REPORT ON PLASTIC WASTE MANAGEMENT

[Signature] [Date] [Remark]

PROJECT REPORT

ON

“PLASTIC WASTE MANAGEMENT”

UNDER THE GUIDANCE

OF

MR. RATAN KAMBLE

(ASSISTANT PROFESSOR)

ACPCE

Where Knowledge Is Second Nature

ELECTRICAL ENGINEERING DEPARTMENT

A.C. PATIL COLLEGE OF ENGINEERING

2020-21

SIGNATURE:

DATE:

REMARK:

PROJECT REPORT

ON

PLASTIC WASTE MANAGEMENT

Submitted to:

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A group report submitted in partial fulfilment of term work for the subject

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EXECUTIVE SUMMARY

Detailed Project Report on Plastics Waste Management system for Mumbai, Maharashtra.

Regulatory Need: This Report is based on "Plastics Waste (Management and Handling) Rules 2011, of Ministry of Environment and Forest, Government of India. This innovative and pioneering Plastic Waste Management system takes in to account the extended producer responsibility (EPR) of plastic industry, as well as the responsibility of the urban local bodies (ULB), in organizing Plastics waste collection of littered- left out plastic waste. This is through the recyclable waste collection centers, recycling facility and litter free campaign. It also harnesses most of the informal sector workers in a formal set up, as is mandated in various regulatory guidelines.
Socio-Environmental Responsibility: Plastics are good, Plastics litter is the problem. It is not commercially viable for the waste pickers. Litter picking needs a separate viability gap funding, and so is its recycling, which is not so profitable either. Though most of the waste management laws are plastic centric, this small pieces of metalized plastics and carry bags are the main contentious issue in most of the other waste streams, and more so in MSW. A solution is developed here by harnessing, informal sector, recycling network in a workable formal setup. This can also meet the partial cost of litter management. ULBs give space as in the law, waste traders gets an identity, and the faceless waste pickers gets extra income with a little extra responsibility of litter free area management. The system has been test marketed and experimented. To innumerate:
1. The Rag Pickers / Scavengers, which are presently highly unorganized, need to be converted into an organized self –sustainable work force. 2. With proper system development Rag Pickers / Scavengers will get the right price for their work/effort. 3. With collection centers this work force can get better price for their work/effort and with better remunerations/income. Their social acceptability will also increase. 4. Presently Rag pickers/ Scavengers sort the plastic form dump heaps and foul smelling places. To work in these highly inhospitable environments, they tend to become drug addicts/alcoholics.

Figure 1 depicts the rapid growth of Municipal Solid Waste from 1990 to 2010 in India. The graph shows that the projected solid waste collection rising up to 235 Million ton/year in financial year 2041, which is shown in figure no. 1. These rising line also shows that, how the Indian cities are being engulfed into waste dump sites all around them. With a local baseline study in camera, the plastics waste left out at dumpsites is found to be 11%, which corroborates with a few national studies, could be a clean raw material for the recycling plant if collected from homes and is as envisaged in this report.

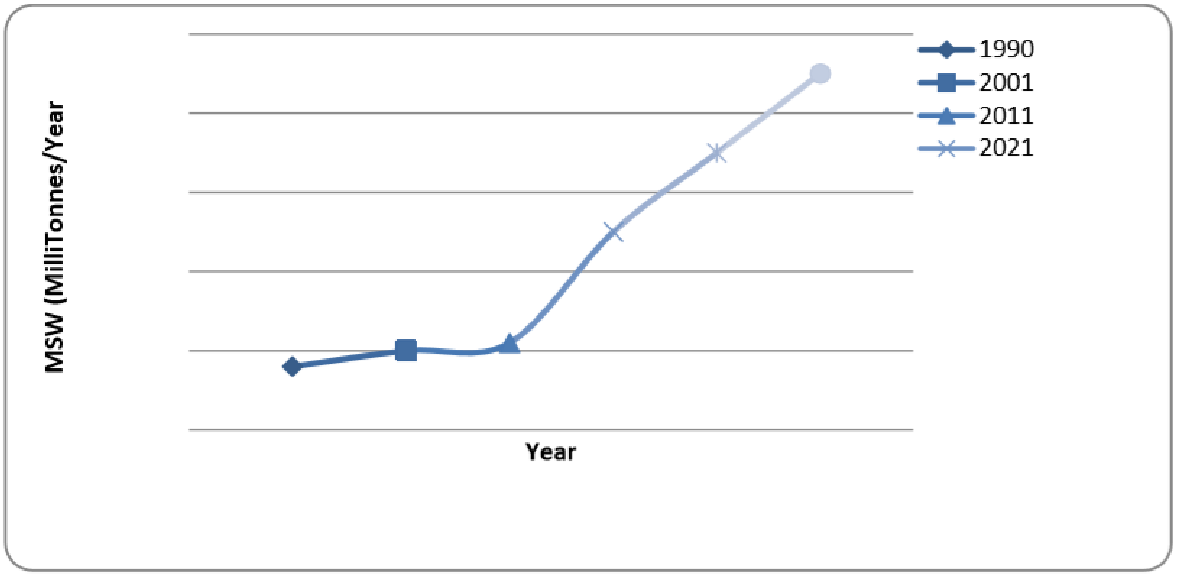


Figure no. 1: The projected solid waste collection rising up to 235 Million ton/year

CHAPTER 1

INTRODUCTION

1. INTRODUCTION

1.1 Objective

The law - Plastics Waste (Management and Handling) rules have been enacted in 2011, by Ministry of Environment, Forest and Climate Change, Government of India, and has yet not been implemented in any city or a municipal body in its correct form. For this there is a need for system designing, which encompasses the responsibility of municipal body, getting the plastics industry involved under extended producer responsibility and getting the informal sector in a formal regulated framework.

This forms the basis of this project for the first time in the country under a contract of an ULB. This replicable system is based on in-depth grass root experience in a varieties of waste streams across India and leaves a very few questionable modalities. The costs associated with the municipal waste sorting systems, which were designed for the waste having recyclable content of more than 60% have resulted in mass failures all over the country. And the diversion to waste to energy – with all its emphasis now, leaves the questions of feasibility – exactly for the same reason. If recyclable content having combustible values, remains less than 50% in our waste — the feasibility will always be questionable. The major hurdle is realization by the same regulatory agencies, and resistance of ULB operatives, for reasons best known to them. The proactive initiatives by city managers can make it successful with right understanding, commitment, and enthusiasms.

We believe this customized system will be set a trend to address the plastics litter problem, and plug in the loopholes in the most of the waste streams, where the laws are plastic centric. As of now, not one ULB in the Country transports the recyclable waste, an activity, which we see everywhere in urban landscape run by informal sector. The focus here is all based on contribution made by informal recycling network and their better participation in this innovative system, making rag picking a phenomenon on the verge of extinction.

This reverse supply chain network has all its dimensions of retail management – a contemporary foray of corporate world. The systems management, the operative protocols, the technology intervention, the engineering conceptualizations, all goes with advance understanding of inclusive growth. The compulsive contribution of populace has sentimental base in the guilt of awareness to cause of death to our birds, livestock, harm to earth and waters, rivers, and oceans.

The over-all objective of this work is three-fold.
i. To investigate the actual supply chain network of plastic waste from households to commercial units along with the other recyclables.
ii. To identify and propose a sustainable plastic waste management by installing Waste Exchange centers and bins for collection of recyclables with all the plastic waste and a Waste Processing Unit for primarily non-recyclable plastics waste.
iii. Preparation of a Project Report, system design, sourcing of equipment, and necessary modalities for implementation and monitoring.

1.2 Scope of the work.

I. Conduct a survey and mark suitable places for opening waste exchange centers, earmark the populace, which can be served with each of them, and identify and register the informal recyclable waste traders and collectors to be connected with them.
II. Design and execute a customizable system, for plants and machinery, and norms of regulatory clearances.
III. Source the equipment, install and commission, and stake holders meet, and awareness campaign.
IV. Source a part of the funding for the project under EPR, CSR & VGF.
V. Monitor the operations for 10 year.

1.3 Overview

The increased use of plastics in product manufacturing and in packaging application in the recent times has increased the quantity of plastics in all the waste streams to a great extent. The quantum of waste is ever increasing due to increase in population, development activities, changes in life style, and socio-economic conditions. It is estimated that approximately 15722 ton per day (TPD) of plastic waste is generated in India on the basis of per capita consumption based on population of India (Ref. 2.) Plastics and its waste in life time analysis perspective throws another point, the recyclability. The most frequently asked question about a product is 'How long will it last?' Lifetime expectancy is often many years, the service conditions may be complex, and there is a scarcity of definitive data on durability. The situation is complicated by the fact that there are a vast number of degradation agents, service conditions, properties of importance and different plastics.

There are many inherent difficulties in designing durability tests. In many cases, the time scale involved is such that accelerated test conditions are essential. Whilst large amounts of durability data are generated by accelerated methods, much of it is only useful for quality control purposes and relatively little has been validated as being realistically capable of representing service.

Most assessments of the lifetime of plastics are made by considering some measure of performance, such as impact strength, and specifying some lower limit for the property, which is taken as the end point. Lifetime is not necessarily measured in time. For example, for some products it will be thought of as the number of cycles of use.

1.4 The History of Plastics

From a historical viewpoint, the development of plastics can be regarded as one of the most important technical achievements of the twentieth century. In just 50 years plastics have permeated virtually every aspect of daily life, paving the way for new inventions and replacing materials in many existing products. The success of these products has been based on their properties of resilience, resistance to moisture, chemicals and photo- biodegradation, their stability and the fact, that they can be molded into any desired form.

The original breakthrough for the first semi-synthetic plastics material - cellulose nitrate, occurred in the late 1850's and involved the modification of cellulose fibers with nitric acid. Cellulose nitrate had many false starts following its invention by a Briton, Alexander Parkes, who exhibited it as the world's first plastics in 1862. The world's first plastic was reproduced at the turn of the twentieth century, and was based mainly on natural raw materials. Only in 1930 were thermoplastics, made from the basic materials styrene, vinyl chlorine and ethylene, introduced onto the market. However, the main growth of the plastics industry did not take place before the 1960's, reaching production of over 40 million ton per year in 1973. Following a temporary drop in production during the oil crises and the economic recession in the beginning of the 1980's, the world production of plastics continued to increase to approximately 77 million ton in 1986, and 86 million ton in 1990.

1.5. What is Plastic?

Plastic is the general term for a wide range of synthetic or semi synthetic polymerization products. They are composed of organic condensation or addition polymers and may contain other substances to improve performance or economics. There are few natural polymers generally considered to be "plastics". These polymers are broken in presence of suitable catalyst, into monomers such as ethylene, propylene, vinyl, styrene and benzene. These monomers are then chemically polymerized into different categories of plastics. This subject is dealt in a separate chapter in this document.

1.6 Categories of plastics

Table no. 1: The typical thermoplastic and thermosetting resins

S. No.	Thermo plastic	S. No.	Thermoset Plastic
1	Polyethylene Tetraphthalate (PET)	1	Bakelite
2	Polypropylene (PP)	2	Epoxy
3	Poly Vinyl Acetate (PVA)	3	Melamine
4	Poly Vinyl Chloride (PVC)	4	Polyester
5	Polystyrene	5	Polyurethane
6	Low Density Polyethylene (LDPE)	6	Urea-Formaldehyde
7	High Density Polyethylene (HDPE)		

1.7 Description of Plastic Waste

Plastic products have become an integral part of our daily life as a basic need. It is produced on a massive scale worldwide and its production crosses the 150 million ton per year globally. In India approximately 8 Million ton plastic products are consumed every year (2008). Its broad range of application lies in films, wrapping materials, shopping and garbage bags, fluid containers, clothing, toys, household and industrial products, and building materials. It is a fact that plastics will never degrade and remains on landscape for several years. Mostly, plastics are recyclable but recycled products can again be recycled but the litter left over in earth system and water systems are more hazardous to the environment. The recycling of a virgin plastic material can be done many times, but after every recycling, the plastic material is deteriorated due to thermal pressure. Considering, 70% of plastic consumption is converted as waste over time, approximately 5.6 million ton per annum (TPA) plastic waste is generated in country, which equals to 15342 ton per day.

Plastic waste has a significant portion in total municipal solid waste. Though, there is a formal system of waste collection in urban areas, however, informal sectors i.e. rag pickers, collect only value based plastics waste such as pet bottles etc. Plastic carry bags, metalized plastics and low quality plastic less than 20 micron do not figure in their priorities, because collecting them is not profitable. This is primarily because the rewards are not much as compared to the efforts required for collection, and this leads to plastic bags and other packaging materials continuing to pose a major threat to the environment.

Moreover, the major concern for this waste stream is that these are non-biodegradable and remains in the environment for many years. Clogging of drains by plastic waste is a common problem. The packaging and poly vinyl chloride (PVC) pipe industry are growing at 16-18% per year. The demand of plastics goods is increasing from house hold use to industrial applications. It is growing at an annual rate of 22% annually. The polymers production has reached to 8.5 million ton.

1.8 Waste Generation and Composition in India

The rate of waste generation in India is growing very quickly owing to urbanization and higher incomes. The current composition of waste carries a high potential for recycling that is barely exploited. Generally, about 15 percent of waste materials—which consist mainly of paper, plastic, metal, and glass—can be retrieved from the waste stream for further recycling (as shown in figure no. 2). Another 35 to 55 percent of waste material is organic waste, which can be converted into useful compost, leaving only 30 to 50 percent that needs to go as inert or as soil supplement.

