TCE ENVIS RP

Included in GSDP Waste Management

Under MoEF & CC, GoI

PWM Manual

Plastic Waste Management

TRAINING MANUAL

Ver.1.0 - Revision 1

Plastic Waste Management - Manual

Plastic Waste in Solid Waste

INTRODUCTION TO POLYMERS

Polymers form a very important class of materials without which the life seems very difficult. They are all around us in everyday use; in rubber, in plastic, in resins, and in adhesives and adhesives tapes. The word polymer is derived from greek words, poly= many and mers= parts or units of high molecular mass each molecule of which consist of a very large number of single structural units joined together in a regular manner. In other words polymers are giant molecules of high molecular weight, called macromolecules, which are build up by linking together of a large number of small molecules, called monomers. The reaction by which the monomers combine to form polymer is known as polymerization. The polymerization is a chemical reaction in which two or more substances combine together with or without evolution of anything like water, heat or any other solvents to form a molecule of high molecular weight. The product is called polymer and the starting material is called monomer.

Historical Development of Polymers

Polymers have existed in natural form since life began and those such as DNA, RNA, proteins and polysaccharides play crucial roles in plant and animal life. From the earliest times, man has exploited naturally-occurring polymers as materials for providing clothing, decoration, shelter, tools, weapons, writing materials and other requirements. However, the origin of today's polymer industry is commonly accepted as being the nineteenth century when important discoveries were made concerning the modification of certain natural polymers. In eighteenth century, Thomas Hancock gave an idea of modification of natural rubber through blending with certain additives. Later on, Charles Goodyear improved the properties of natural rubber through vulcanization process with sulfur. The Bakelite was the first synthetic polymer produced in 1909 and was soon followed by the synthetic fiber, rayon, which was developed in 1911. The systematic study of polymer science started only about a century back with the pioneering work of Herman Staudinger. Staudinger has given a new definition of polymer. He in 1919 first published this concept that high molecular mass compounds were composed of long covalently bonded molecules

Polymer Classifications:

Classification of polymers giving the basis of classification and examples in each case is shown in Table

Origin:

There are on one side the natural polymers including proteins, nucleuo proteins and enzymes, the polysaccharides, natural rubber, natural gums, natural silk and other natural fibres, cellulosic and lingo-cellulosic, viz, cotton (cellulosic), and jute, ramie, flax, hemp, sisal, coir etc. (all lingo-cellulosic) containing different percentages (10 – 24%) of hemicellulose as well; lignin content is the least in flax (3 – 4%) and the highest in coir (30 – 34%). Lignin and hemicellulose contents of jute, a major bast fibre produced in India, are 11 – 14% and 20 – 23% respectively. Semi-synthetic (modified natural) polymers and synthetic polymers are also called man – made polymers. Synthetic polymers are man – made from the very outset. **Classification of Polymers:**

Basis of Classification	**Polymer Types**	**Examples**
1. Origin	(a) *Natural* (as available in nature)	Natural rubber, natural silk, cellulose, proteins, starch etc.
	(b) *Semisynthetic* (Man – made)	Hydrogenated, halogenated and cyclo (natural) rubber; cellulosics (cellulose esters/ethers), etc.
	(c) *Synthetic* (Man – made)	Polyethylene, polypropylene, poly-styrene, polybutadiene, nylon poly-amides, polycarbonates, phenolics, amino resins, epoxy resins etc.
2. Thermal response	(a) *Thermoplastics* (they soften or melt on heating and harden on cooling over many cycles of heating and cooling and retain solubility and fusibility).	Polyethylene, polypropylene, poly-styrene, nylon polyamides, linear polyester [poly (ethylene terephthalate)] , etc.
	(b) *Thermosetting* (they usually soften or melt initially on heating, but fast undergo chemical changes to finally turn insoluble and infusible).	Phenolic resin, amino resins, epoxy resins, diene rubbers (vulcanized), unsaturated polyesters.

3. Mode of formation	(a) *Chain – growth or addition*	Polyethylene and other polyolefins, Polystyrene and related vinyl polymers etc.
	(b) *Step – growth or condensation*	Polyesters and polyamides, polycarbonates, phenol (urea, melamine) – formaldehyde resins, epoxy resins etc.
4. Line Structure	(a) *Linear* (having no branches)	High density polyethylene (HDPE), polyvinyls, bifunctional (polyesters and polyamides) etc.
	(b) *Branched* (having branches)	Low density polyethylene (LDPE), higher poly (α-olefins), phenolic resoles and resitols, poly (3-hydroxy alkanoates) etc.
	(c) *Cross linked or network* (having a complex network structure)	Phenolic C-stage (resite) resin, C-stage amino (urea / melamine-formal-dehyde) resins, cured epoxy resin and unsaturated polyester resin etc.

Basis of Classification	**Polymer Types**	**Examples**
5. Application and Physical properties	(a) *Rubbers* (showing long – range elasticity)	Natural rubber, (1, 4 cis poly isoprene) synthetic rubbers (polybuta-diene, SBR, nitrile rubber, polychlo-roprene rubber, polylacrylate rubber, polyurethane rubbers, silicone rubbers etc.)
	(b) *Plastics* (shapable under pressure, aided by heat)	Polyethylenes, polypropylene (isotactic), polystyrene, poly (vinyl chloride), nylon polyamides linear aromatic polyesters and polyamides, polycarbonates, acetal resins etc.
	(c) *Fibres* (available in fibrillar or filamentous form)	Cotton (cellulose), natural silk, artificial silk (rayons), poly (ethylene terephthalate) fibre, nylon polyamide fibres etc.
6. Tacticity	(a) *Isotactic* (stereoregular)	Poly (α-olefins) and all vinyl and related polymers.
	(b) *Syndiotactic* (do)	
	(c) *Atactic* (stereo irregular)	

7. Crystallinity	(a) *Crystalline* (crystallinity, $\geq$ 50%)	Polyethylene (HDPE and LDPE), polypropylene (isotactic), stretched nylon polyamides, polyoxymethylene etc. cellulose (cotton) fibre.
	(b) *Semi – crystalline* (crystallinity, 30 – 50%)	Polybutene, cellulosics (cellulose esters (rayons) particularly if stretched), Gutta percha (1, 4 trans polyisoprene) etc.
	(c) *Amorphous or non-crystalline* (crystallinity < 25%)	Natural rubber and most synthetic rubbers,N-alkylated(>15% alkylation) nylon polyamides, poly (methacry-lates and acrylates) poly (vinyl acetate), polystyrene etc.

Thermal response:

A molecule of a linear polymer may be schematically represented by a simple line of finite length (straight or zig – zag, but usually wavy)(fig. 2 (a)). A molecule of a branched polymer may, however, be represented by a line of finite length with short or long finite – length branches attached to some of the repeat units in the chain molecule, fig.2 (b). A cross linked polymer can be represented by a network structure that may be a planar network as in graphite or space network, as in diamond, Fig. 2 (c and d). A linear polymer is best exemplified by high-density polyethylene (HDPE), while a branched polymer is exemplified by low-density polyethylene (LDPE) or poly (α – olefins). Linear and branched polymers are commonly thermoplastics, that are soluble and fusible, while the network resins or polymers are examples of thermosetting resins or polymers that turn ultimately insoluble and infusible.

