground of non-availability of waste plastic, cost etc shall involve approval of the Ministry.

b) All the agencies responsible for preparation of project reports / estimates for the National Highways and Centrally sponsored works are expected to analyse and clearly bring out reasons of inclusion or otherwise of provision of use of waste plastic in wearing coats in the proposal.

3. The contents of this Circular may be brought to the notice of all concerned in your Organization. Feedback on these guidelines is solicited.

4. This issues with the approval of competent authority.

Yours faithfully,

Amiyanshu

Assistant Executive Engineer (S,R&T) (Roads)
For Director General (Road Development) & Spl Secy

Copy to:

1. PS to Hon'ble Minister (RTH&S) – for kind information
2. Sr. PPS to Secretary (RT&H) – for kind information
3. PS to DG (RD) & SS
4. PPS to SS&FA– for kind information
5. All Technical officers in the Ministry of Road Transport & Highways
6. All ROs and ELOs of the Ministry of Road Transport & Highways
7. The Secretary General, Indian Roads Congress
8. The Director, IAHE
9. Technical Circular File of S&R Section
10. NIC for placing on the website under "What's New"

VI. Use of Plastic in Tamil Nadu while constructing Roads

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From
Dr.P.SENTHILKUMAR, I.A.S.,
Commissioner of Municipal
Administration,
Ezhilagam Annexe, VI Floor,
Chepauk, Chennai-600 005.

To
All Corporation Commissioners(except Chennai),
All Regional Directors of Municipal Administration,
All Municipal Commissioners and Executive Officers of Municipalities.

AUG 2011

Letter Roc.No.29255/E3 /2011,Dated: 01.08.2011.

Sir

Sub: Roads-Usage of plastic from waste in laying of bituminous road-certain guidelines issued-regarding.

Ref: 1)D. O. letter no 15583/budget-2/2011 Dt 04/07/2011 of the Deputy Secretary of MA&WS Dept
2) D O letter from the Secretary of MA&WS Dept in letter no 17916/Budget-2/2011-1,Dt 25/07/2011

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1) In the departmental review meeting conducted by the Hon'ble Chief Minister on 12.7.2011, it has been decided that plastic roads would be laid in such a way that available plastic waste would be utilized to the maximum extent possible in all the ULBs.

2) In the ref 2nd cited, the Government has asked to issue. preparation of draft guidelines for laying roads mixed with plastic waste for adoption by all the ULBs.

3)Since the Thiagarajar College of Engineering, Madurai has been a pioneer in introducing the concept ,a Technical team headed by the Chief Engineer ,O/o Commissioner of Municipal Administration visited Thiagarajar College of Engineering, Madurai along with the City Engineer Madurai Corporation and some Engineers from the Madurai region inspected the roads laid with plastic waste. It has been observed that bitumen with shredded waste plastic at 10% of the weight of Bitumen would lead to reduction as plastic waste. It was suggested that the concept of mixing of plastic waste in BT roads could be taken up in the low traffic narrow roads initially.

4)In the above circumstances a set of draft guidelines is prepared based on the presentations made by Dr.R.Vasudevan ,Thiagarajar College of Engineering,Madurai and the suggestions by the technical team on the roads for laying of plastic roads and enclosed in Annexure I.Certain instructions issued by the National Rural Road Development Agency and relevant to urban roads have also been included in the guidelines.

The details of the roads laid using plastic in Tamil Nadu are mentioned below:

The Plastic Waste Mixed Roads laid by District Rural Development Agency (DRDA) of Tamil Nadu are as follows

No	Name of District	Length in km	Cost in Rs. Lakhs
1	Kancheepuram	41.165	120.480
2	Coimbatore	63.250	432.750
3	Cuddalore	43.00	146.410
4	Dharmapuri	34.191	150.660
5	Dindigul	36.670	121.780
6	Kanyakumari	28.021	123.422
7	Karur	30.190	155.060
8	Madurai	54.500	268.460
9	Nagapattinam	31.071	138.857
10	Namakkal	53.780	232.477
11	Perambalur	34.850	220.460
12	Erode	60.110	295.760
13	Pudukkottai	22.930	73.920
14	Ramnad	13.500	54.845
15	Salem	31.685	120.810
16	Sivaganga	22.405	94.800
17	Thanjavur	37.604	199.340
18	The Nilgiris	6.900	34.250
19	Theni	25.000	72.000
20	Thiruvallur	15.000	50.000
21	Thiruvarur	32.705	139.120
22	Trichy	43.000	171.300
23	Tirunelveli	32.890	179.500

No	Name of District	Length in km	Cost in Rs. Lakhs
24	Tiruvannamalai	39.100	172.000
25	Tuticorin	37.000	205.650
26	Vellore	52.770	211.260
27	Villupuram	54.100	282.940
28	Virudhunagar	25.200	102.800
29	Krishnagiri	28.802	158.72
Total		**1031.389**	**158.72**

More than 1031 Kms of rural roads have been laid by DRDA, Tamil Nadu, distributing a minimum of 40 Kms for each district. This was extended to all the 29 districts of Tamil Nadu.

The plastic waste bitumen road are also laid in various states such as Kerala, Karnataka, Pondicherry, Maharashtra, Uttarakhand, Himachal Pradesh and Andhra Pradesh.

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स्वच्छ भारत

एक कदम स्वच्छता की ओर

Swachhata Pledge

Mahatma Gandhi dreamt of an India which was not only free but also clean and developed.

Mahatma Gandhi secured freedom for Mother India.

Now it is our duty to serve Mother India by keeping the country neat and clean.

I take this pledge that I will remain committed towards cleanliness and devote time for this.

I will devote 100 hours per year that is two hours per week to voluntary work for cleanliness. I will neither litter nor let others litter.

I will initiate the quest for cleanliness with myself, my family, my locality, my village and my work place.

I believe that the countries of the world that appear clean are so because their citizens don’t indulge in littering nor do they allow it to happen.

With this firm belief, I will propagate the message of Swachh Bharat Mission in villages and towns.

I will encourage 100 other persons to take this pledge which I am taking today.

I will endeavour to make them devote their 100 hours for cleanliness.

I am confident that every step I take towards cleanliness will help in making my country clean.

सत्यमेव जयते

Ministry of Housing and Urban Affairs

Government of India