Data pertaining to the physical and chemical composition of the waste has been compiled for 75 cities by CPCB and for 60 cities for plastics waste.. An attempt has been made to establish a relation between the Calorific Value and the biodegradable and paper fractions of the waste generated in various cities. The cities have been classified on the basis of population, i.e. cities having a population of over 20,00,000 are classified as Tier 1 cities, between 5,00,000 to 20,00,000 as Tier 2 cities, between 1,00,000 to 5,00,000 as Tier 3 cities and less than 1,00,000 as Tier 4 cities, in which Mumbai comes in Tier 3 city. Also, the state wise potential of waste to Energy has been calculated using values of various WTE technologies taken from literature reviews of several research papers. Using the projected population figures (Census) for the years 2011, 2015 & 2020 along with the scenarios stating which types of technologies could be used for waste generation to energy conversion as proposed by the authors, the projected waste potential for India for the given years has been calculated. Which all compels us to think differently for us in India –more innovatively.

1.9 Plastics Consumption in India

National plastic waste management task force in 1997 projected the polymers demand in the country. Polymers Demands in India (Million Ton) documents the demand of different polymers in India during years 1995-96, 2001-02 and 2006-07. The comparison of demand and consumption from more than one fourth of the consumption in India is that of PVC which is being phased out in many countries. Poly bags and other plastic items except PET in particular have been a focus, because it has contributed to host of problems in India such as choked sewers, animal deaths and clogged soils.

1.10 Literature Sources

Literature information for this work was gathered from diverse sources. A lot of information was obtained or collected through the internet from different sources such as journals, technical reports on international research work on plastic waste recycling, press releases on recycling and findings of research centers and pilot projects.
Also, important information and recycling techniques were obtained from countries such as Turkey, Egypt, Ghana and South Africa and therefore it is worthwhile learning from their experiences. Majority of the terminologies and techniques on recycling and the practical demonstrations were drawn from the research work of Waste Consultants on Plastic Waste.

Chapter 2

City Of Mumbai

2. City of Mumbai

2.1 Introduction

The city Mumbai, know as Bombay until 1995, is a great port city, situated on the west coast of the Indian peninsula. It is one of India's dominant urban centers and, indeed, is one of the largest and most densely populated cities in the world. Deriving its name from Mumba Devi, a goddess of the local Koli fishing peoples, Mumbai grew up around a fort established by the British in the mid-seventeenth century to protect their trading interests along India's western coast. The city's superb natural harbor provided a focal point for sea routes crossing the Arabian Sea, and Mumbai soon became the main western gateway to Britain's expanding Indian empire. The city emerged as a center of manufacturing and industry during the eighteenth century. Today, Mumbai is India's commercial and financial capital, as well as the capital city of Maharashtra State.

Population: 18,042,000
Description: Area administered by the Municipal Corporation of Greater Mumbai (BrihanMumbai Municipal Corporation or BMC)
Area: 437 sq. km (170 sq. mi)
World population rank 1: 3
Percentage of national population 2: 1.8%
Average yearly growth rate: 3.5%
Ethnic composition: Maratha, Gujarati, Marwari, Sindhi, Punjabi, Bohra, Khoja, Koli, and others

2.2 BRIHANMUMBAI MUNCIPAL CORPORATION (BMC)

2.2.1 Introduction

The Municipal Corporation of Greater Mumbai (MCGM), also known as BrihanMumbai Municipal Corporation (BMC), (formerly the Bombay Municipal Corporation) is the governing civic body of Mumbai, the capital city of Maharashtra. It is India's richest municipal corporation. The MCGM's annual budget exceeds that of some of India's smaller states. It was established under the Bombay Municipal Corporation Act 1888.] MCGM is responsible for the civic infrastructure and administration of the city and some suburbs. In 2015, Trushna Vishwasrao became the first female corporator to serve as its leader.

Today, the BrihanMumbai Mahanagarpalika covers an area of 480.24 sq. kms.

Mumbai being Financial capital of India, floods cause huge damage to economy along with these they also cause a huge loss of life property & cattle giving rise to diseases and emotional disturbances for those who survived. The Mumbai floods of 2005 where more than 1095 lives were lost amid 945 mm rainfall and high tides were a wake up call that city needed to upgrade it's drainage system. The cost of carelessness hit home during the deluge on July 26,2005 when Mumbai was pounded with 944 mm rain in one day that claimed more than 1000 lives. Expert said 2005 floods were as much a result of clogged open surface drains with solid waste including plastic, storm water drains and it's channel as it is due to significant changes in land use across the city and illegal construction and encroachment along natural drains and Mithi river.

Maharashtra state pollution control board (MPCB) affidavit states, plastic directly enters into nullahs by general public and slums areas. Discharge of untreated domestic waste accounts for 93% of sources of pollution for these water bodies. The negligent attitude of Mumbaiites, especially those living near drains and creeks has resulted in massive amounts of plastic waste, majority of which is single use plastic, being dumped into the natural water courses. The analysis by Mumbai based Veermata Jijabai technological Institute(VJTI) spanning years showed that changing rainfall pattern, extensive concretization, open drains along roads choked with plastic and other waste together with more than a century old storm water drain systems has led to an increase in quantum of rain water turning into run- off there by causing frequent inundation in Mumbai.

Everyday, Mumbai dumps 80-100 metric tons of plastic waste into drains and water channels, an application submitted by Environment group Vanshakti before the National Green Tribunal (NGT) in December 2018. The peninsular city bursting with concrete structures was once a mixed wetland ecosystem of mangrove forests. But over past years, mangroves have been levelled and waterways filled with construction debris, leaving city vulnerable to flooding without it's natural protectors. The flood preparedness Guidelines 2019 report by Municipal corporation of Greater Mumbai notes that the process if urbanization has played a major role aggravating the problem as it has caused significant alterations to hydrology, morphology, habitat and Ecology of the city. Inadequate drainage, overflow of Mithi river and a combination of high tides and high river flow all contribute to the regular floods in Mumbai, it states.

BMC revives drive against single-use plastic; seizes 1,028 kg of banned items.
The government had banned the use of disposable plastic, including plastic bags, cups, spoons, plates and tiffin containers, among others, in March 2018. It gave three months to users, retailers and manufacturers to get rid of such items, after which a ban came into effect on June 23

Reviving its drive against single-use plastic in the city on Sunday, all the products manufactured from plastic and thermocol fall under the ban which means that the usage of plastic bags with a handle and without handle, disposable cups, and plates, spoons, forks, glasses, and containers is prohibited in the state. Plastic packaging used to wrap and store products is also banned. The BMC seized 1,028 kg of the banned material and collected Rs 3.75 lakh as penalty amount from 4,081 hawkers, restaurants, shops and other establishments. Over the weekend, BMC officials visited major markets and high footfall zones such as areas around railway stations and hawking areas like Dadar, to raise awareness and conduct inspections. On the second day, officials seized 14.5 kg polythene bags from 315 street vendors and 450 flower shops around Dadar station and 76 shops inside Dadar flower market, recovering a penalty amount of Rs 45,000.

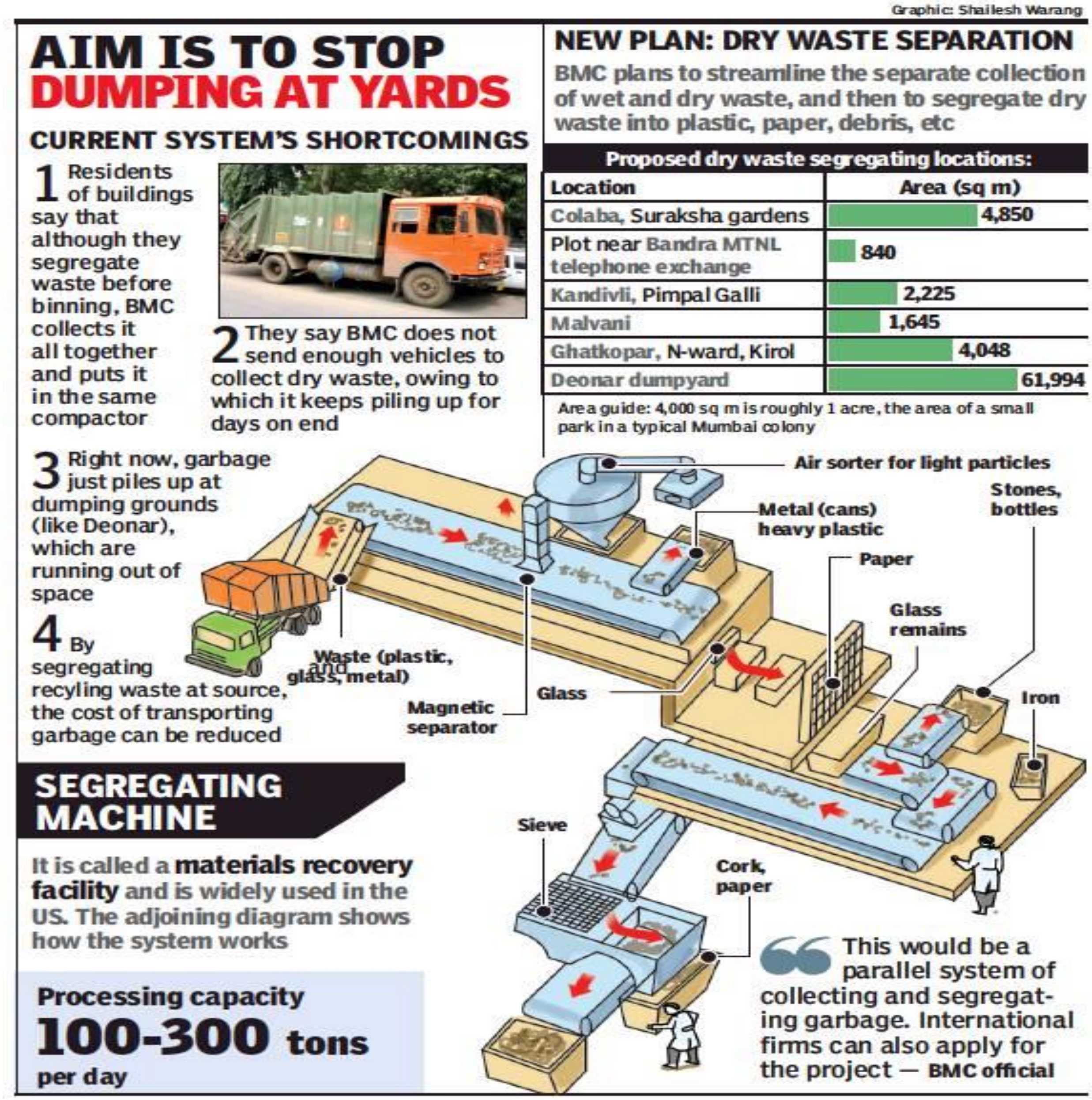
To raise awareness, the BMC has also planned to hold competitions on the theme of plastic ban, encouraging students to deposit banned plastic items in schools and take a pledge to give up single-use plastic. Further, the civic body has also planned to appoint a nodal officer to implement the plastic ban and put into service a toll-free number for complaints against storage, use and transportation of banned items.

Being the implementing agency for the plastic ban, the BrihanMumbai Municipal Corporation (BMC) is not only responsible for collecting the existing stock of plastic lying with citizens but is also liable to dispose and recycle the collected plastic appropriately. The BMC has decided to handover the recycling of the collected plastic to the recycling agencies registered with the Maharashtra Pollution Control Board (MPCB).

As per the BMC, recycling is not the only option but the collected plastic can also be used by cement industries to mix the plastic with cement in their manufacturing units. "There are around 85 locations in the city where plastic collection bins have been placed. The locations include all solid waste management chowkis, municipal markets and other public locations. For plastic bottles, crushing machines will be installed across the city for which the locations are yet to be finalised.
"The collected plastic will be stored in the dry waste segregation centres and it will be collected from here by the registered recycling agencies”.

RECYCLING AGENCY

- Over 400 plastic recycling agencies are registered with the Maharashtra Pollution Control Board.
- Of these, around 50 are in Mumbai and 70 outside the city.



2.2.2 Work Carried out by BMC for waste management

As of now, the civic body collects wet and dry waste from housing societies. The BMC will hire e-bikes that will go door to door to collect hazardous domestic waste. According to officials, the existing vehicles that collect waste have only three compartments each for wet, dry, and electronic waste.

2.3 Beach Cleaning and Recycling Activities

2.3.1 Beach Cleaning

Beach cleaning or clean-up is the process of removing solid litter, dense chemicals, and organic debris deposited on a beach or coastline by the tide, local visitors, or tourists. Humans pollute beaches with materials such as plastic bottles and bags, plastic straws, fishing gear, cigarette filters, and many other items that often lead to environmental degradation. Every year hundreds of thousands of volunteers comb beaches and coastlines around the world to clean this debris. These materials are also called “marine debris” or "marine pollution".

There are some major sources of beach debris such as beach users, oceans, sea drifts, and river flow. Many beach users leave their litter behind on the beaches after activities. Also, marine debris or chemicals such as raw oil drift from oceans or seas and accumulate on beaches. Additionally, many rivers bring some cities' trashes to beaches. These pollutants harm marine life and ecology, human health, and coastal tourism. Hartley et al.’s (2015) study shows that environmental education is important to eliminate many beach pollutants on beaches and the marine environment.

There are two causes of the degradation of marine ecology and marine debris: the direct forces (population growth, technological development[disambiguation needed], and economic growth) and proximity forces (land transformation and industrial processes). We can think of the direct forces as underlying causes of why we consume an excessive amount of goods by industry process. The excessive consumption of goods causes marine debris because the goods have been packaged by manufactured cheap non-recycle materials such as plastic. Solid waste plastics cannot decompose easily in nature and their decomposition process takes thousands of years to million years but plastic breaks down into continuously smaller pieces (>5 mm) forming that is called micro-plastics. Thus, such solid waste products are called marine debris that can be seen all through coastlines and on many beaches through the world. There can be many sources of marine debris such as land-based, marine-based, and other anthropocentric activities. Million tons of land-based waste products such as plastics, papers, woods, and metals end up in seas, oceans, and beaches through the wind, oceans currents (five major gyres), sewage, runoff, storm-water drains and rivers. Massive amount of marine debris has become a severe menace to the marine environment, aquatic life and humankind. Most land-based sources are illegal dumping, landfills, and petrochemical and other industry disposals. Also, other marine-based sources originate from anthropocentric marine activities that are drifted fishing lines, nets, plastic ropes or other petrochemical products from remote islands or lands, shipping vessels or fishing boats by wind and oceanic currents. Marine debris source is also anthropocentric activities of local populations such as beach goers, tourists and city or town sewage.