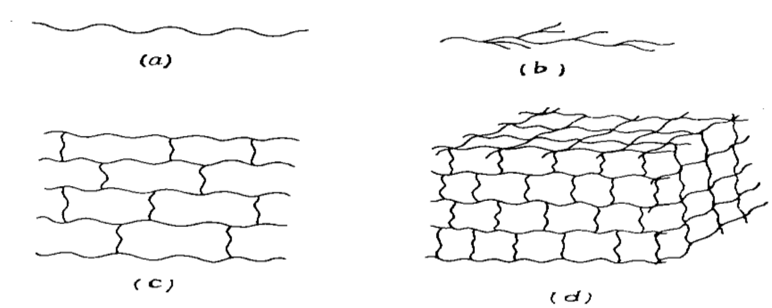


Fig. 2: Line Structures for different types of molecules

Tacticity:

A vinyl and related polymer *(CH_2 – CHR)* is characterized by an asymmetric carbon atom (marked with a little asterisk on it) in each of the repeat units of its chain molecules and a type of stereo chemical difference that may arise in the segments of the chain is *d –, l –* isomerism. Considering head to tail linkage of the repeat units, the stereo sequences may be all – *d* – or all – *l* – sequences, identified in terms of tacticity or spatial disposition of the substituent group, *R* as isotactic;

H H H H H H H H

– C – C – C – C – C – C – C – C – *(– d – d – d – d –)*

H R H R H R H R

Isotactic

Or

(like sequences)

H R H R H R H R

– C – C – C – C – C – C – C – C – *(– l – l – l – l –)*

H H H H H H H H

For alternate appearance of *d –* and *l –* sequences, the relevant polymer is called syndiotactic. The syndiotactic sequence or stereoisomer may be represented as

H H H R H H H R H H

– C – C – C – C – C – C – C – C – C – C –

H R H H H R H H H R

Syndiotactic

(Alternate sequences; (– d – l – d – l – d –))

A third distinguishable long chain sequence called atactic sequence would be given by a random spatial disposition of the substituent – *R* groups, also exemplified by a random mix of isotactic and syndiotactic sequences, viz.

H H H H H R H H H R H R

– C – C – C – C – C – C – C – C – C – C – C – C –

H R H R H H H R H H H H

Atactic

(Random sequence, (– d – d – l – d – l – l –))

Isotactic sequence is distinctive as being very regular, while atactic sequence is one that is highly irregular. Syndiotactic sequence may be viewed as regularly irregular or vice versa. Isotactic and syndiotactic polymers are considered as stereospecific or stereoregular while atactic polymers are viewed as random or stereo–irregular. The overall molecular symmetry and crystallinity are in the order isotactic $\geq$ syndiotactic >> atactic. Isotactic polymers are generally characterized by high melting temperature (T_m) and high mechanical properties with relatively high resistance to solvents and chemicals.

Need of Plastic In Society

During its short history of only less than 75 yrs, plastics have emerged as the material of choice in a diverse variety of applications. The World production of plastics has been on the increase exponentially and in 2013 stood at 288 MMT of resin. In terms of global per-capita consumption during the last few decades, plastics clearly outperformed competing materials such as wood, metal or glass as a material of construction. There is a continuing trend of the substitution of these competing materials by plastics in building, packaging, construction and medical devices. The reason behind this impressive market success of plastics is attributed to its unique functionality and low cost. Plastics are relatively lower in density and can therefore be inexpensively transported, durable under most environments, bio-inert allowing it to be used in food-contact uses, formable into complex shapes, recyclable at low cost and are cost-effective in most applications. With increase in global population and greater per capita use in developing regions of the World, plastics as a material is destined to continue its impressive record of use into the foreseeable future.

While numerous chemical classes of families of plastics have been developed a majority of the plastics products in use are based on only 5-6 of these. Those families of plastics used in high-volume (referred to as the commodity thermoplastics) are as follows: polyethylenes [PE], polypropylenes [PP], polystyrenes [PS], poly (vinyl chloride) [PVC] and poly(ethylene terephthalate) [PET]. These are referred to as *thermoplastic* as they can be melted at high temperatures and reformed into different shapes, enabling them to be recycled with ease. Another group of plastics (that includes polyurethanes and epoxy resins for instance) are the *thermosets* that do not melt and are not re-formable on heating.

Commodity thermoplastics are converted into market products via several steps. The virgin plastic resins are manufactured primarily out of petroleum oil and natural gas feed stocks via polymerization processes. This yields the familiar plastic 'prils' the raw material for product fabricators. This resin is often mixed intimately with other chemicals or additives, to allow high-temperature processing without degradation and to impart the specific properties demanded by the final product. This 'compounding' step involves mixing the chemicals with the melted plastics followed by re-pelletization. The plastic compound is then fabricated into useful products using a range of processing techniques such as extrusion and injection molding. The products are distributed to users and enjoy useful lifetimes that can range from a few minutes (in case of a food-service product such as a foam cup) to several decades in case of building products (such as an underground sewer pipe.) The useful life of most plastics products end due to cosmetic changes in appearance or health concerns on re-use (for example with single-use food service products such as plates or cups.) These post-use plastics are either recovered for reprocessing (recycling) or incinerated for energy recovery.

The Benefits of Plastic Industry

Plastic has benefited our society in a number of ways. In fact, plastic has helped aeronautics technology take giant steps forward over the past 50 years, including advancements in satellites, shuttles, aircraft, and missiles. As a result, civilian air travel has improved, as well as military air power and space exploration. In addition, the building and construction, electronics, packaging, and transportation industries have all benefited greatly from plastic.

Plastic in Aeronautics

Plastics were first introduced to the world of aerospace during World War II, mostly because other materials were limited. During the war, plastic slowly started to be used as a substitute for rubber in items such as fliers' boots and fuel-tank linings. Eventually, it became the preferred material for these applications. Plastic was then used with airborne radar systems and viewed as a significant advancement in this technology because it allowed waves to pass through with minimal loss.

The fact that plastic was able to withstand heat also lead to its being recognized as an important material in aerospace technology. Today, plastics are used in the solid fuel boosters form rockets and in the ablative shields for reentry of space shuttles.

Plastic materials are also used in the making of helicopters because they are rigid and durable, yet flexible enough to withstand the vibrations made by helicopters. The fact that plastic is both lightweight and strong also has its advantages in the field of aerospace because the weight of the aircraft can be reduced by using plastic. This results in improved aerodynamics, which leads to improved fuel efficiency and performance. In fact, reducing the weight of a jetliner by just one pound saves $1,000 in fuel during the liner's lifetime.

Plastics in the Building and Construction Industry

Plastics play a significant role in the building and construction industry as well. In fact, the industry is the second largest consumer of plastic, followed only by the packaging industry. In the construction industry, plastics are used for items such as pipes and valves. They are also used for decorative elements and heavy-duty uses because they are so easy to handle, are durable, and are attractive. Some decorative places plastics are commonly found include bathroom units, plumbing fixtures, flooring, siding, panels, insulation, windows, doors, gratings, glazing, and railings.

Within piping and valves, plastics are highly used because of their superior resistance to corrosion. In fact, they can be used for everything from freshwater to saltwater, from crude oil to laboratory waste. In addition, they are much lighter than other materials and easier to install. They are also less expensive.

Plastics and the Use of Electronics

Plastics are used with electronic devices for a wide number of purposes. Due to the thermal and insulating properties of plastic, it is ideal for use in house wiring. In fact, nearly all modern homes use plastic electrical connectors, switches, and receptacles.

Small appliances also take advantage of plastic. Plastic is durable, yet lightweight and attractive. Therefore, it is great for making small appliances such as can openers, food processors, microwave ovens, mixers, coffee makers, shavers, irons, and hair dryers. Even refrigerators use a special plastic foam for insulation purposes, while the interior is made from plastic that is durable and easy to clean. Without plastic, these products would last about half as long and would use 25-30% more energy.

Computers as we know them today would probably not exist without plastic. Plastic made smaller computers possible by being able to house all of the electronics necessary within a dust free and well-insulated environment. Components such as circuit boards and computer chips are able to be miniaturized without losing their abilities - or while also improving their performance - thanks to the use of plastic.

Of course, plastic has also made it possible to introduce electronics to children at younger ages. Even newborns can enjoy electronic toys to stimulate and entertain them as they grow. Thanks to plastic, these toys can be made to be safe and durable.

Plastics and Packaging

Plastic is so versatile, it can be used for a variety of packaging purposes. If the product needs to be well protected, the plastic can be rigid and tough. If, on the other hand, the packaging needs to be convenient to carry, the plastic can be flexible. Or, a combination of the two can be achieved. Furthermore, the packaging can be designed into any shape or size desired and it can be clear or any color imaginable.