Marine debris consists of millions of tons of abandoned plastic fishing gears. Nearly 640,000 tons of plastic gears damps the oceans every year. According to Unger and Harrison, 6.4 tons of pollutant dumps the oceans every year, and the most of them are consist of by durable synthetic fishing gear, packaging, materials, raw plastic, and convenience items. Such extremely durable plastic gears cannot decompose in the seawater and marine environment and they wash up on beaches driven by inshore currents and wind. Such discarded gears such as plastic fishing lines, nets, and floats are called "ghost gear". About 46% of the 79 thousand of ghost gear that is the size of many football fields has been found at the Great Pacific Garbage Patch constituted in 2018. The discarded fishing nets and lines kill or inflict myriad marine animals such as fish, sharks, whales, dolphins, sea turtles, seals, and marine birds every year. And about 30% of fishing populations have been declining and %70 other marine animals suffer by abandoned gears each year. Besides, the huge fishing industry is an important driver of declines marine ecology by overfishing activities. Overfishing causes when big fishing vessels catch tons of fish faster than stock refills. Moreover, overfishing impacts 4.5 billion people who depend on at least 15% of fish for protein, and fishing is the principal livelihood.

The process of beach cleaning requires good management methods, adequate human resources, and funds. Solid litters cleaning methods are very different than oil spill cleaning methods. The beach cleaning process may be done using machinery such as sand cleaning machines that rake or sift the sand or/and other chemicals such as oil dispersants. This beach cleaning may be done by professionals company, civic organizations, the military or volunteers such as the Great Canadian Shoreline Cleanup and Marine Conservation Society.

Mechanical vs. manual cleaning

There are two types of beach cleaning- mechanical and manual. These methods are also referred to as mechanical grooming and nonmechanical grooming. Mechanical beach cleaning is defined as litter and/or organic material removal that relies on the work of automatic or push machinery that rakes or sieves the most superficial layer of sand. Manual cleaning involves individuals picking up trash exclusively by hand. The suggested beach cleaning approach incorporates manual and mechanical cleaning as this combination is most cost effective and environmentally sound.

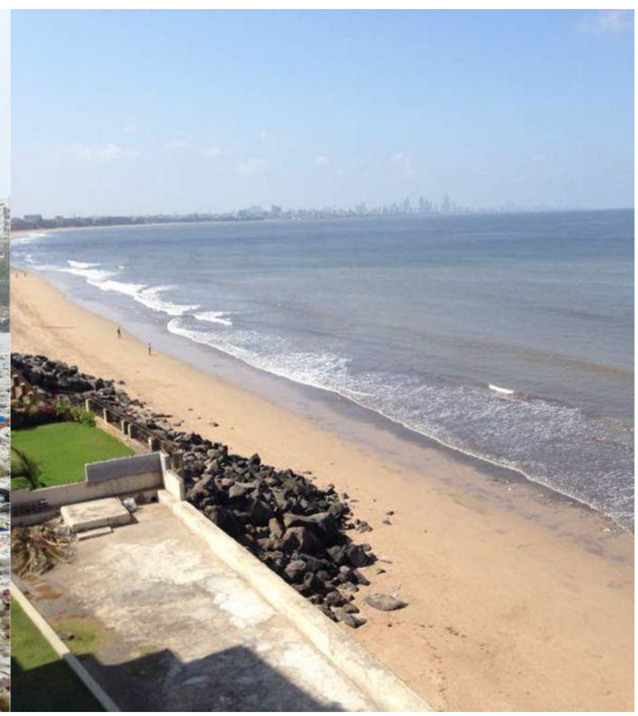
Combination of mechanical and manual cleaning methods

This method allows urban and more intensely used beaches to manage larger quantities of litter while minimizing the environmental impact of mechanical cleaning. In fact, beaches cleaned less than three times a week sustain a level of biodiversity and species abundance that is similar or only slightly lower than beaches that are strictly cleaned by hand. For example, Morton et al. (2015) found that mechanical beach cleaning did not affect biodiversity but concede that this likely due to the fact that the beach only underwent mechanical cleaning once to twice a week and had moved wrack from popular sections of the beaches to less commonly visited sites. Additionally, Stelling-Wood et al. (2016) studied ghost crab populations as an indicator species for overall biodiversity on sandy beaches and discovered that the frequency of mechanical beach cleaning was the most influential factor on population size. Beaches that were mechanically cleaned less than three times a week housed the highest number of ghost crabs. Our ocean and the array of species that call it home are succumbing to the poison of plastic. Examples abound, from the gray whale that died after stranding near Seattle in 2010 with more than 20 plastic bags, a golf ball, and other rubbish in its stomach to the harbor seal pup found dead on the Scottish island of Skye, its intestines fouled by a small piece of plastic wrapper. According to the United Nations, at least 800 species worldwide are affected by marine debris, and as much as 80 percent of that litter is plastic. It is estimated that up to 13 million metric tons of plastic ends up in the ocean each year—the equivalent of a rubbish or garbage truck load's worth every minute. Fish, seabirds, sea turtles, and marine mammals can become entangled in or ingest plastic debris, causing suffocation, starvation, and drowning. Humans are not immune to this threat: While plastics are estimated to take up to hundreds of years to fully decompose, some of them break down much quicker into tiny particles, which in turn end up in the seafood we eat. Research indicates that half of sea turtles worldwide have ingested plastic. Some starve after doing so, mistakenly believing they have eaten enough because their stomachs are full. On many beaches, plastic pollution is so pervasive that it's affecting turtles' reproduction rates by altering the temperatures of the sand where incubation occurs. A recent study found that sea turtles that ingest just 14 pieces of plastic have an increased risk of death. The young are especially at risk because they are not as selective as their elders about what they eat and tend to drift with currents, just as plastic does. Plastic waste kills up to a million seabirds a year. As with sea turtles, when seabirds ingest plastic, it takes up room in their stomachs, sometimes causing starvation. Many seabirds are found dead with their stomachs full of this waste. Scientists estimate that 60 percent of all seabird species have eaten pieces of plastic, a figure they predict will rise to 99 percent by 2050. While dolphins are highly intelligent and thus unlikely to eat plastic, they are susceptible to contamination through prey that have ingested synthetic compounds. Plastic in our oceans affects creatures large and small. From seabirds, whales, and dolphins, to tiny seahorses that live in coral reefs…… ... and schools of fish that reside on those same reefs and nearby mangroves. Plastic waste can encourage the growth of pathogens in the ocean. According to a recent study, scientists concluded that corals that come into contact with plastic have an 89 percent chance of contracting disease, compared with a 4 percent likelihood for corals that do not. Unless action is taken soon to address this urgent problem, scientists predict that the weight of ocean plastics will exceed the combined weight of all of the fish in the seas by 2050.

In Mumbai, 'World's Largest Beach Clean-Up' Has Transformed the Versova Shore

Mumbai, the most populous city in India, is known for its beaches. But piles of trash and sewage contamination have made them unsafe for visitors in recent years. Some are more polluted than others. In a study of nine Mumbai beaches between November 2015 and May 2016, Juhu, Versova and Aksa were in the worst shape. Nearly two years ago, residents of Versova decided to take matters into their own hands, inspired by Mumbai-based lawyer and environmentalist Afroze Shah In October 2015, Shah moved to his new apartment near Versova beach and noticed plastic waste on the beach, reaching 5.5

feet (1.67 meters) high in some portions. He and his 84-year-old neighbour, Harbansh Mathur, began to clean up the trash. Seeing their efforts, dozens of locals joined as volunteers and about 50,000 kilograms of waste was removed during the first clean-up on the 2.5-kilometre shore. Still tons of waste needed to be removed, so they launched a weekly clean-up drive inviting more volunteers. By December 2015, the local authorities provided tools such as garbage trucks and excavator machines for the volunteers and the drive transformed into a movement over the next six months. The volunteer base grew to 300 participants a week from all walks of life. Soon, the Versova Resident Volunteers (VRV) group was formed and they updated their progress regularly on Facebook. In July 2016, VRV's efforts were recognised internationally as the United Nations Environment Programme (UNEP) called it the "world's largest beach clean-up in history". By January, the group started cleaning the 52 toilets near the beach to stop sewage from ending up in the sea. By March, VRV had cleared five million kilograms (5,000 metric tons) of trash from Versova beach alone. And the volunteers are still at it: The UNEP recognised Shah's achievement by making him a Champion of the Earth, the United Nations' highest environmental award. India's Prime Minister Narendra Modi also praised Shah's initiative as an "inspiring example" in the fight against pollution: The initiative is spreading. This one is from the Kahn (Khan) river cleanup in Indore, about 600 kilometres from Mumbai: And people are wanting more: According to UNEP, 13 million tons of plastic waste end up in the world's oceans every year and the world needs to act now. People now have a successful example in Versova beach, but many more steps are needed to reduce plastic wastes and make waste disposal more efficient.



2.3.2 Recycling Activities

There is significant scavenging and recycling activity. Scavengers normally salvage large size plastic films, sheets; carry bags, corrugated boxes, and metals. About 20% recyclables are scavenged from various spots. The details forms part of our actual survey for the waste exchange centers.

Plastic Bottle Machines at Railway Stations

Several of Mumbai's stations now have 'Swachh Bharat Recycling Machines'
These allow people to swap their used bottles for discount coupons
The idea is to encourage people to recycle and keep the stations clean
Bottles which would otherwise end up strewn across railway platforms and tracks can now help pay for your groceries! A unique initiative started by Western Railway and the Wockhardt Foundation has set up 'Swachh Bharat Recycling Machines' across stations in Mumbai allows people swap their used plastic bottles for reward points and discounts. This plastic can be recycled to produce polyester yarn which can be used in clothing. The idea has taken off and the machines have been hugely successful among the city's commuters.

How does this work?

It is quite simple, really. People horizontally insert the Polyethylene terephthalate (PET) bottle into the chute, where it is analyzed and crushed by the machine. A single machine has the capacity to hold and process 5,000 bottles per day. In return, the machine gives users the option to consider the bottle as a donation, get Paytm points or receive discount coupons for 'Sahakari Bhandar' and 'Reliance Fresh' stores.

This projected debuted on June 5, 2016, which was also the World Environment Day, with one of these machines being installed in South Mumbai's Churchgate station. Since then, with the positive response from the public as an impetus, similar machines have been installed at Dadar, Mumbai Central, Goregaon, Andheri, Santacruz and Bandra stations.

"We want to bring this number up to 20," says Mukul Jain, Divisional Railway Manager of Mumbai Central Division of Western Railway, "This roll-out should be completed in the next two months. After this, we will look at the possibility of installing these elsewhere as well."

For now, Wockhardt Foundation is working on making this even more attractive by introducing more discounts from other stores and eateries. Mr. Jain tells NDTV, that one of the companies with which negotiations are ongoing is a leading pizza chain.

"While the response has been really good, we hope that we'll be able to attract even more people to use the machines with more rewards," he says.

A Sustainable Business Model

What is incredible is that this project has been made self-sufficient and does not cost the railways anything.

"What we wanted was that these machines would be run at no expense to the railways. In fact, we were looking at ways that this could generate revenue as well. For instance, the sides of the machine can be used as advertising space," Mr. Jain says.

He estimates that the advertising on a single machine can earn the railways over ₹2 lakh. Additionally, the crushed PET bottles are being recycled into polyester yarn which can be used to make clothes—offering a model which is a win-win for the government, the environment and everyone else involved.

Railway ban use of Plastic completely from 02.10.2019. For helping the passengers to recycle the plastic Indian Railway installed **Plastic bottle Recycling Machines** at Railway stations , it is also a part of **Swachh Bharat project** and **Go Green Mission**.

Passengers can put their used plastic bottle and metal cane for recycling in this machines. In some railway stations passenger are getting rewards like discount coupons also for this good deed. The coupons with discounts of 20-25 percent can be redeemed at selected brands. The crushed bottles will be sent for recycling to fibre-manufacturing companies and used as raw material for making clothes, carpets and grocery bags. Plastic Bottle recycling Machines are very easy to use. These machines have been designed as a cost-effective means for disposal of waste plastic bottles. The crusher places the empty bottle into the receiving aperture; the horizontal in-feed system allows the user to insert containers one at a time. Once a bottle is inserted, it is crushed to reduce it's size. The machine, which is about the size of a refrigerator, can consume around **5,000 bottles in a day.**

Plastic Bottle recycling Machines at Railway Stations : How to use

- First we have to **put empty bottle** into the machine.
- In some cases, When the bottle is accepted by the machine, three options on the screen will appear — **donation, mobile recharge and discount** from an outlet with which the machine-provider has tied up for discounts.
- The user can **select either option and a printout** will be issued.

General Instruction

- Put used Plastic Bottle only
- Do not insert Glasses/Aluminum/Tin etc.
- Select the desired coupons.

Features of Plastic Bottle recycling Machines at Railway Stations

- Noiseless bottle
- Resembling a vending machine

Plastic Bottle Machines : List of the Stations

List of stations having Plastic Bottle Machines at Railway Stations:

North Central Railway

Allahabad and Kanpur : North Central Railway has installed bottle crushing machines at 06 stations including Allahabad and Kanpur Jn. With each recycled bottle passenger is eligible for discount in select outlets at Railway stations besides contributing in environment protection

South Western Railway

Authorities of **Mysuru division** of South Western Railway (SWR) have installed automatic noiseless bottle crushing machines on Platform 1. Mysuru division is currently in the process of entering into a memorandum of understanding (MoU) with plastic manufacturers for collecting crushed pieces of plastic, which is expected to generate revenue for the division. More machines such as the plastic bottle crusher are expected to be installed in other stations coming under the division. The Railways is exploring possible tie-ups with private companies to undertake such ventures under their Corporate Social Responsibility initiatives.

Central Railway and Western Railway

Mumbai Metro :- Train passengers on the **Versova-Andheri-Ghatkopar** have an option to dispose of plastic bottles. Mumbai Metro One Private Ltd (MMOPL), which operates this Metro One, have installed crushers to recycle of discarded bottle at its stations on Monday. To begin with, these crushers were installed at six stations **– DN Nagar, Andheri, Chakala, Marol Naka, Saki Naka and Ghatkopar**. Of the total 12 Metro stations, the stations with Swachh Bharat Recyling Machines have the most number of footfalls.

Mumbai Suburban Stations

Indian Railway installed Bottle/can recycling machine at the Churchgate railway station in Mumbai. Railway is planning to put such machines at 10 stations namely Mumbai Central, Dadar, Bandra (local), Bandra terminus, Santacruz, Andheri, Goregaon, Borivali and Bhayandar, Starting with one machine placed at Churchgate station, there are currently 20 machines near ticket counters at Churchgate, Mumbai Central, Dadar, Bandra, Santacruz, Andheri and Goregaon stations.

South Eastern Railway

PET Bottle Crusher Machine has been installed at **Chakradharpur Station,CKP division**, South Eastern Railway. First machine installed in South Eastern Railway.

Southern Railway

- **Kochi Metro Rail Limited** also installed plastic bottle recycling machines in selected metro stations from **Aluva to Palarivattom**. KMRL has installed the facility in three Metro stations as part of its green initiatives to make the city environment friendly.

Plastic Bottle Recycling Machines in Trains

In order to Beat Plastic Pollution Western Railway has installed a bottle crushing machine in the Pantry Car of one rake of Mumbai-Delhi Rajdhani Express, a first on Indian Railways. It can crush 3000 bottles per day and is capable of recycling 90% PET waste bottles at the source.

This machine can accept all types of PET bottles from 200 ml to 2.5 liters capacity and has an internal storage bin of approx. 20 liters which is equivalent to 1500 bottles. Move by WR of installing a PET bottle cursing machine is expected to reduce carbon footprints by 100% recycling and will also avoid littering in landfill from bottle waste.

Chapter 3

Plastic And Source Of Plastic Waste

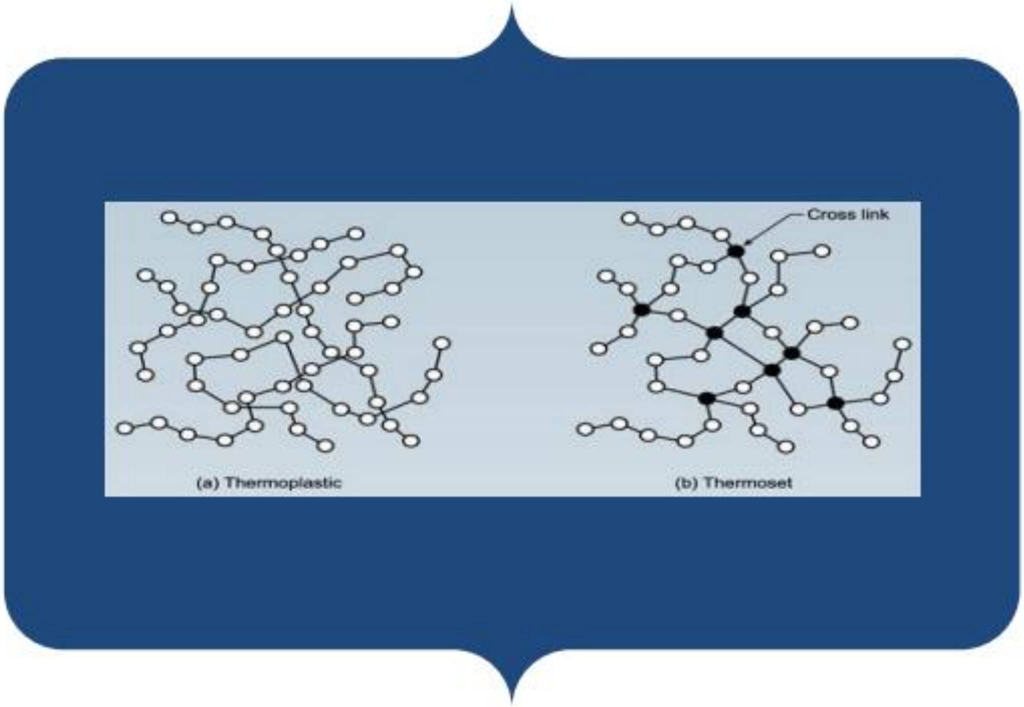
3. PLASTIC AND SOURSE OF PLASTIC WASTE

3.1 Plastic Materials

Plastics are man-made organic materials that are produced from oil and natural gas as raw materials. Plastics consist of large molecules (macromolecules), the building blocks of all materials. The molecular weights of plastics may vary from about 20,000 to 100,000 mg/L. Plastics can be regarded as long chains of beads in which the so called monomers. Development of plastics production worldwide ethylene, propylene, styrene and vinyl chloride are linked together to form a chain called a polymer. Polymers such as polyethylene (PE), polystyrene (PS) and polyvinyl chloride (PVC) are the end products of the process of polymerization, in which the monomers are joined together. In many cases only one type of monomer is used to make the material, sometimes two or more. A wide range of products can be made by melting the basic plastic material in the form of pellets or powder . Plastics can be either thermoplastics or thermosets, having melting which is given in table below

Polyolefin	Melting point (^{0}C)
LDPE	115
LLDPE	123
HDPE	130
Polyethylene (PE)	135
Polypropylene (PP)	170
Polystyrene (PS)	240
Polyethylene terephthalate (PET)	245
Polyamide 6 (PA6)	233

Materials that repeatedly soften on heating and harden on cooling are known as thermoplastics. They can be melted down and made into new plastic end products. Thermo plastics are similar to paraffin wax. They are dense and hard at room temperature, become soft and moldable when heated, dense and hard again and retain new shapes when cooled (see Figure for a schematic overview of the structure of thermoplastic and Thermoset). This process can be repeated numerous times and the chemical characteristics of the material do not change. In Europe, over 80% of the plastics produced are thermoplastics. Thermosets, on the other hand are not suitable for repeated heat treatments because of their complex molecular structures (see Figure below).The structure of thermosetting materials resembles a kind of thinly meshed network that is formed during the initial production phase. Such materials cannot be reprocessed into new products unlike thermoplastics. Thermosets are widely used in electronics and automotive products. The properties of plastics can be modified by a number of substances known as additives.



3.2 Types of Plastics

In industrialized countries, literally hundreds of plastic materials are available commercially. In economically less developed countries however, fewer types of plastics tend to be used. In both economically less developed and industrialized countries, the four types of plastics that are most commonly reprocessed or recycled are polyethylene (PE), polypropylene (PP), polystyrene (PS) and polyvinyl chloride (PVC). Each of these can be subdivided according to their density, the type of process involved in their manufacture, and the additives they contain. These four types are briefly described below.

3.2.1 Polyethylene (PE)

The two main types of polyethylene are low density polyethylene (LDPE) and high density polyethylene (HDPE). LDPE is soft, flexible and easy to cut, with the feel of candle wax. When very thin it is transparent, when thick it is milky white, unless a pigment is added. LDPE is used in the manufacture of film bags, sacks and sheeting, blow-molded bottles, food boxes, flexible piping and hosepipes, household articles such as buckets and bowls, toys, telephone cable sheaths, etc. HDPE is tougher and stiffer than LDPE, and is always milky white in color, even when very thin. It used for bags and industrial wrappings, soft drinks bottles, detergents and cosmetics containers, toys, jerry cans, crates, dustbins, and other household articles.

3.2.2 Polypropylene (PP)

Polypropylene is more rigid than PE, and can be bent sharply without breaking. It is used for stools and chairs, high-quality home ware, strong moldings such as car battery housings, domestic appliances, suitcases, wine barrels, crates, pipes, fittings, rope, woven sacking, carpet backing netting surgical instruments, nursing bottles, food containers, etc.

3.2.3 Polystyrene (PS)

In its unprocessed form, polystyrene is brittle and usually transparent. It is often blended (copolymerized) with other materials to obtain the desired properties. High-impact polystyrene (HIPS) is made by add in grubber. Polystyrene foam is often produced by incorporating a blowing agent during the polymerization process. PS is used for cheap, transparent kitchen ware, light fittings, bottles, toys, food containers, etc.

3.2.4 Polyvinyl chloride (PVC)

Polyvinyl chloride is a hard, rigid material, unless plasticizers are added. Common applications for PVC include bottles, thin sheeting, transparent packaging materials, water and irrigation pipes, gutters, window frames, building panels, etc. If plasticizers are added, the product is known as plasticized polyvinylchloride (PPVC), which is soft, flexible and rather weak, and is used to make inflatable articles such as footballs, as well as hosepipes and cable coverings, shoes, flooring, raincoats, shower curtains, furniture coverings, automobile linings, bottles, etc. Other types of plastics include polycarbonate (PC), polyethylene terephthalate (PET), he polyurethane (PU) and nylon or polyamide (PA). Table no.8 depicts the types of plastics and their variations in bending strength.

Types of Plastics and variation in bending strength

Type of Plastic	Percentage of Plastic	Bending strength in Kg	Compression strength (Ton)
PE	10	325	250
	20	340	270
	25	350	290
Poly propylene	10	350	280
	20	370	290
	25	385	310
PS	10	200	155
	20	210	165
	25	215	170
PE foam	10	310	250
	20	325	265
	25	335	290
PP foam	10	340	270
	20	360	290
	25	365	270
Laminated plastic	10	360	290
	20	385	310
	25	400	335
BOPP	10	380	300
	20	400	310
	25	410	330

3.3 Sources of Plastic waste

Plastics can be used for many purposes, and thus, waste plastics are generated from a wide variety of sources. The main sources of plastic waste in Mumbai can be classified as follows: industrial, commercial and municipal waste.

3.3.1 Industrial waste

Industrial waste and rejected material (so-called primary waste) can be obtained from large plastics processing, manufacturing and packaging industries. Most of this waste material has relatively good physical characteristics; i.e., it is sufficiently clean, since it is not mixed with other materials. It has been exposed to high temperatures during the manufacturing process which may have decreased its characteristics, but it has not been used in any product applications. Many industries discard polyethylene film wrapping that has been used to protect goods delivered to the factory. This is an excellent material for reprocessing, because it is usually relatively thick, free from impurities and in ample supply. Many industries may provide useful supplies of primary waste plastics: • The automotive industries: spare-parts for cars, such as fan blades, seat coverings, battery containers and front grills.

• Construction and demolition companies: e.g. PVC pipes and fittings, tiles and sheets.
• Electrical and electronics industries: e.g. switch boxes, TV screens, etc.

Considerable amounts of waste plastics generated by many industries remain uncollected or end up at the municipal dump. Industries are often willing to cooperate with private collecting or reprocessing units.

3.3.2 Commercial waste

Workshops, craftsmen, shops, supermarkets and wholesalers may be able to provide reasonable quantities of waste plastics for recovery. A great deal of such waste is likely to be in the form of packaging material made of PE, either clean or contaminated. Hotels and restaurants are often sources of contaminated PE material.

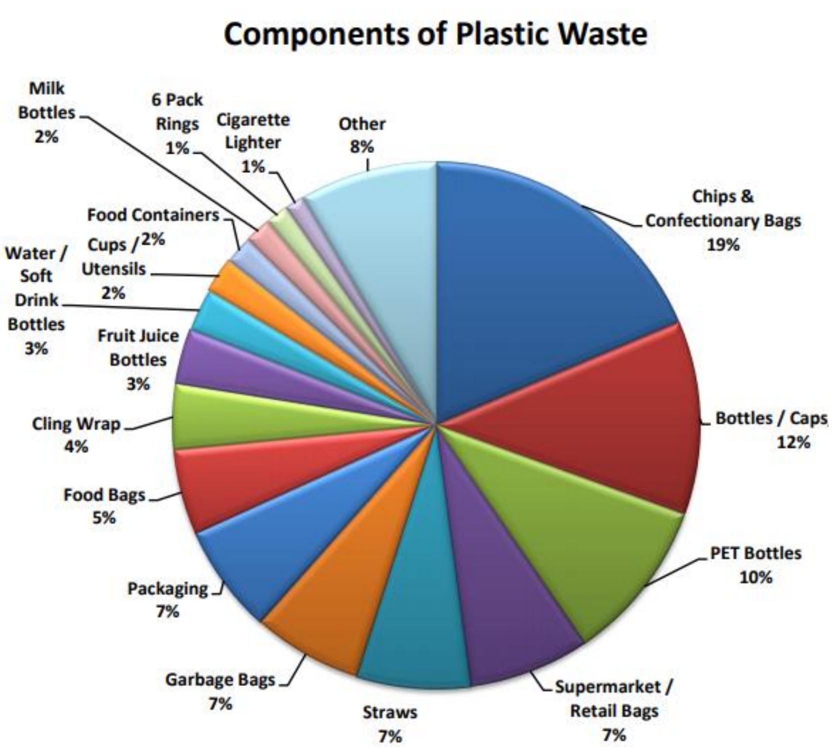
3.7.3 Municipal waste

Waste plastics can be collected from residential areas (domestic or household waste), streets, parks, collection depots and waste dumps. In Mumbai, considerable amounts of plastic waste can be found within the Municipal Solid Waste stream due to the littering habit of the population. The most common type of plastic waste within the municipal waste stream is the “sachet” water film bags that are discarded in discriminately soon after consuming its contents. In Asian countries in particular, the collection of this type of waste is widespread. However, unless they are bought directly from households, before they have been mixed with other waste materials, such waste plastics are likely to be dirty and contaminated. Sometimes the plastics can be separated and cleaned quite easily, but contamination with hazardous waste is not always visible and may be more difficult to remove. Litter that has been waiting for collection for some time may have been degraded by sunlight. This is mainly a superficial effect, however, and does not always mean that the plastics cannot be reprocessed. The data on waste generated based on income with characterized of some Asian countries as given below in table.