Plastic packaging helps keep people, the earth, and animals healthy in a number of ways. For example, plastic packaging is used by medical facilities to dispose of needles and other items that may be contaminated. Similarly, fragile medical devices are often shipped in plastic containers because they can be precisely designed to prevent them from being damaged during shipping. Intravenous bags are also made with special see-through plastic to help the medical staff monitor the flow and intake of important nutrients and medicines.

Plastic is also used to store a variety of goods commonly found in the home. By creating shatterproof bottles with plastic, family members are protected from harm if the product should accidentally fall. Leak proof and child-resistant packaging can also be created with plastic.

Multi layered (ML) packaging comprises a thin foil of aluminum, which is sandwiched, or laminated in a matrix of paper and/or plastic layers. As per the CPCB, “multi layered packaging” means any material used or to be used for packaging and having at least one layer of plastic as the main ingredients in combination with one or more layers of materials such as paper, paper board, polymeric materials, metalized layers or aluminum foil, either in the form of a laminate or co-extruded structure.

Perfect Plastic: How Plastic Improves Our Lives

Strong, lightweight, and moldable, plastics are used in thousands of products that add comfort, convenience, and safety to our everyday lives. Plastics in carpets, blankets, and pillows keep us comfortable in our homes. Plastics in bottles and coolers allow us to take food and drinks with us anywhere. Plastics in portable electronic devices let us access the Internet or communicate with family and friends on the go. Plastics in sports players' helmets and police officers' bullet-proof vests keep them safe.

Plastic's light weight, strength, and ability to be molded into any form makes it an ideal packaging material. Rigid plastic keeps fragile items secure and flexible plastic makes easy-to-carry bags. Plastic is used for food and non-food packaging. Foods stay fresh longer when packed in plastic, which reduces waste by reducing the amount of spoiled food that must be discarded and decreases the amount of preservatives needed to keep food fresh. Advances in plastic technology has made plastic packaging more efficient: the average packaging weight for a product has been reduced over 28 percent in the last decade. Plastic packaging is convenient for consumers: clear plastic lets shoppers view the item they are purchasing and plastic packaging is easy to open. Plastic packaging protects food, medicine, and other products from contamination and germs when it is displayed and handled. Plastic also protects consumers. Tamper-proof packaging keeps consumers safe and child-proof packaging keeps children safe from accidental poisoning by medications or chemicals. Plastic is shatter-proof, which reduces the potential for injury from broken items.

Plastics and Transportation

Because plastic is both lightweight and durable, it makes an ideal material for manufacturing cars, trucks, and other vehicles. Plastics make up ten percent of new vehicle's total weight, and over 50 percent of their volume. Steering wheels, door liners, and stereo components are made of plastic, as are less visible parts, such as engine components. As plastic technology advances, many car companies envision using more plastic to lighten the weight of cars and trucks to make them more fuel-efficient. For every ten percent reduction in weight, a car or truck will save five to seven percent in fuel usage. Reduction in vehicle weight translates into a reduction in carbon dioxide emissions: every pound of vehicle weight that can be eliminated means 25.3 pounds of carbon dioxide emissions are saved over the vehicle's life.

Plastics also make vehicles safer and more comfortable. Life-saving seat belts and airbags are made of plastic. Plastic padded pumpers, door frames, foam door panel inserts, plastic foam filled roof supports, and pillars are structural components that keep occupants safer during a crash. Molded plastic fuel tanks are less likely to split apart during a collision and shatter-proof headlights are less likely to break. The windshield of most cars contains a layer of plastic between two sheets of glass, which makes the windshield less likely to break during a collision. Plastics are also used to make the seats and dashboards more attractive and easy to use. Interior features of vehicles, such as carpets, are often made of recycled PET plastics, giving new life to used plastic beverage containers.

Plastics and Energy Efficiency

Plastics can make your home more energy-efficient. Plastic sealants and caulks can seal up window leaks and plastic foam weather stripping can make doors and windows draft-free. Clear plastic sheeting for windows improves insulation and decreases drafts in the winter. Plastic blinds, window shades, and drapes help insulate windows by keeping out the sun in warm months to keep the house cooler and by keeping in heat during the winter months. Plastic awnings and reflective films also help shade the home. Many brands of high efficiency LED light bulbs are made from recycled plastic. Plastic insulation in the walls, floors, attic, and roof of your home keeps heat in during the winter and out during the summer, which saves you energy and money on your heating and cooling. Plastic foam spray fills large and small holes in walls, doors, and attics.

Plastics in Sports

Plastics are used in many sports to increase athlete efficiency and safety. Plastic helmets—used in many sports, from football to skateboarding—made from molded polycarbonate with interior plastic foam padding reduce head injuries and concussions. Mouth guards reduce injury to the teeth, jaw, and mouth during collisions and plastic foam pads protect players' shoulders, hips, tailbones, knees, and thighs from injury. Plastic foam pads down and distance markers in football and foam-wrapped goalposts protect players from injury during accidental collisions. Soccer players play with a plastic foam ball and polypropylene netting and benefit from foam shin guards, latex foam goalie gloves, and light-weight cleats. Even the turf of a football or soccer field may be made of plastic, which reduces water and fertilizer use and is recyclable. Plastic has many other uses in sports—from tennis players' lightweight and strong rackets to beach volleyball's wound nylon and plastic ball and runners' shock-absorbing shoes.

Plastics and Medicine

Plastics increase the efficiency and hygiene of medicine from the surgery suite to the physician's office. Plastic syringes and tubing are disposable to reduce disease transmission. Plastic intravenous blood, fluid, and medicine bags let health care workers more easily view dosages and replacement needs. Plastic heart valves and knee and hip joints save lives and make patients' lives more comfortable. Plastic prosthesis help amputees regain function and improve their quality of life. Pill capsules made of plastic ensure correct dosage release in the body over time, which lets patients take fewer pills. Plastic catheters and balloons allow doctors to open blocked blood vessels and insert plastic vessel supports to keep them open and dissolve harmful deposits. In addition to plastic eyeglass lenses, contact lenses, and eyeglass frames, plastics help victims of eye injuries or disease see again: silicone artificial corneas can restore patients' vision. Molded plastic hearing aids assist people with hearing loss to fully participate in conversations again.

PLASTIC WASTE MANAGEMENT

Introduction

- The first commercial plastic was developed over one hundred years ago, but the plastic became major consumer material only after the growth of the petrochemical industry in the 1920s.
- Now plastics have not only replaced many wood, leather, paper, metal, glass, and natural fiber products in many applications, but also have facilitated the development of entirely new types of products that are so versatile in use that their impacts on the environment are extremely wide ranging Once hailed as a 'wonder material', plastic is now regarded as a serious worldwide environmental and health concern essentially due to its non-biodegradable nature. Careless disposal of plastic bags chokes drains, blocks the porosity of the soil and causes problems for groundwater recharge.
- Plastic disturbs the soil microbe activity, and once ingested, can kill animals. Plastic bags can also contaminate foodstuffs due to leaching of toxic dyes and transfer of pathogens. The rapid rate of urbanization in India has led to increasing plastic waste generation.
- In fact, a major portion of the plastic bags i.e. approximately 60-80% of the plastic waste generated in India is collected and segregated to be recycled. The rest remains strewn on the ground, littered around in open drains, or in unmanaged garbage dumps.

PLASTIC INDUSTRY PROFILE

- The plastics industry in India has made significant achievements ever since it made a modest but promising beginning by commencing production of Polystyrene in 1957.
- The growth of the Indian plastic industry has been phenomenal - the growth rate is higher than for the plastic industry elsewhere in the world.
- Per capita consumption of plastic in India is less as compared to China and other developed countries.
- Packaging presents a major growth area where there has been a spiraling demand for plastics.
- Among the commodity plastics, polyethylene and PET are predominantly used in

packaging. Low density polyethylene (LDPE) is used in the manufacture of carry bags and PET is used in packaging beverages like soft drink and mineral water. PET in particular presents a major growth area in the years to come.

SOURCES OF PLASTIC WASTE

Plastic wastes are generated from a variety of sources and can be broadly classified as consumer, industrial, computer and other wastes.