Country	GDP, PPP capita estimated for 2077 (USD)	Waste generation (Kg/capita/day)	Composition (% wet weight basis)						
			Bio - degradable	Paper	Plastic	Glass	Metal	Textile/ leather	Inert and others
Hong Kong	35,385	2.25	38	28	19	3	2	3	9
Japan	33,010	1.1	26	46	9	7	8	-	12
Singapore	31,165	1.1	44.4	28.3	11.8	4.1	4.8	-	6.6
Taiwan	31,040	0.667	31	26	22	7	4	9	-
South Korea	23,331	1.0	25	26	7	4	9	29	-
Malaysi	12,702	0.1-0.8	40	15	15	4	3	3	20
Thailand	9426	1.1	48.6	14.6	13.9	5.1	3.6	-	14.2
China	8854	0.8	35.8	3.7	3.8	2	0.3	-	47.5
Philippines	5409	0.3-0.7	41.6	19.5	13.8	1.3	4.8	-	17.9
Indonesia	5096	0.8-1	74	10	8	2	2	2	2
Sri Lanka	5047	0.2-0.9	76.4	10.6	5.7	1.3	1.3	-	4.7
India	3794	0.3-0.6	42	6	4	2	2	4	40
Vietnam	3502	0.55	58	4	5.6	1.6	1.5	1.8	27.5
Lao PDR	2260	0.7	54.3	3.3	7.8	1.5	3.8	-	22.5
Nepal	1760	0.2-0.5	80	7	2.5	3	0.5	-	7

Commercial Plastic material	Nature of Plastic	Thickness (μ)	Softening point (°C)
Cup	PE	150	100-120
Carry bag	PE	10	100-120
Water bottle	PET	210	170-180
Cool drinks bottle	PET	210	170-180
Chocolate covers	Polyester + PE + metalized polyester	20	155
Parcel cover	PE	50	100-120
Supari cover	Polyester + PE	60	120-135
Milk pouch	LDPE	60	100-120
Biscuit covers	Polyester + PE	40	170
Decoration papers	BOPP	100	110
Film	PE	50	120-130
Foam	PE	NA	100-110
Foam	PS	NA	110

Physical properties of waste plastics



3.4. Hazardous effects of Plastics

Polluting Substances

In terms of environmental and health effects it is important to differentiate between the various types of plastics. Most plastics are considered nontoxic (PVC is an important exception). Polyethylene (PE) and polypropylene (PP), for example, are inert materials (2), but it should be realized that plastics are not completely stable. Under the influence of light, heat or mechanical pressure they can decompose and release hazardous substances. For example, the monomers from which polymers are made may be released and may affect human health. Both styrene (which is used to make polystyrene, PS) and vinyl chloride (used to make PVC) are known to be toxic, and ethylene and propylene may also cause problems (3). The environmental effects of plastics also differ according to the type and quantity of additives that have been used. Some flame retardants may pollute the environment (e.g. bromine emissions). Pigments or colorants may contain heavy metals that are highly toxic to humans, such as chromium(Cr), copper (Cu), cobalt (Co), selenium (Se), lead (Pb) and cadmium (Cd) are often used to produce brightly colored plastics.

Cadmium is used in red, yellow and orange pigments. In most industrialized countries these pigments have been banned by law. The additives used as heat stabilizers (i.e. chemical compounds that raise the temperature at which decomposition occurs), frequently contain heavy metals such as barium (Ba), tin (Sn), lead and cadmium, sometimes in combination (Nagelh out, 1989).

Chapter 4

Plastic Waste Management

4. PLASTIC WASTE MANAGEMENT

4.1 PWM

Plastic Waste Management will involve activities associated with segregation, collection, storage, transportation, processing and disposal. Plastic waste disposal in an environmentally sustainable manner should be achieved by adopting principles of economy, aesthetics, and energy conservation and pollution control. It encompasses planning, organization, administration, financial, legal and engineering aspects involving interdisciplinary relationships.

India as a developing country needs simpler, low cost technology keeping in view of maximum resource recovery in environmental friendly manner. An advanced technological solution for plastic waste disposal available in developed countries but cannot be directly adopted in developing countries due to difference in waste characteristics, financial constraints and socio-cultural aspects. With the aim of restrain littering and have proper disposal process for plastic waste, following activities are required to enforce in plastic waste management.

4.1.1 Two-Bin/bag collection System

In order to follow appropriate plastic disposal technologies, segregation at source is essential. The recyclable waste material should be separated from food waste and other biodegradable waste, in a separate bin at the source of waste generation, by having a two bin/bag system for waste storage. It is proposed to have recycling waste collector is a waste trader of the network, and gives a plastics bag free to every household. The bags are clearly labeled/marked on them "Recyclable Waste" which could also be a bag for easy handling, since it will contain mostly dry waste and not wet "Bio-degradable Waste". This will be replaced when full with another bag. This way the plastic waste is separated out easily from other recyclable materials. The bio-degradable waste goes to the Municipal waste processing site for conversion into fertilizer and recyclable waste can be handed over to newly net worked this recycling system. The reuse of recyclable waste material will reduce processing cost drastically as well address the segregation needs and environment pollution.

4.1.2 Waste Exchange Center (WEC) as Porta cabin

A WEC is a waste collection point, placed in earmarked communities. It is most suitable for almost of the recyclable waste collection. The methodology as devised here is based on the operability of a system, which has three major factors:

1. Responsibility of a Urban local Body with respect to Plastics waste management as is in the PWM rules.
2. Harnessing the informal sector working for recyclable waste into a formal system.
3. Rehabilitation of waste pickers.
4. Picking the Litter lying around harming the earth and ecosystem.

There are usually a separate containers/ bag hangers for the collection of plastics, which are subsequently sorted into valuable and refuse fractions. For some polymers where cleanliness of the material is important, may be collected separately. Large sized containers and disposal apertures permit the collection of bulkier goods such as furniture, pipes, windows etc. They also enable some degree of control to be exerted over the types of waste deposited. Porta cabins can be used for temporal or fixed deposits as shown in figure no 1. The collection schemes established for industrial and commercial sectors usually have better results than for the household waste and municipal waste (from retail, small business). There are two main reasons for this. Firstly, the waste is concentrated in a reduced number of places; this is in contrast to household waste arising, which are geographically more dispersed, making collection more difficult. Secondly, wastes from industry are cleaner and better identified than wastes from households, which give a better value to this waste. Nevertheless, some professional sectors, like the agricultural or construction sectors, do generate quantities of films contaminated by such as earth, humidity etc.

Porta-cabin for collection of all Plastic Waste

4.1.3 Quality control

As already mentioned, the quality of the sorted plastics has a direct influence on its sale price. In order to maintain the desirable quality, routine quality control must be established. Samples of sorted materials should be analyzed in detail and the results compared with the requested quality.

This enables streams that have sorting deficiencies to be identified. A more detailed analysis will identify the cause of a bad sorting: misunderstanding of the sorting instruction, equipment failing etc. In order to maintain the desirable quality, routine quality control must be established. Samples of sorted materials should be analyzed in detail and the results compared with the requested quality. This enables streams that have sorting deficiencies to be identified. Reduction of volume and storing sorted waste plastics which can be bulky to transport and store. To make these activities more economical, some type of volume reduction process is necessary.

4.1.4 Bailing

This device reduces the volume of plastic waste by compacting, so that storage and transportation becomes relatively easier Baling is a suitable option for both films and bottles, providing a reduction in volume that aids storage, transportation and management of the waste plastics. The baler must be compatible with the baled materials and with the flow. Over-compaction may weld the waste together making it difficult to separate, whilst under compacted bales will be unstable and difficult to stack. Most balers can be used for several materials, but adjustments may be necessary. The choice of baler strapping is also important; it must be strong enough to contain long-term baled material and particularly if the material is to be stored outdoors, be rust-resistant. Polyester strapping or stainless steel is commonly used. For plastic bottles, previous perforation of the bottles improves the density of the bales.

4.1.5 Pre-shredding

For the big pieces of waste plastics, such as pipes or window frames, pre-shredding can be an interesting option in order to reduce the stocking area and the transportation costs. However, it is the responsibility of the sorting plant to evaluate the benefits of such equipment in relation with its price. This type of equipment can also be helpful in reducing the volume of other waste. As for the baler, the two important points to check are the material compatibility and the outflow of materials to shred. It is important to note that shredded material, particularly mixed shredded plastics are not accepted by some markets because quality standards beyond common sorting processes are required and therefore assured applications for the shredded material should be investigated.

4.1.6 Storing sorted waste plastics

Rain does not affect the quality of plastics; however, UV light does degrade the physical and chemical structure of most plastics. The effect of UV degradation varies according to the virgin polymer, therefore if plastics are to be stored outside, they should be protected by tarpaulins or other UV-protective material. To avoid contamination by dust and dirt, plastics should be stored on clean concrete floors; storage of the material on pallets can also reduce contamination. Where plastics are to be stored indoors, fire-safety and prevention systems should be installed. Plastic is flammable and while it is difficult to ignite baled plastics; it is much easier for non-baled material. As such, these considerations must be integrated into the planning stages of storage areas.

4.1.7 Collection and transportation

The collection and transportation of plastic waste on a daily basis is an imperative step. Since the waste cannot be removed as fast as it is littered, it is stored and transported as soon as possible at specific pre-defined frequencies by private traders.. The system of storage and types of vehicles are often compatible.

4.2 Micro Planning -life cycle assessment

An efficient and cost beneficiary system of waste management requires micro planning for collection, storage, transportation processing and disposal of plastic waste. This should also ensure an effective participation of the Government, citizens and NGO's in planning and waste management system.. Integrated sustainable waste manage model as shown in figure below.

Life-cycle analysis is a technique used to quantify the environmental impact of products during their entire life cycle. The different parts of the life cycle are examined from raw material extraction, manufacture, transport and use through to waste processing. For each stage, an inventory is made of the energy and material consumption and of any emissions to the environment. This makes it possible to identify components where improvement can be made to benefit the environment.

This type of investigation of products may bring economic advantages, as often material and energy consumption are reduced. Environmentally friendly products also have a marketing advantage, as consumers are becoming increasingly aware of 'green' issues. In addition, legislation is being introduced across the world to enforce environmentally friendly practices. The concept of product responsibility is commonplace and manufacturers and end-users must now consider the cradle to grave pathway of each product.

There are many different types of environmental impact. For example, plastics are generally produced from fossil fuels, which are gradually becoming depleted. The production process itself involves energy consumption and further resource depletion. During production, emissions may occur to water, air or soil. Emissions of concern include heavy metals, chlorofluorocarbons, polycyclic aromatic hydrocarbons, volatile organic compounds, sulfur oxides and dust. These emissions have effects such as ozone depletion, carcinogenicity, smog, acid rain, etc. Thus, production of a plastic product can have adverse effects on ecosystems, human health and the physical environment.

The Association of Plastics Manufacturers in Europe (APME) has been at the forefront in developing eco-profiles for the plastics industry and users of plastic products. ISO has been active in generating new standards on environmental management, notably the ISO 14000 family of standards. The Indian center For Plastics in Environment (ICPE) has conducted this study and is available on their website.

As one of the principal uses of life cycle assessment is to improve environmental performance from the first stages of product development. There are many factors to consider for each environmental impact assessment, so a system has to be used to highlight the most significant factors for comparisons to be made. One major advantage of plastic materials is their lightweight and strength - a thin polymer film may perform the same job as a thick layer of natural material, thus resulting in reduced material use and reduced energy costs in transport.

Life cycle analysis is a crucial technique for the plastics industry in the 21st Century. Manufacturers and suppliers need to demonstrate that they are acting responsibly towards the environment in all aspects of production, from the design phase through consumer use and abuse, to disposal of end of life components. This overview of the subject explains the factors to be considered, the terminology, the organizations involved in developing these techniques and the legislation, which is driving the whole process forward. The ISO standards relating to environmental management are also discussed briefly in the document.

4.3 Recycling of Plastic Waste

The practice of recycling post-manufacturing plastic waste has been in vogue, since the last many years. The recycling of plastic is done through different methods. The compacted bales of plastic waste should reach the recycling units by a dedicated supply chain network on a daily basis. Recycling of plastics waste is carried with a view to make an alternative product for better profit. Following issues should be taken into account, while recycling the plastics.

- Minimize the pollution level during the process
- Enhance the efficiency of the process, and
- Conserve the energy

The collected plastic from WECs of Mumbai has to be channeled properly to recycle unit, and the multilayered metalized plastic, which is littered in the area has to be recycled primarily at the plant. The selection of technological options to recycle/reuse of plastic wastes is depends upon the quality and quantity of plastics waste , the plant will receive. While determining the methodologies of recovery system, it is required to make a distinction between different recovery options namely:

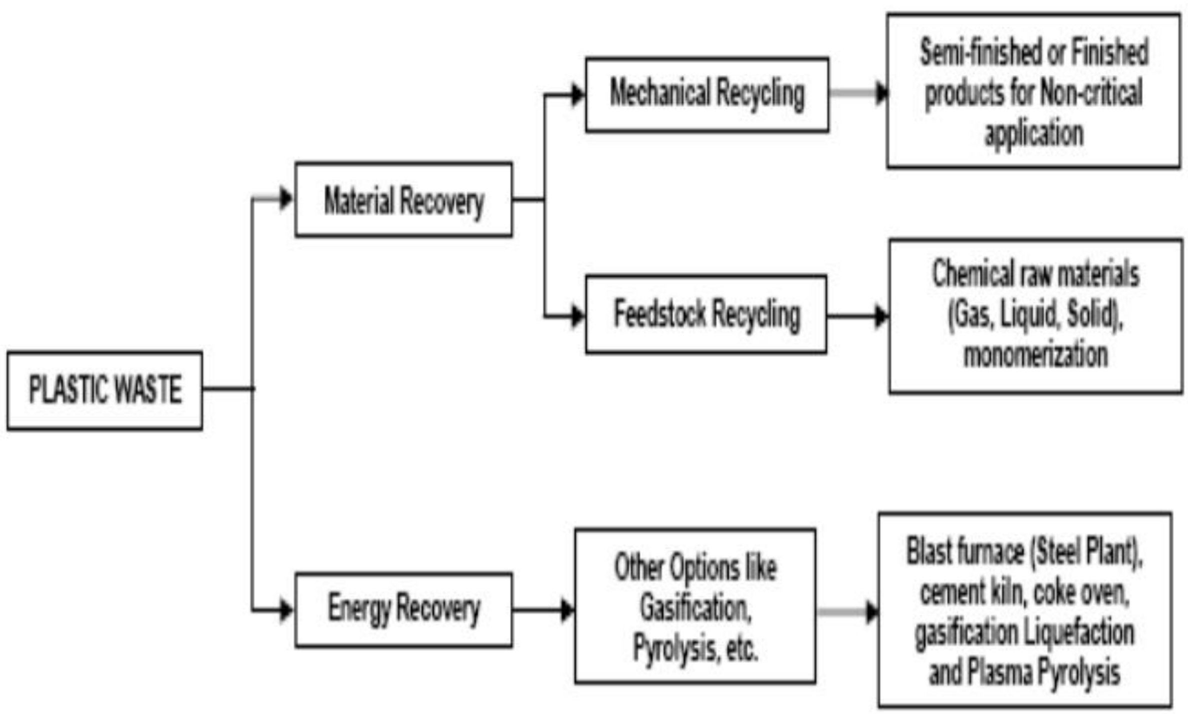
Primary Recycling (Conversion of waste plastic into products having performance level comparable to that of original products made from virgin plastics);

Secondary Recycling (Conversion of waste plastics into products having less demanding performance requirements than the original material);

Tertiary Recycling (The process of producing chemicals/ fuels/ similar products from waste plastics); and

Quaternary Recycling (The process of recovering energy from waste plastics by incineration). However, International Standards like ISO refers Plastics Recycling as a Recovery Process. The recovery has been divided into two categories namely material recovery and energy recovery.

The process flow chart for recovery process is depicted in Figure below:



4.3.1 Mechanical Recycling

Mechanical recycling involves processing of waste in to a product with characteristics similar to those of original product. This is the most preferred and widely used recycling process due to its cost effectiveness and ease of conversion to useful products of daily use. The limitation of this process is that the process requires homogenous and clean input. The process of mechanical recycling of waste plastics into products of varying usefulness mostly involves the essential steps namely:

- Collection/ Segregation (Plastic wastes are separated/segregated by Flotation Process in which varying density property of plastic waste is made use for segregating plastics);
- Cleaning & Drying (Post consumer plastic wastes require cleaning and drying than industrial waste. The wastes generated during these processes require proper treatment and disposal methods);
- Sizing/ Chipping (Cleaned plastic waste products should be sized/chipped to fed into the extruders for processing and palletizing and these operations depends upon the type and size of the plastic waste);
- Agglomeration/Coloring (Depending upon the end product, sized plastic waste is mixed with color master batch in high speed mixers/ agglomerators);
- Extrusion/ Pelletisation(Chipped plastics are plasticized and re-granulated to make the plastic material ready for fabrication) and finally fabrication into End Product.

4.4 Technological Disposal Options

The selection of appropriate technology for plastic waste disposal and its processes for the management of plastic wastes are available in market. Several processes and technologies have been explored and developed for plastic waste management. Some of these are:

- Chemical recycling of pet bottles into fibers
- Processing of plastic waste in Blast Furnace
- Co-incineration of plastic waste in cement kilns
- Utilization of plastic waste in road construction with bitumen
- Plasma Pyrolysis Technology for disposal of plastic waste and
- Gasification,

4.4.1 Chemical recycling of pet bottles into fibers

This method of plastic recycling, involves the breaking down of polymer chain in to their basic components, which can then be used in various industries. The feedstock plastic recycling process is flexible and more forbearing to the plastic additives, as compared to the mechanical plastic recycling. This is the most costly method of recycling. The varying end products are obtained by using following process;

Monomerization: The waste plastics are initially broken down into their constituent monomers by chemical reaction (depolymerization). These monomers are then extracted for use as the raw material in new plastic products. Monomerization produces higher quality plastic raw materials than material recycling. Which in turn enables the production of high quality plastic products with the same (or almost the same) quality as virgin raw material. Among other products, this enables the recycling of waste PET bottles into new PET bottles, which is not possible with other recycling technologies. About 50% recovery is possible through this process. The limitations of this process is that, the large scale process setup along with clean and single resin plastic waste as input is required.

4.4.2 Processing of plastic waste in Blast Furnace

Plastic waste can be co-incinerated as fuel in the iron and steel industry. This will reduce coal consumption and hence in reduction in the consumption of energy. The proportion of waste plastic added to coal should be about 1% by mass. Increased addition of waste plastic will reduce the heating strength of the coal/coke18. The use of plastic in coke ovens-a typical high-temperature process in the iron and steel industry was put in practice in the year2000 at Nippon Steel Corporation, Japan. In this process, the collected and baled plastic waste that has been agglomerated by pre-treatment is mixed together with coal and charged into coke oven. The mixed plastic waste and coal are carbonized in an oxygen-free reducing atmosphere at about 1,100 to 1,2000C. As a result, the waste plastic is thermally decomposed into coke (about 20%), tar/light oil (about 40%) and coke oven gas (about 40%). These products obtained by the carbonization of waste plastics have their own uses. When plastics are used together with coke, CO2 emission is significantly less. The excessive reducing gases are also used for blast furnace stove and power generation.

4.4.2.1 Blast Furnace: Plastics waste can be used as an alternative raw material in blast furnaces to generate energy for manufacturing of iron. Plastic waste can be successfully used as a reducing agent in blast furnaces for the manufacturing of iron from its ore. Use of coke in blast furnace provides only one type of reducing agent- carbon Monoxide. In contrast, use of plastic waste provides one additional type of reducing agent – Hydrogen. Advantage of this process includes use of all types of plastics including laminated plastics without creating any environmental pollution19. The high temperature inside the blast furnace around 20000C ensures that there is no possibility of any dioxins formation even if PVC is processed.

Furthermore, as the reducing atmosphere in the low- temperature region at the top of the furnace contains no oxygen, no dioxins are produced or resynthesized in the lower temperature zone also.

The plastics waste is first formed into suitable size either by crushing or pelletizing as necessary, and subsequently injected into the blast furnace from the tubers at the base of the furnace with hot air. The injected plastic waste material is broken down to form reducer gas- Carbon Monoxide (CO) and Hydrogen (H2). The reducer gas rises through the raw material layers in the blast furnace and reacts with iron ore to produce pig iron. The gas, after the reduction reaction, is recovered at the top of the blast furnace which has energy content to the tune of 800 kcal/NM3 and is reused as a fuel gas in heating furnaces within the steel plant.

4.4.3 Co-incineration of Plastics Waste in Cement Kilns

Keeping in view the problems associated with the disposal of plastic waste, CPCB initiated a study on "Co-incineration of plastic waste in cement kiln" in collaboration with Indian Centre for Plastics in the Environment (ICPE), MP Pollution Control Board and ACC Ltd. Co-incineration refers to the usage of waste materials as alternative fuels to recover energy and material value from them. The temperature in the cement kiln process is about 14000 ° C.

Excess level of oxygen and counter flow operation with the flue gases moving in a direction opposite to the materials lends a high degree of turbulence to the process. The presence of an alkaline reducing environment (lime) and the pre-heating of the raw materials by a preheated tower (>100 meter tall) acts as an ideal scrubber for hot flue gases before they are emitted into the atmosphere. The 3Ts- Time, Temperature and Turbulence in cement kilns provides extremely high destruction removal efficiency (DRE) for the plastic wastes. Coincineration leaves no residue as the incombustible, inorganic content of the waste materials are incorporated in the clinker matrix. Therefore, after the waste is co-incinerated, it becomes a part of the product. Co-incineration ranks higher on the waste disposal hierarchy and eliminates the need for landfills and incineration.

Based on the above study, the CPCB permitted the RDF and mixed plastics to be used in cement kilns and steel furnaces, as alternative fuel, which operates above 1200 degree centigrade.

4.4.4 Utilization of plastic waste in road construction

To address the plastics waste disposal issue, an attempt has been made to describe the possibilities of reusing the plastics waste (post-consumer plastics waste) in road construction. Central Pollution Control Board (CPCB) Delhi has published "Indicative Operational Guidelines on Construction of Polymer – Bitumen Roads for reuse of waste plastics (PROBES/101/2005-06). The document explains the method of collection, cleaning process, shredding, sieving and then mixing with bitumen for road laying. This study was carried out by Thiagaraj college of Engineering, Madurai and the report was circulated to all the State Pollution Control Boards / Pollution Control Committees and other road laying agencies for References.

By using this technology (plastics waste coated aggregate bitumen mix), several roads have been laid in the States of Tamil Nadu, Maharashtra, Puducherry, Kerala,Andhra Pradesh and Goa. To evaluate the performance of the built roads using plastics waste coated aggregate (PCA) bitumen mix and also to generate data base for evolving Standards by Indian Road Congress (IRC), CPCB has instituted a study on "Performance Studies of Polymer Coated Bitumen Built Roads during 2002-2007" to Thigarajar college of Engineering, Madurai. In this report parameters suggested by Central Road Research Institute (CRRI) and Indian Road Congress (IRC) have been incorporated. Further details of each test and its comparison with the IRC Standards have also been given in this report.

4.4.4.1 Process Details

Mini Hot Mix Plant

Step I: Plastics waste (bags, cups, thermocole) made out of PE, PP, and PS cut into a size between 1.18 mm and 4.36mm using shredding machine, (PVC waste should be eliminated)

Step II a: The aggregate mix is heated to 1650°C (as per the HRS specification) and transferred to mixing chamber.

Step II b: Similarly the bitumen is to be heated up to a maximum of 1600 C (HRS Specification) to have good binding and to prevent weak bonding. (Monitoring the temperature is very important)

Step III: At the mixing chamber, the shredded plastics waste is to be added over the hot aggregate. It gets coated uniformly over the aggregate within 30 to 45 secs, giving a look of oily coated aggregate.

Step IV: The plastics waste coated aggregate is mixed with hot bitumen and the resulted mix is used for road construction. The road laying temperature is between 1100c to 1200°C. The roller used is 8-ton capacity

Central Mixing Plant: The modified process can also be carried out using central mixing plant. The shredded plastics are added along the aggregate in the conveyor belt. A special mechanical device is developed which will spray the plastics inside the chamber to coat the plastics effectively. This also can be used as an alternative method CMP helps to have better control of temperature and better mixing of this material thus helping to have a uniform coating.

4.4.5 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. Plasma Pyrolysis is the thermal disintegration of carbonaceous material in oxygen-starved atmosphere. When optimized, the most likely compounds formed are methane, carbon monoxide, hydrogen carbon dioxide and water molecules.

4.4.5.1 Process Technology:

In Plasma Pyrolysis, the plastics waste is fed in to primary chamber at 850o 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 plastic 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 1500°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 sterio- thermophilus and bacillus subtilis immediately. Segregation of waste is not necessary, as the very high temperatures ensure treatment of all types of waste without discrimination.

4.4.6 Gasification

Gasification is a recycling method where waste plastics are processed into gases such as carbon monoxide, hydrogen and hydrogen chloride. These gases are then used as the chemical raw material for the production of chemicals such as methanol and ammonia. Almost all types of plastics, including those containing chlorine, can be recycled under the gasification method. This method is therefore suitable for miscellaneous plastics or plastics that are hard to sort.

In this process, the long polymer chains are broken down into small molecules, for example, into synthesis gas. The process may be fixed bed or fluidized bed gasification. In the fluidized process sand is heated to 600~8000°C at first- stage low temperature gasification furnace and plastic introduced into the furnace. Waste plastic break down on contact with the sand to form hydrocarbon, carbon monoxide and hydrogen. The gas from the low-stage gasification furnace is allowed to pass in second-stage high temperature gasification furnace with a steam at a temperature of 1.300~1,5000°C to produce a gas composed primarily of carbon monoxide and hydrogen.

At the furnace outlet, the gas is rapidly cooled to below 2000 °C to prevent the formation of dioxins. The gas then passes through a gas scrubber, and any remaining hydrogen chloride is neutralized by alkalis and removed from synthetic gas (2).Slag is produced as a by-product, which can be utilized as raw material for civil engineering works and construction materials. There are problems in controlling the combustion temperature and the quantity of unburned gases.

4.5 Assessment and Quantification of Plastic Waste Quantification in Sixty Cities

CPCB has sponsored a study to CIPET for Assessment and Quantification of Plastic Waste generation in sixty major cities. The objective of study is given below;

- To assess the type, nature and quantum of plastics waste in the country through field survey and physical assessment at 60 towns and Cities.
- Establish a Co-ordination mechanism with local Municipal/Metro corporations in identifying the dump grounds/Localities of higher waste generation for the physical assessment/characterization of MSW as per the prescribed methodology.
- To report on the existing methodology for collection of waste by urban local bodies/Municipal bodies in different states of the country.
- To suggest the viable and appropriate recycling technologies at major cities with investment estimation for effective Plastics waste Management (based on "Zero Waste Concept").

4.6 Biodegradable & Compostable Plastics

Compostable Plastics: The Plastics that undergoes degradation by biological process during composting to yield CO_2, water, inorganic compounds and biomass at rate consistent with other known compostable material and leave no visible, distinguishable or toxic residue.