- Consumer waste generated from residential households, markets, small commercial establishments, hotels and hospitals include milk pouch, carry bags, cups/glasses, buckets/mugs, pens, mats, luggage, TV cabinets, footwear, etc.
- Industrial sector generates barrels, crates, films, jerry cans, tanks, cement bags, tarpaulins, etc. as plastic wastes.
- Floppy, CD, monitor, printers, etc. are included in computer wastes.
- Other sources of plastic wastes include automotive, agricultural and industrial wastes; and the construction debris.

PROBLEMS RELATED TO PLASTIC WASTE

- The plastic content of the municipal waste is picked up by rag pickers for recycling either at primary collection centers or at dumpsites.
- Moreover, since the rag-picking sector is not formalized, not all the recyclables, particularly plastic bags, get picked up and are found littered everywhere.
- Littering is a very common phenomenon in India. One of the offshoots of littering is the choking of drains, streams, etc.
- Plastic films, bags are not permeable, and so they tend to hold other type of wastes thus blocking the way. This gives rise to flooding of the streets in the urban low lying areas with wastewater emanating foul smell and causing breakthrough of serious health hazards.
- Recently, cow deaths have been reported due to the consumption of scattered plastic bags along with the organic matter.
- Plastics are recycled mostly in factories, which do not have adequate technologies to process them in a safe manner. This exposes the workers to toxic fumes and unhygienic conditions.

- Dioxin, a highly carcinogenic and toxic by-product of the manufacturing process of plastics, is one of the chemicals believed to be passed on through breast milk of the mother to the nursing infant. Burning of plastics, especially PVC releases this dioxin and also furan into the atmosphere.
- Since toxic dyes and chemicals are used as additives during the recycling, the workers engaged in the recycling of plastic are constantly exposed to various toxic compounds.
- Polybag recycling is carried out in shanties, this problem is compounded due to poor ventilation, as workers find themselves inhaling contaminated air. Child labour itself is a big issue. Indian collection sector employ children below the age of 15 to collect them because of the low wages to be paid to the child and the ease of availability of child labour.
- Backyard smelters and plastic recycling units dot India's suburban/urban sites, taking lead battery scrap and plastic waste imported from developed countries such as Australia and the United States. The dangerous toxins emitting from the smelters have affected human, animal and plant life.
- The current situation is that the plastic recycling in the country is creating more problems and with the influx of plastic waste import it is getting aggravated. If imported, India should also import the technology along with the waste.
- Although plastics contribute only about 7% by weight to MSW, they may contribute 15% or more to the total heat content of MSW. Hydrogen chloride (HCl) gas is emitted during combustion of polyvinyl chloride (or other chlorinated polymers), and may result in corrosion of municipal waste combustor internal surfaces.

STATUES RELATING TO PLASTIC WASTE MANAGEMENT IN INDIA

In the last few years, state and central governments have started paying attention to the issues of plastic waste seriously. Consequently many legislations, acts and rules have been formulated to bring the situation under control. Responsibility to protect the environment and enforcing the existing regulation lies within the Ministry of Environment and Forests (MOEF).

- Government of Himachal Pradesh introduced HP Non-biodegradable Garbage (control) Act 1995 prohibiting throwing or deposing plastic articles in public places.

- The MOEF issued the criteria developed by Central Pollution Control Board (CPCB) in association with the Bureau of Indian Standards (BIS) for labeling 'plastic products' as 'Environment - friendly' under its 'Ecomark' scheme. One of the requirements for fulfilling this criterion is that the material used for packaging shall be recyclable or biodegradable.
- The Prevention of Food Adulteration Department of the Government of India issued directives to various catering establishments to use only 'food-grade' plastics while selling or serving food items. 'Food-grade' plastics meet certain essential requirements and are considered safe, when in contact with food. The intention is to preventing possible contamination, and to avert the danger from the use of the recycled plastics.
- **Recycled Plastics Usage Rules, 1998** were drafted in exercise of the powers conferred by clause (viii) of sub-section (2) of section 3 read with section 25 of the Environment (Protection) Act, 1986 (29 of 1986). It prohibits usage of carry bags made of recycled plastics for storing, carrying and packing the food stuffs. It allows the usage of carry bags, etc. [2] if the following conditions are satisfied, namely: -
  a) carry bags and containers made of recycled plastics conform to the specifications mentioned in the Prevention of Food and Adulteration Act, 1954 and the rules made there under;
  b) such carry bags and containers are not pigmented :
  c) the minimum thickness of carry bags made of recycled plastics shall not be less than 25 micron; and
  d) reprocessing or recycling of plastics is undertaken strictly in accordance with the Indian Standards, IS 14534 :1998 entitled " Guidelines for Recycling of Plastics" published by the BIS and the end product made out of recycled plastics is marked as "recycled" along-with the indication of the percentage of use of recycled material.
  e) The minimum thickness of carry bags made of virgin plastic shall not be less than 20 micron.
- **Recycled Plastic Manufacture and Usage Rule (1999)** addresses the issue of plastic bag. The rule prohibits the usage of carry bags and containers made of recycled plastic bags for storing, carrying and dispensing or packaging of foodstuffs. It mandates the

use

of only virgin bags of 20 micron of natural colour without any dyes and pigments for packaging foodstuffs. The rule specifies minimum thickness of the carry bags of virgin [5] plastic to be of 20 micron and of the recycled plastic to be of 25 micron. It allows the use of recycled poly bags of a minimum thickness of 25 micron for non-food applications provided the dyes and pigments used conform to the specification in the Food Adulteration Act. The rule calls for recycling of plastics to be carried out according to the Guidelines for Recycling of Plastics

- **Guidelines for Plastics Packaging and Packaging Waste in India** aims to 4prevent the production of packaging waste, encourage reuse of packaging, recycling and other forms of recovering packaging waste thereby reducing the final disposal of such waste. The guidelines cover all plastic packaging used in the market today. They emphasize the need to think of recycling not when the product waste accumulates, but at the start of the development process [5]. The guidelines call for establishing an organized system for recycling, reuse and recovery of plastics along with appropriate incentives and penalties.
- **Guidelines for Recycling of Plastics** were published with a view to bring discipline to the recycling practices in the country. These guidelines not only prescribe standards for the segregation and processing of plastic wastes but also instruct the manufacturer of plastic products to mark the basic raw material on the finished product. Also, it is necessary to indicate the percentage of recycled content in the product [5, 8].

WAYS TO REDUCE THE IMPACTS OF PLASTICS WASTES

Source Reduction: There are number of ways of achieving source reduction. Examples include:

- Modify design of product or package to decrease the amount of material used.
- Utilize economies of scale with larger size packages.
- Utilize economies of scale with product concentrates.
- Make material more durable so that it may be reused.
- Substitute away from toxic constituents in products or packaging.

Potential plastic markets that may be considered for source reduction include packaging, building and construction, consumer products, electrical and electronic, furniture and furnishings, transportation, adhesives, inks, and coatings.

Recycling: India ranks highest in terms of plastic recycling percentage (60%) in the world, whereas the world average is only 20% [1]. Recycling methods could be classified by following types [2]

- **Primary Recycling:** Melting, molding and solidification.
- **Secondary recycling:** Melting and extrusion or injection.
- **Tertiary Recycling:** Physical and chemical methods that include thermolysis (pyrolysis, catalytic cracking, hydro cracking, etc.) and depolymerisation (alcoholysis, hydrolysis, acidolysis, aminolysis, etc.).
- **Quaternary Recycling:** Incineration with energy recovery

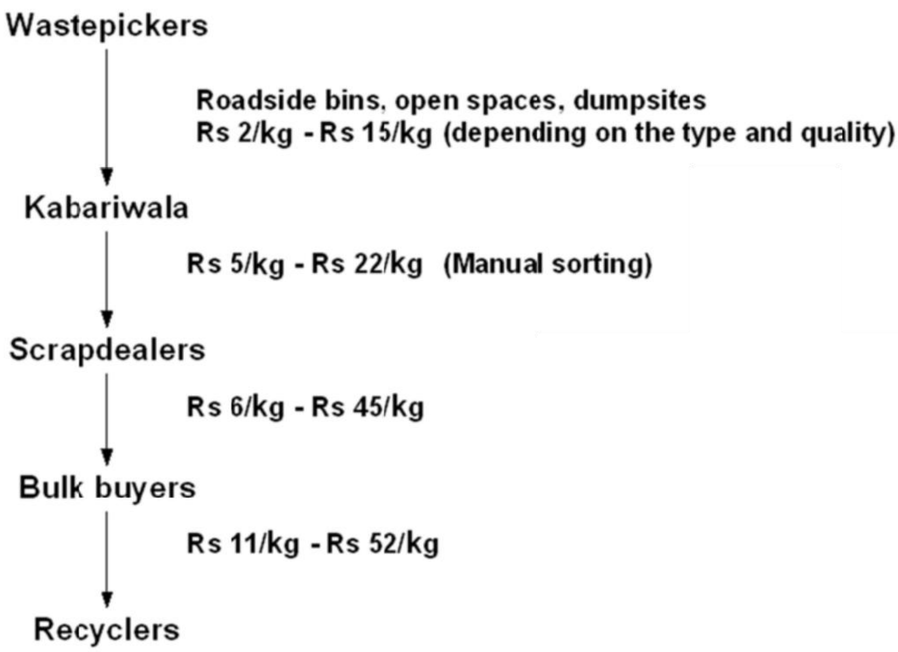
Phases of Plastic Recycling: Recycling plastics from MSW encompass four phases of activity collection, separation, processing/manufacturing and marketing [3].

Collection: Collection of plastics involves formal (municipal) sector and informal sector comprising of wastepickers, kabariwala, scrap dealers and bulk buyers. The municipality derives its funds for waste management either through funds designated by the Central Government and funds derived from property taxes.

Separation: It involves both formal and informal sector. Plastics segregated from MSW include a variety of resins. It is not necessary to separate plastics by resin type to allow their recycling, but separation by resin allows the production of the highest-quality recycled products.

Processing/Manufacturing: It may involve three different types of processes. *Primary processes* are defined as industrial recycling of manufacturing and processing scrap. Typically, such scrap is blended with virgin resins and reintroduced into plastics production processes. *Secondary processes* encompass a continuum of processing alternatives. One end of this continuum is defined by processes that consume clean, homogeneous resins that can be used to manufacture products interchangeable with those produced from virgin plastic resins. At the other end of this continuum are processes that consume mixed recycled plastics in the manufacture of products that do not replace or compete with virgin plastic products, but replace structural materials such as wood and concrete in product applications. *Tertiary processes* involve the chemical or thermal degradation of recycled plastics into chemical constituents that serve as fuels or chemical feed stocks. Tertiary processes may use either homogeneous or mixed plastics as inputs.

Marketing: This is the most important phase for the continuous recycling of plastics by informal sector. Homogeneous recycled resins are processed into products that compete in markets with virgin plastics. With currently available technologies, most mixed recycled plastics are processed into generally lower value products that compete in markets. Value addition of plastic waste across the informal sector is shown in following figure [4].



There are many problems for the plastic recycling industry in India. The supply of recovered plastic is rather volatile due to the decrease in the recovery rate year by year and the dependency on the fluctuating international market. Most plastic recycling enterprises are small and medium sized factories with obsolete equipment and technologies. Financial limitations are a constraint to the technical improvements needed to satisfy market demand. Plastic cannot be recycled indefinitely. In continuous recycling, plastic becomes too contaminated and degraded for use as a secondary material. Secondary pollution occurs during the recycling process. Some factories cannot afford to install pollution control facilities and must therefore discontinue production [5].

DEGRADABLE PLASTICS

Bioplastics are biodegradable plastics, whose components are derived from renewable raw materials. These plastics can be made from abundant agricultural/animal resources like cellulose, starch, collagen, casein, soy protein polyesters and triglycerides [6]. Large scale use of these would help in preserving non-renewable resources like petroleum, natural gas and coal and contribute little to the problems of waste management. Biodegradable plastics degrade over a period of time when exposed to sun and air [7]. Various types of plastic degradation processes and reasons for degradation are given in Table.

Table- Types of plastic degradation processes

Photodegradation	Degradation caused through the action of sunlight on the polymer
Biodegradation	Degradation that occurs through the action of microorganisms such as bacteria, yeast, fungi, and algae etc.
Biodeterioration	Degradation that occurs through the action of microorganisms such as beetles, slugs, etc.
Autooxidation	Degradation caused by chemical reactions with oxygen.
Hydrolysis	Degradation that occurs when water cleaves the backbone of a polymer, resulting in a decrease in molecular weight and a loss of physical properties
Solubilization	Dissolution of polymers that occurs when a water-soluble link is included in the polymer.*

*Note: soluble polymers remain in polymeric form and do not actually “degrade.” They are included here because they are sometimes mentioned in the literature on degradable plastics.

Though the demand for biodegradable plastics is increasing, acceptance of biodegradable polymers is likely to depend on factors like [8]

- Customer response to costs.
- Possible legislation by Governments.
- The achievement of total biodegradability.

Immediate application areas identified in India for biodegradable plastics are agricultural mulch, surgical implants, industrial packaging, wrapping, milk sachets, foodservice, personal care, pharmaceuticals, medical devices, recreational, etc. However, the legal framework for the 4 utilisation of biodegradable materials is still very unclear. Within waste management, local authorities in many parts of the world including India don't treat bioplastics as compostable material.

Salient Features of PWM Rules, 2016:

The salient features of the PWM Rules, 2016 are given below:

- PWM Rules, 2016 shall apply to every Waste Generator, Local Body, Gram Panchayat, Manufacturer, Importer, Producer and Brand Owner.
- Carry bag made of virgin or recycled plastic shall not be less than fifty microns in thickness. The provision of thickness shall not be applicable to carry bags made up of compostable plastic, complying IS/ISO:17088.
- Waste Generators including institutional generators, event organizers shall not litter the plastic waste. They shall segregate waste and handover it to authorized agency and shall pay user fee as prescribed by ULB for waste management or spot fine in case of violation.

- Within a period of six months from publication of PWM Rules, 2016 in official Gazette, Producer, Brand Owner shall work out modalities for waste collection system for collecting back the plastic waste generated due to their products, in consultation with local authority/State Urban Development Department and implement it within two years thereafter.
- Promote use of plastic waste for road construction or energy recovery or waste to oil or co-processing in cement kilns etc.
- Only the registered shopkeepers or street vendors shall be eligible to provide plastic carry bags to the customers for dispensing the commodities after paying

plastic waste management fees (minimum ₹48,000 per annum) to concerned Local Body.