Biodegradable plastics made with bio based polymers have been available for many years. Their high cost, however, has meant they have never replaced traditional non-degradable plastics in the mass market. Types of Biodegradable Plastics: There are several degradable plastic are reported such as: Biodegradable, Compostable, Hydro-biodegradable, Photodegradable and Biodegradable. Biodegradable Plastic Products: Starch-based products including thermoplastic starch, starch and synthetic aliphatic polyester blends, and starch, Naturally produced polyesters, Renewable resource polyesters such as PLA, Synthetic aliphatic polyesters, Aliphatic-aromatic (AAC) co polyesters, Hydro-biodegradable polyester such as modified PET, Water soluble polymer such as polyvinyl alcohol and ethylene vinyl alcohol, Photodegradable plastics, Controlled degradation additive master batches.

4.7 Plastics Waste Reduction Model

Waste Reduction Model (WARM) to estimate streamlined life-cycle greenhouse gas (GHG) emission factors for various plastics, beginning at the waste generation References point. The WARM GHG emission factors are used to compare the net emissions associated with management of plastics in the following four materials management alternatives: source reduction, recycling, land filling, and combustion (with energy recovery).

The general outline of materials management pathways for plastics in WARM for background information on the general purpose and function of WARM emission factors. WARM also allows users to calculate results in terms of energy, rather than GHGs. Plastics included in WARM are high-density polyethylene (HDPE), low-density polyethylene (LDPE), polyethylene terephthalate (PET), linear low-density polyethylene (LLDPE), polypropylene (PP), general purpose polystyrene (PS), and polyvinyl chloride (PVC). These plastics were chosen for WARM because they represent plastics commonly found in the MSW stream and comprehensive and complete data were available from a consistent source for these plastics due to the large number of end applications for plastics (e.g., bags, bottles and other consumer products) and the lack of data specific.

4.8 Plastics recycling & sustainable development

The recycling of plastic waste can be a positive contribution to a sustainable development policy, integrating environmental, economic and social aspects, within a framework of effective legislative instruments. Continuing advances in sorting and processing technologies is increasing the accessibility of waste previously deemed unsuitable for recycling. Greater ranges of materials are now accepted for recycling; while developments in collection and sorting systems continue to increase the quality of recycle waste generated. This is supported by R&D into new markets for secondary plastics, which is essential if plastics' recycling is to be sustainable. Research into new and existing practices will expand opportunities for secondary materials; what is currently not technically or economically viable may be so in the future. It should look towards the material needs of the present, using best available technologies and practices to meet market demands, while appreciating the impacts that future technological and material quality requirements will have on current practice.

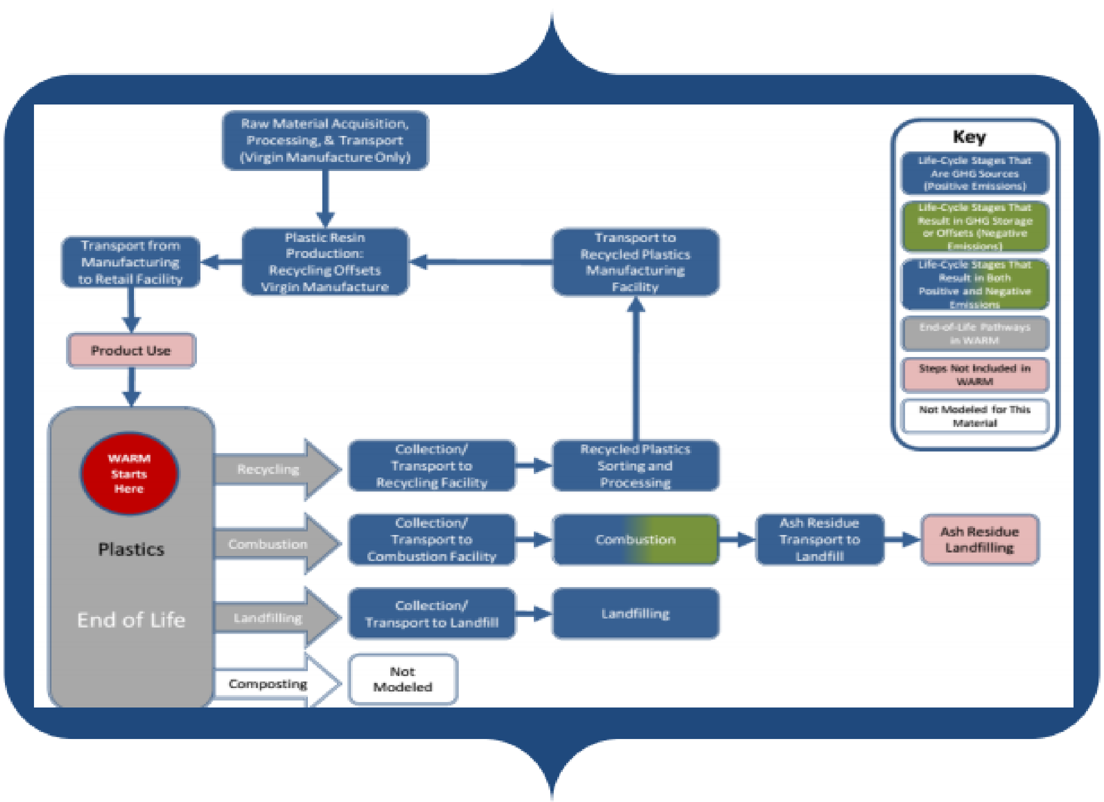
The benefits of recycling can be categorized into these aspects such as; environmental, economic, social and Environmental awareness of the population. These are briefly explained below.

4.8.1 Environmental aspects

There is this one environment system, which we all share and it must be treated with the respect and care it deserves. It is already been exploited to the maximum in its resource use and it makes sense to use them again if possible. This means that reserves last longer into the future. Moreover, recycling of plastic waste conserves natural resources, particularly raw materials such as oil and energy. The more that is recycled, the longer will natural resources be available for future generations. It means that there is less environmental impact due to mining, quarrying, oil and gas drilling, deforestation and the likes. If there are fewer of these operations, the environment will be safe from continuous destruction and degradation.

Another positive effect of recycling on the environment is that it may reduce emissions of substance such as carbon dioxide (CO2) into the atmosphere. From life- cycle analysis of reprocessed plastics and virgin plastics, it is known that the emissions of CO2, SO2, NOX (NO and NO2) are much smaller for recycled plastics compared to that for virgin materials (3). Hence the environment will be better safe from air pollution and global warming if recycling is adopted on large scales. Recycling of plastic wastes will also safe both ground and surface waters from pollution. This is because if discarded randomly, they choke gutters and even find their way into water bodies that serve as sources of drinking water for communities and towns. They also help to breed leachate that can seep into the ground there by contaminating groundwater bodies as well.

Life Cycle of Plastics in Waste Reduction Model



4.8.2 Economic aspects

Resource recovery reduces the quantity of raw material seeded in production processes. The reuse of plastic say therefore helps to reduce the dependence on ported raw materials and to save foreign currency. Due to increasing cost of virgin plastics as a result of dwindling oil reserves, the use of reprocessed pellets for product manufacture will save recycling companies from folding up as a result of high cost of importation of virgin pellets. The low energy and water consumption will save recycling companies from paying huge bills that could otherwise have adverse effect on their operations

4.8.3 Creating employment

Recycling can be an opportunity to create local jobs in collection, sorting, communications, administration and reprocessing. The reprocessing can be undertaken locally, regionally or beyond, and consequently the positive economic aspects of increased employment can be local or dispersed further afield. Job creation obviously brings many positive social effects.

4.8.4 Social aspects

The introduction of an intensive recycling strategy can avoid the need of new or additional incineration or landfill capacity. The setting up of such facilities is a challenge for the public authorities, which will inevitably face some degree of Nimby phenomenon, although this can be mitigated through effective, sustained public communications. However, in many cases recycling costs are higher than incineration; hence the cost for the citizen will go up.

Recycling of plastic wastes helps to keep the environment clean. Therefore diseases associated with filth will be prevented and this will save foreign exchange in the importation of drugs to fight cholera and malaria that may result from the rubbish heaps. Recycling will also create a healthy environment for tourists attraction Recycling is a source of job creation. Through recycling, numerous poor people will get employed particularly at the collection stage and hence be able to earn their living. This will help raise social standards and to eliminate vices in society.

4.8.5 Environmental awareness of the population

The introduction of recycling programs will heighten public environmental awareness. As a consequence, a significant fraction of population feels motivated to participate in schemes where they are offered. There often follows an increased demand – with local elected representatives targeted - to improve and extend the existing services to a wider variety of waste plastics. This enhanced awareness can be linked beneficially to plastics in general, improving the image of these materials (which are often associated with wastage, the throw-away society and litter). In addition, including plastics in multi-material collection schemes can raise the overall amount of materials collected from curbside collection schemes by between 20 – 30 per cent.

4.9 Bottlenecks of Plastic Recycling

Plastic waste recycling has increased the world over and has been largely successful. Nevertheless, much more effort must be done in order to reach terms of sustainable development. There are still some difficulties that the plastic recycling industry must overcome regarding technological bottlenecks for multilayered plastics recycling and those of demand from end-markets for the recycled materials.

Chapter 5

PLASTIC WASTE RECYCLING PLANT, MACHINERY AND EQUIPMENTS

5. PLASTIC WASTE RECYCLING PLANT, MACHINERY AND EQUIPMENTS

The primary engineering is done with industry interaction and focus has been on sorting systems with the technology intervention. Once sorted the products will be sent to recycling Industry and processed in house which does not sell routinely.

After the tendering and selection of the bidders as supplier, we have found the cost quoted as L1 (Lowest 1) is Rs.3, 25,000/- for the porta-cabins (Per Unit) and Rs. 1,76,90,000/- for the integrated sorting, bailing, shredding and conveyor belts (1 Unit). This price does not include excise duty of 12.5% and central sales tax of 5.25% besides other costs.

5.1 ELECTRICAL ITEMS AND DETAILS

For the Turnkey solution for the Waste Collection, Sorting and Recycling Facility following electrical items will be needed for proper and smooth operation.

Electrical Items and Details		
S. No	**Items**	**Details**
1	Transformer	• A 90KVA Transformer will be needed with necessary civil work, area coverage and earthing etc.
2	Main Control Panel	• A Main Control Panel (Distribution) inside the shed will be needed to distribute power to the different motors and the lights. • The Distribution Panel should have all the safety features for Overload, Short facing and should have necessary controls, buttons and bulbs. • It should also have provision for controlling the Power Factor etc.
3	Cabling/ Wiring	• All the Cables from Transformer to Distribution Panel, Distribution Panel to all Motors and equipment's should be provided along with proper cable trays or associated civil work. • Electrical wiring and fittings for light load inside and outside the shed.
4	Safety Features	• All safety features and latest systems and norms should be used to install and commission the electrical systems.

5.2 MACHINERY AND EQUIPMENT'S WITH BASIC DETAILS

Complete System Requirements			
S. No.	**Equipment**	**Quantity**	**Working Details**
1	VIBRATOR	1	A Vibratory Screen is needed to separate dust from the waste which is to be fed on to the Sorting Conveyor. All the collected waste is loaded on to this vibrator to remove dust.
2	FEED CONVEYOR	1	A Feed Conveyor will needed to convey the waste from the vibrator to the Sorting Conveyor
3	SORTING CONVEYOR	1	This is a slow moving 600mm wide Flat conveyor. The plastic/waste which can be monetized will be picked from the conveyor and will be dumped on any of the side conveyors (1 TO 3). All the waste which is of value will be hand sorted and the rest will go to the other side for shredding.
4	SIDE CONVEYORS	3	Side conveyors will be provided to convey the sorted waste to the bailing presses.
5	BAILING PRESS	2	Vertical Type Pressing balers will be needed to bale the sorted waste. Tied bales will be made and stored for selling.
6	SHREDDER CONVEYOR	1	An input conveyor for the shredder is required to charge the shredder. The waste will fall on this conveyor from the Sorting Conveyor and will primarily all waste which cannot be monetized.
7	SHREDDER	1	Shredder with a capacity of 500 Kg/hr is required to shred the waste. The shredded waste will be sold as RDF (Residual Derived Fuel) to any cement plant nearby Jhansi.
8	DISCHARGE CONVEYOR	1	A discharge conveyor will carry the shredded waste to one of the Bin for final removal from the Collection Facility.
9	BINS	14	Numbers of Collection Bins will be needed next to the sorting conveyors for collecting any foreign material which needs sending for land filling, dust and shredded waste. Some Bins will be used to collect material from side conveyors before bailing.

OPTIONAL EQUIPMENTS			
10	**BIO-CLAVE**	**1**	This is state of the art equipment which is optional and can be used if the waste coming from the Collection Centers is wet. This equipment removes all the moisture from the waste before it is transferred to the Vibrator Depending on the Height of the shed this unit will be provided with a Vibrator conveyor to take its output to the vibrator.
11	**FINE SHREDDER**	**1**	The fine shredder can be used to further shred the output of the shredder. This is primarily to make it compatible for to be used in Road Laying.
12	**PELLETIZING LINE**	**1**	In future if the quantity of the waste is very high then a complete Pelletizing line can be established to make granules which can be used to make products of Second Generation of Plastics. The complete line will include Washing Equipment, Associated ETP plant, Storage Tanks for water, Agglomerator, Extruder, Rotary Pelletizer.
13	**LUMBER MAKING MACHINE**	**1**	• Plastic Extrusion Plant & Machinery (with standard accessories) •**Production:** 80-100 Kg/Hr •**Power:** 300 HP •**Area:** 5000 Sq.Ft. •**Water:** 8-10Ltrs (80% reusable) •**Manpower:** 5 Skilled
14	**FUEL OIL MAKING MACHINE**	**1**	Gasolysis (Pyrolysis) is the decomposition of a condensed substance by heating. It does not involve reactions with Oxygen, or any other regents, but can take place in their presence. With this technology shredded plastic can be used to make fuel. With approximate batch of 100Kg of Plastic we can get approximately 30-40 Liters of fuel in 4 Hrs of cycle time.

5.3 OTHER MACHINERY

5.3.1 Single Shaft Shredders

Single shaft shredders are suitable to process waste materials which cannot be cut by using other types of size reduction machines. Waste materials which is very large in size or resistant to cutting action of other types of crushers and shredders can be recycled with single shaft shredders. Small sized rotating blades of single shaft shredders tear a small particle of material in each pass. By this way hard to process material sizes can be reduced easily and effectively. They are constructed very strong to last longer. Single shaft shredders are equipped with sieves. By changing with proper hole sized sieves, output material particle size can be determined.

5.3.2 Double Shaft Shredder

Double-shaft shredders are built to process many different kinds of waste streams in large volumes. Geometry of the shredder blades can be customized depending on material to be shredded. Two counter rotating shafts with special design blades and spacer combs placed between blades and attached to shredding chamber walls cut material into pieces with great force.

By this way hard to process material sizes can be reduced easily and effectively. They are constructed very strong to last longer. Single shaft shredders are equipped with sieves. By changing with proper hole sized sieves, output material particle size can be determined.

5.3.3 Agglomeration Machines

Agglomeration machines are a cost efficent way of recycling thin walled polymers. Agglomeration machines are used for physically transform loose plastic material into chips suitable to be fed the hopper of an extruder.

Agglomerator is a cylinder with five to nine stationary and two rotating blades at the bottom which create friction and heat. This process causes material to reach to the softening point. In this stage, operator add some water to create a kind of shock.

After water evaporates, material comes out from pneumatic operated discharge door as chips. Agglomerators can be used as material drier and densifier. Netplasmak manufactures agglomerators in various drum sizes.

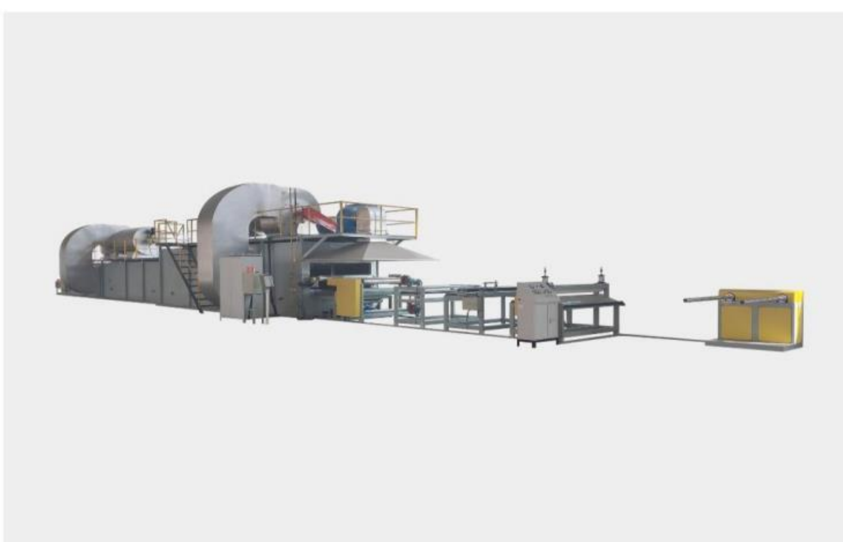
5.3.4 PLASTIC CRUSHING MACHINES GRANULATORS

Crushing machines are very important part of recycling. As per customer request, plastic crushers produced between 300– 1500 mm rotor sizes with capacity between 100 kg/hr to 2000 kg/hr. Crushing machines grinds waste plastics such as PE, PP, PVC, PET, Rubber, ABS, PS, PC waste materials. Plastic granulator's fixed and rotary blades are positioned with angle makes scissors movement. This prevents the dust, heat and also sound pollution with maximum capacity. Crushers produced with heavy-duty tough chassis and MIG welding method with heavy-duty bearings absorb vibrations and shocks caused during the crashing.

- Made of heavy-duty steel with GMAV - Gas metal arc welding
- Horizontal profiles in the funnel prevents the material from deflecting back during crushing.
- Heavy-duty type bearings easily absorb the crushing impacts.
- Power is transferred to the rotor via the B-type V belts in the safety shelter.
- Crushing Machine is designed to allow automatic opening closing of the body via the hydraulic unit in order to prevents loosing time when replacing the blades.
- In order to extend the lifetime of the blades and increase the product of the crushing process, the rotor and fixed blades are made of DIN 2379 material and heat-treated at 58 HRC.

Our crushing machine's crushing chamber is easily accessible. It is controlled by a hydraulic piston.

Crusher sieve can be changed quickly and easily Crushing machine's chamber is accessible from top and from bottom. Top part and bottom part is opened by pneumatic or hydraulic pistons.



5.4 Development of Plastic Bottle Shredding Machine

5.4.1 Introduction

Waste is now a global problem, and one that must be addressed in order to solve the world's resource and energy challenges. Everything we consume becomes waste including plastic bottles. Plastic is most commonly used material in the world today. They come in five major categories, the Polyethylene terephthalate (PET), High density polyethylene, Polyethylene (HDPE), the polyvinylchloride (PVC), the polypropylene (PP), Low density polyethylene. The disposal of waste plastics (PET, PP, etc.) is a biggest challenge, as repeated recycling of PET bottles poses a potential danger of being transformed to a carcinogenic material and only a small proportion of PET bottles are being recycled.

Plastic are synthetic organic materials produced by polymerization. They are typically of high molecular mass and may contain other substances besides polymers to improve performance and or reduce cost. These polymers can be molded or extruded into desired shapes. Plastic bottles are made from a petroleum product known as polyethylene terephthalate (PET), and they require huge amounts of fossil fuels to both make and transport them. It's harder to recycle plastic bottles than you think. Some plastic bottles consumed throughout the world, most of them are not recycled because only certain types of plastic bottles can be recycled by certain municipalities.

They either end up lying stagnant in landfills, leaching dangerous chemicals into the ground, or they infiltrate our streets as litter. There is a big disadvantage of plastic that is difficult to decompose. So we have to recycle the plastic and there are various methods for plastic recycling. As well as the scrap collectors also avoid to taking the plastic bottles because of its high volume and less weight. Machinery available is costly, so overcome this problem it is need to develop a low cost cutting machine. The project is about development of plastic bottle cutting machine which would help to the scrap collectors to crush the used plastic bottles and would thereby help in waste management and disposal the transportation cost also reduces. A cutting machine is designed to reduce large volume into smaller pieces.

Cutting is a process of transferring a force amplified by mechanical advantage through a material made of molecules that bond together more strongly and resist deformation more, than those in the material being crushed do. The equipment mainly consist a cutter, whose basic

5.4.2 Working principle

The plastic bottles have more volume compared with its weight, so due to this plastic bottles take more space than other scrape so the scrap collector avoids taking plastic bottles. If we crush or cut this plastic then it is convenient and economical to scrap collector to transportation and this cut plastic can be directly used for further processing. So we decide to make plastic cutting machine which is motor operated so it is affordable to the customer.

The bottle crusher is cutting the parts from the bottles with rotary cutting tool within a specified depth and the speed limit, then the two parts separately or it will be truncated. The machine is powered by motor. The principle of operation is as follows:

- Align the plastic bottle into the hopper.
- Cutter will rotate when the shaft is rotated after starting of motor.
- Bottle will cut when contact with the cutting tool.
- The scroll will fall in the collector provided. There are steel structural bar of L shaped are used of 3 types. The steel bars were welded to form the base of the machine.
- Type 1 plate with 600 mm length with 4 nose.
- Type 2 plate with 450 mm length with 2 nose.
- Type 3 plate with 300 mm length with 2 nose.

Figure 1: View of shredder.

Figure 2: Final model.

Chapter 6

CASE STUDY

6. CASE STUDY

6.1 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.

6.2 Reverse Vending Machine (RVM):

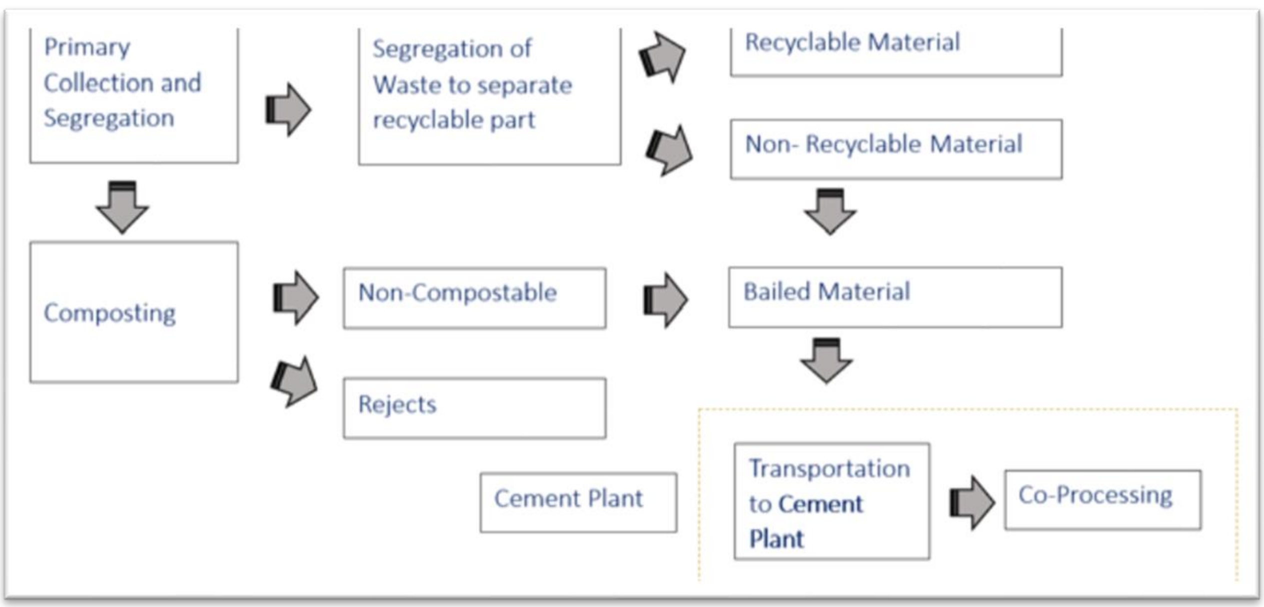
Machine specification

- 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.

6.3. 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. Coprocessing indicate substitution of primary fuel and raw material by waste, and/or material from waste. Waste material such as plastic waste used for coprocessing 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:



6.4 Plastic to Alternate Fuel

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.

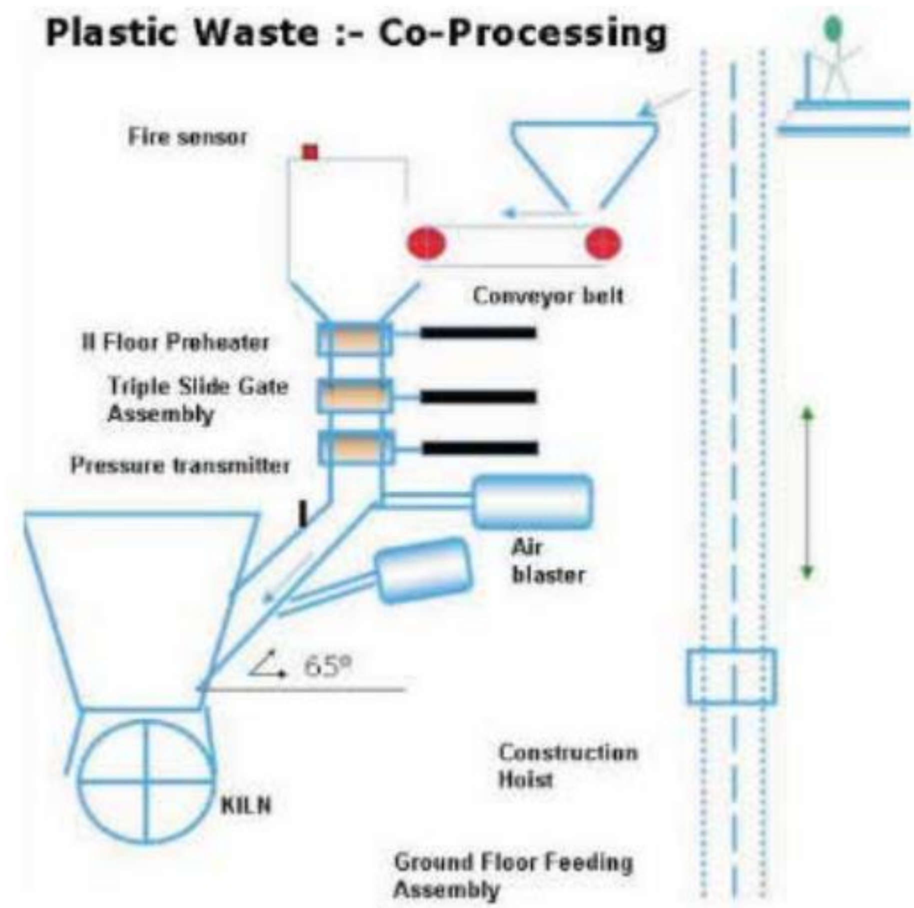
Project Details:

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 nonrenewable energy sources.


Plastic Waste :- Co-Processing
Fire sensor
Conveyor belt
II Floor Preheater
Triple Slide Gate Assembly
Pressure transmitter
Air blaster
65°
Construction Hoist
KILN
Ground Floor Feeding Assembly

Chapter 7

Conclusion

7.1 Conclusion

Thus, we have studied about plastic waste management along with types of plastic, its nature, how it is handled etc. We have also learned about various case studies. We learnt about how BMC operates and how precautions should be taken in future for proper handling of plastic. Also, we have studied how plastic has an adverse effect on nature and environment and how beach cleaning and other precautions are been taken.