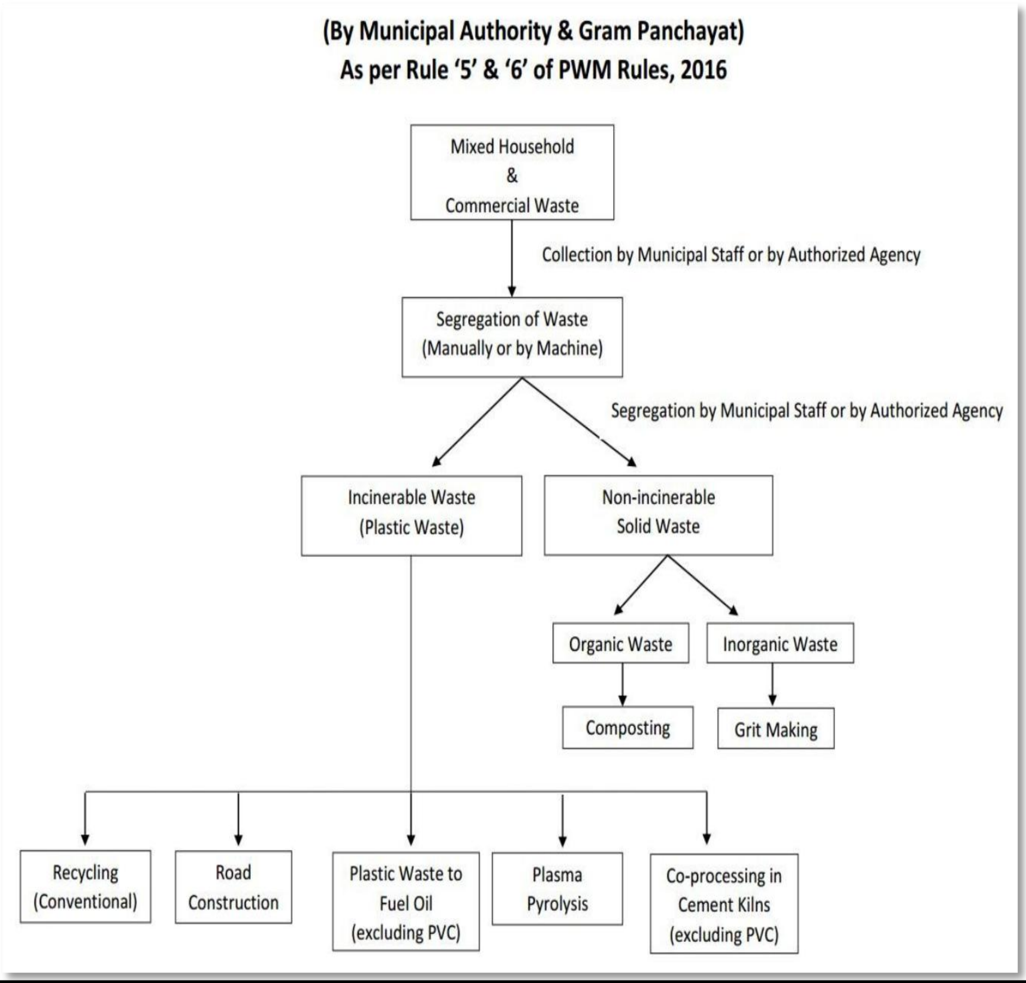
- SPCB/PCC shall be the authority for enforcement of the provisions of PWM Rules, 2016, relating to registration, manufacture of plastic products and multi-layered packaging, processing and disposal of plastic wastes.
- Concerned Secretary-in-charge of Urban Development of the State or a Union Territory and concerned Gram Panchayat in the rural area of the State or a Union Territory shall be the authority for enforcement of the provisions of PWM Rules, relating to waste management by waste generator, use of plastic carry bags, plastic sheets or like, covers made of plastic sheets and multi-layered packaging.

Present Status of Plastic Waste Management in India:

- As per the Annual Reports on Implementation of Plastic Waste Management Rules, 2016, the following key issues have been emerged;
- The manufacturing, stock, sale & use of less than fifty microns (<50μm) plastic carrybags is continued in majority of States/UTs. Besides, carrybags/films are manufactured, stocked sold and used without proper label or marking.
- Shopkeepers/Street vendors willing to provide plastic carrybags shall registered with Local Body by paying ₹48000/ annum @4000/month.
- Widespread littering of plastic waste is continued on road-side, railways tracks, open areas, open drains, river banks, sea-shores, beaches, public places like Bus-station/Bus-stops, open market etc.
- The estimated plastic waste (PW) generation in 25940 tons/day (based on per capita PW generation)
- A number of unlicensed/unregistered plastic manufacturing & recycling unit are running in residential or non-conforming areas.
- Accumulation of PW may lead to chocking of drains, cause land infertile, on ingestion by cattle's may lead to death etc.
- No proper system evolved by majority of Municipal Authorities for collection, segregation and disposal of PW.
- Many States/UTs have not constituted State Level Monitoring Committee (SLMC)

Body for implementation of PW (M&H) Rules, 2011.

- Open burning of PW is continued &may contaminate ambient air quality resulting into diseases to human beings



Technologies for Disposal of Plastic Waste:

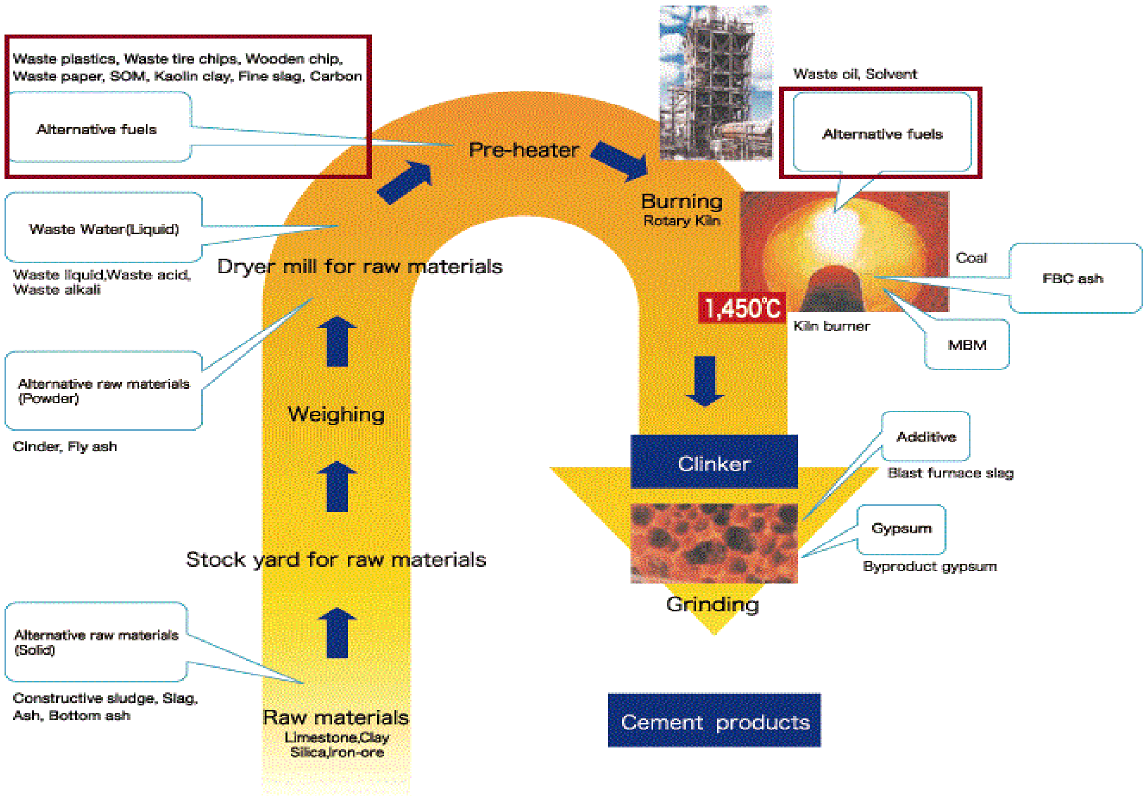
The provision '5(b)' of PWM Rules, 2016, encourages the use of technologies for disposal of plastic waste. The major technologies for the disposal of plastic waste are discussed below:

Utilization of Plastic Waste in Road Construction: -

Plastic waste is collected and segregated (except chlorinated/brominated plastic waste) from mixed MSW. The segregated plastic waste is stored and should be transported to the location working site for drying. The dried plastic waste is shredded to 2-4 mm size and added to heated stone aggregate followed by mixing. Further, the coated aggregate is mixed with hot bitumen, which is used for laying and compaction. The use of plastic waste in road construction shall follow the IRC: SP:98- 2013, titled as “Guidelines for the use of waste plastic in hot bituminous mix (dry mixing) in wearing courses”. Presently, several roads have been constructed by using plastic waste with bitumen in many of the States/UTs, such as: Tamil Nadu, Himachal Pradesh, Nagaland, West Bengal, Pondicherry etc.

Co-processing of Plastic Waste in Cement Kilns: -

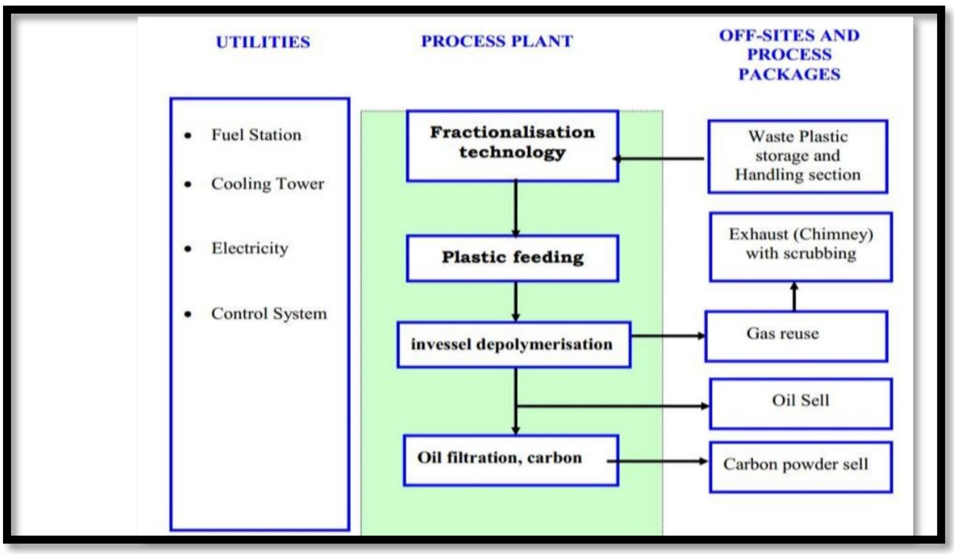
Co-processing refers to the use of waste materials in industrial processes as alternative fuels and raw material (AFR) to recover energy and material from them. Due to the high temperature and long residence time in cement kiln, all types of wastes can be effectively disposed without any harmful emissions. As per the Basal Convention, variety of



wastes including hazardous wastes, get disposed in an environmentally safe and sound manner through the technology of co-processing in cement kiln. In cement plants, plastic waste is used as Alternate Fuel and Raw-material (AFR), subjected to higher temperature around 1400ºC-1500ºC. During the process, energy is recovered while burning of plastic waste and its inorganic content get fixed with clinker. It requires an automatic feeding mechanism for feeding plastic waste to cement kilns. This technology is used successfully in some of the States where, cement plants (have facility for co-processing of waste) are present, such as: Gujarat, Tamil Nadu, Karnataka, Chhattisgarh, Himachal Pradesh, Madhya Pradesh, Odisha etc. Flow diagram for co-processing of plastic waste in cement kilns is shown at **Figure.**

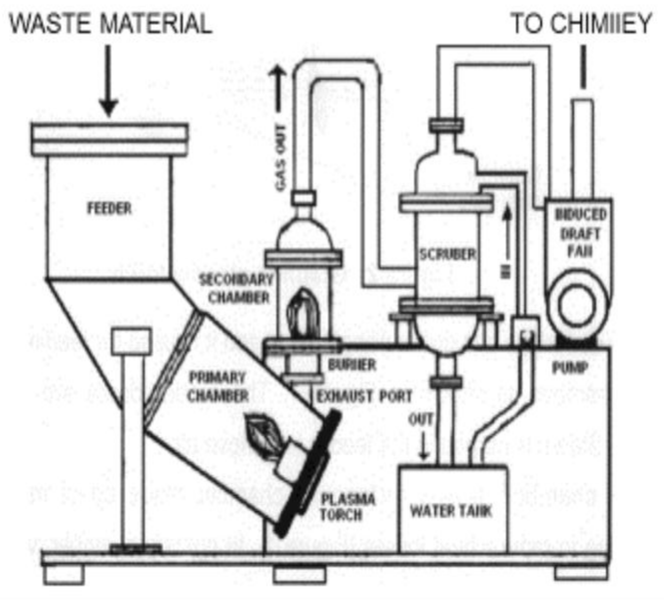
Conversion of Plastic Waste into Fuel-oil: Refused-derived Fuel (RDF): -

For converting plastic waste into fuel-oil (RDF), plastic waste is collected and segregated. The segregated plastic waste is then fed into multi fractionalization, where the unwanted material is rejected for better handling & processing. The segregated plastic waste (only HD, LD, PP and multilayer packaging except PVC) is then fed into in-vessel for depolymerisation system. The Catalytic Gasolysis in-vessel is designed to handle polymers. The selection of catalyst depends on the type of raw material used. The reactor operates at high temperature and in absence on Air. At high temperature, the polymers are Gasolysied to small chain hydro carbon linkage. The vapors produced are condensed in the Condensers and collected as crude oil.



Disposal of plastic waste through Plasma Pyrolysis Technology (PPT): -

Plasma pyrolysis technology is the disintegration of organic/inorganic compounds into gases and non- leachable solid residues in an oxygen-starved environment. Plasma pyrolysis utilizes large fraction of electrons, ions and excited molecules together with the high energy radiation for decomposing chemicals. In this process the fourth state of matter i.e. plasmas (core temperature is around 20,000°K) is used for dissociating molecular bonds. Different types of plastic waste such as polyethylene bags, soiled plastic, metalized plastic, multi-layer plastic and PVC plastic can be disposed through PPT. In Plasma Pyrolysis, firstly the plastics waste is fed into the primary chamber at 850 ^{O}C through a feeder. The waste material dissociates into carbon monoxide, hydrogen, methane, higher hydrocarbons etc. Induced draft fan drains the pyrolysis gases as well as plastics 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 1050^{O}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). This process is used by few Municipalities and hospitals; however, this can be useful for tourist place, hill stations, pilgrimage, coasts and other remote places.



Plastic Road Laying:

This is plastic age. Plastics otherwise polymers have found their uses in many fields like packaging, electrical and electronically, fertilizers, agriculture, toys and engineering materials, domestic appliances, building materials and so on. Ten metric tons is the expected consumption for 2017 and it will rise to 20 Metric tons in 2020. Today plastics have become common man friend. It occupies all the essential things in their life like furniture's, plates, etc. The most important application or use of the polymeric materials is their use in packaging industry as carry bags, tea cups, sheets and films, multi layered films and thermocoles. This occupies 35 % to 40 % of the total plastics consumed every year. The polymers used for the manufacturing of packing materials are polyethylene, polypropylene and poly styrene. PVC is used in the manufacturing of wires, electrical tube, flex etc. These packing materials once used are thrown away into the environment / solid waste as waste materials. These materials get collected in places like water canals, rivers and mostly it will mix with the municipal solid waste (nearly 9 %). This results in water clogging, creating stagnation of sewage water and poor hygienic conditions. Moreover plastics are not bio degradable. The accumulation of waste plastics at various corners is an eye shore. The presence of waste plastics in the MSW also contaminates the organic waste available in the MSW, which is used for manure conversion. Thus plastic waste had become a major cause for the environmental pollution.

Government does not have any clue to avoid this pollution; rather they are planning to ban the use of plastics. Plastic manufacturing is a major industrial development of our country, in which more than 10 crore peoples are engaged. More over the plastic industry comes under the subsidy industrial scheme of the government. Hence the banning of use plastics will result in a major economical disorder in the country. To avoid this situation the government had even taken various steps to reduce the use of plastics like increasing the thickness of carry bags, creating awareness to reduce the use of plastic material, recycling of recyclable waste plastics and reuse of waste plastics. So the banning of plastics will not be solution for plastic pollution. Finding solution to plastic pollution is the need of the hour.

Plastics are always common man's friend. It finds its use in every field and the consumption of plastics increases day by day. Nearly 50% of the plastic consumed is used for packing. The most used plastic materials for packing are carry bags, cups, thermocoles and foams. These materials are made from polymers like Polyethylene, polypropylene and polystyrene. (The tubes and wires are made out of poly vinyl chloride)

These materials, once used are thrown out or littered by us more because of wrong culture. They mix with Municipal Solid Waste. As they are non- biodegradable, the disposal is a problem and they cause social problems contributing for environmental pollution as they are disposed either by burning or by land filling.

Yet these packing materials (either mono layer or laminated poly layers made out of poly ethylene, poly propylene and poly styrene) can be easily used for various uses like road construction and block making, without affecting the environment. (Poly Vinyl Chloride is not used –note) and it is the best way to dispose the waste plastics.

These plastic materials when heated to around 120^0c to 150^0c, they melt and in their molten state they can be used as a binder. Only if they are heated to temperature more than 250^0c they may decompose producing gaseous products which results in air pollution. Coating molten plastic over granite stone can be done around 150 ^{o} C and the coating helps to bind with bitumen strongly resulting in better mix for road construction and the quality of the stone also improves by closing the voids. PVC is not used due to its toxic nature.

Plastics waste (Carry bags, cups, thermocoles and foams) is shredded into small pieces (between 1.6mm – 2.5mm). The granite stone is heated to around 170^0c. The shredded plastics waste is added to the stone. It get melted and coated over stone in just 30 seconds. Then the bitumen is added and mixed. The mix is used for road construction. From rural roads to National High ways all types of roads can be laid using this technique.

Waste plastics like carry bags, disposal cups, thermocoles, multi layer films and polyethylene and polypropylene foams can be used without segregation and cleaning. The process needs no new machinery and it is in situ process. The overall consumption of bitumen is less by 10 to 15% and thus the coat is reduced. By laying I Km single lane plastic road, 10 lakhs carry bags are consumed with a saving of 1 ton of bitumen (Rs 40,000).

It also helps to avoid the entry of 3 tons of CO_2 in the atmosphere, if it is otherwise disposed by burning. Value addition to waste plastics is being created. Use of pavement scrap waste for plastic tar road reduces the cost by 50%.

Plastic tar road has double strength, compared to ordinary bitumen road. It can withstand both heavy load and heavy traffic. It is not affected by rain or stagnated water. And hence no pot hole is formed. There is no rutting and raveling. The life of the road is not less than seven years and there is no need for maintenance expenditure. Performance studies of the plastic tar road were carried out as per Central Road Research Institute specification and the results are very good. It has been published by CPCB and NRRDA as monographs.

A comparative study for 25mm thickness SDBC-10mm^2

Material	Plain bitumen process	Plastic-tar road
60/70 Bitumen	30kg	27kg
Plastic waste	-	3kg

Monitoring of test roads were carried out using structural evaluation, functional evaluation and conditional evaluation studies. Generally all the roads laid over a period from 2002 to 2006 are performing well. The results obtained for these roads helped to conclude that these roads are performing very well in spite of their age. Under the similar conditions most of the bitumen roads are not performing well at all. These roads have not developed even small cracking and a pothole. The roads were distributed over the different localities of Tamil Nadu exposed to various environmental conditions like temperature, rainfall, etc., yet the roads are performing well.

In the construction of plastic tar road, the technology can be used in both mini hot mix plan and in central mixing plant and hence there is no problem of scaling up of this technique to larger extent. In the case of financial benefits, by using this process an extent of 10 % of the total project cost will be reduced. This is due to the reduction in the use bitumen and reduction in maintenance cost expenditure of the road. The life of the road is not less than 10 years.

Reuse of waste plastic in road construction is a suitable solution for the disposal of waste in an eco friendly and thus avoiding the pollution created by the plastics in the environment. Presently the waste plastics are either land filled or incinerated. Both the processes are non technical and it will affect the environment in near future. In this context since the project of plastic road laying avoids land filling and incineration of waste plastics, it is considered as an effective process for the disposal of waste plastics.

Scientifically plastics are the byproduct obtained from petroleum refineries and hence they are hydrocarbons only. Bitumen is also byproduct obtained from petroleum distillation. Hence there should be compatibility between plastics and bitumen and also with other products from petroleum distillation. This behavior was tested and proved technically.

Attempts were made to modify bitumen by dissolving plastics in bitumen. This was partly successful but we could dissolve only lower percentages of plastic (1 % to 3 %) in bitumen. Moreover the scaling is also very difficult and the process involves high costing. Hence there is a need for another alternative method. A newer method has been developed by coating waste plastics over hot stone aggregate and uses the same for road construction. Here the consumption of waste plastics is high (10 % to 15 %). This method is patented in 2002 by Dr. R. Vasudevan. This technology was also coded by the Indian Road Congress in 2013(IRC-SP-98-2013). Using this technology more than 50, 000 Kms of road has been laid in India.

For a 1 Km length road of width 3.75 m we need one ton of plastics. India has 41 lakhs Kms of roads. If all the roads are converted/made to plastic tar road we need more than 100 lakh tons of waste plastics and practically India does not have this much waste plastics. We have only 16 lakhs tons of waste plastics only.

The performances of the roads laid were also studied under the guidance of Central Pollution Control Board, New Delhi. The results obtained were highly encouraging. Moreover the use of waste plastics in this technology is high and we can use 10 % to 15 % of waste plastics to the weight of bitumen.

Critical Challenges in Implementing Plastic Tar Road Process:

The process is very simple and in situ, no external industries are involved. The plastic tar roads are performing very well even after 10 years without any permanent deformations like rutting, raveling, edge cracking and potholes. It helps to use waste plastics and the process is eco friendly and hence the disposal of waste plastics is not a problem.

1. Though plastics waste is available in large quantity it is not properly collected and made available for the use of this technique.

2. Self help group consists of village ladies are being employed for the collection of waste plastics. They have been given financial aid and support by the government. Since the road laying contractors are not in favor of this technology, the self help groups are not able to get expected business.
3. Awareness among the technology group is less and they show less interest in the process.
4. Awareness camps can help the younger generation. But it is not properly extended or promoted in spite of government schemes like Swachh Bharat.
5. This technology is made in India. Yet it has not taken off as expected.
6. The role of politician is very important, who can only promote this technology.
7. Presently, the addition of waste plastics in process of road laying is done manually. If the process is automated the process will become still more successful.
8. Most of the contractors are not in favor of this technology as the plastic roads are durable in nature and cannot be relayed soon.

Further works helped to develop other products like PLASTONE blocks a substitute for paver blocks. This product consumes a large amount of waste plastics. Plastone blocks can be used as road side paver block. The Plastone blocks manufacturing process also helps in the reduction in the use of cement, sand and water, since the process use waste plastics as a binder. Hence by using these technologies almost all the plastic waste available in the country can be reused and the disposal of waste plastics will no longer be a problem.

Moreover the waste plastics which were thrown to the streets will get a **value addition**. The use of waste plastics in the present project directly creates a demand for waste plastics in the market. Already in many states the self help group and some other NGOs are been involved in the process of collection waste plastics. They collect and shred the waste plastics and sell it to the concerned authorities for Rs 20 to 25 per Kg. This becomes a good employment.

The government is also taking measures under **Swachh Bharat**, which has become handy to collect the waste plastics. A system is to be developed to collect the waste plastics, shredding and construction of road. Cooperation from the engineers and the contractors is very much needed. If the system works well, the problem of disposal of waste plastics is almost solved.

The project also insists in the practice of good garbage culture among the public. The project can become success if the segregation of waste plastics at source is practiced in all over the country. When the waste plastics mix with the MSW, the segregation becomes a tough job. The project also suggest various possibilities in collecting the waste plastics at source, like two bin system, awareness camps for the public and own your ownership technique. Awareness camps and lectures are being organized to educate the school students to motivate them and help to collect the waste plastics at the source. It is partly successful too.

K K Plastic Waste Management:

K K Poly Blend is a polymer blend made out of plastic carry bags/packing material. The K K Poly Blend is cheaper than all existing bitumen modifiers and is the best binding agent for bitumen.

Process Adopted: We have devised an end to end process for collecting all kinds of plastic waste from the garbage, its sorting, cleaning and shredding to manufacture flakes called as KK Poly Blend; using exclusively patented in-house manufactured machineries for this purpose. This blend is mixed in the ratio of 8: 100 to the total weight of bitumen in hotmix plant. In hotmix plant, we pump the material using specially designed machineries where the blend is sprayed on aggregate at 160 degree Celsius. The plastic gets coated to aggregate and then over coated with bitumen thereby enhancing the bonding strength of aggregate and bitumen. The mix needs to be laid minimum of 100 degree Celsius while asphalting roads for better results.