STUDY OF THE UTILIZATION OF WASTE TYRES & LI-ION BATTERIES FROM ELV IN AUTOMOTIVE INDUSTRIES AND NRPW THROUGH CO-PROCESSING IN CEMENT PLANTS AS AN ALTERNATIVE FUELS & RAW (AFR) MATERIALS PROMOTING CIRCULAR ECONOMY

Thesis submitted in partial fulfilment of the requirements for the degree of

MASTER OF ENGINEERING IN

MECHANICAL

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By

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FACULTY OF ENGINEERING AND TECHNOLOGY
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CERTIFICATE OF APPROVAL*

This foregoing thesis is hereby approved as a credible study of an engineering subject carried out and presented in a manner satisfactory to warrant its acceptance as a prerequisite to the degree for which it has been submitted. It is understood that by this approval the undersigned do not endorse or approve any statement made, opinion expressed or conclusion drawn therein but approve the thesis only for the purpose for which it has been submitted.

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CERTIFICATE OF RECOMMENDATION

We hereby recommend that the thesis presented under our supervision by ***Mr. Subir Sardar*** *entitled* ***"study of the utilization of waste tyres & li-ion batteries from elv in automotive industries and nrpw through co-processing in cement plants as an alternative fuels & raw (afr) materials promoting circular economy*** *be accepted in partial fulfillment of the requirements for the degree of Master of Mechanical Engineering.*

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DECLARATION OF ORIGINALITY AND COMPLIANCE OF ACDEMIC ETHICS

I hereby declare that this thesis contains literature survey and original research work by the undersigned candidate, as part of his Master of Mechanical Engineering (Automobile Engineering) studies.

All information in this document have been obtained and presented in accordance with academic rules and ethical conduct.

I also declare that, as required by these rules and conduct, I have fully cited and referred all material and results that are not original to this work.

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List of publication:

1. Recycling of Lithium Ion Batteries in the Automobile Industry to Reduce Carbon Emissions, Sadhan Kumar Ghosh1, Subir Sardar, in Waste Management, Sustainable Development and Circular Economy (www.iswmaw.com).

2. “New product derived from potential of waste tyre pyrolysis” Sadhan Kumar Ghosh, Subir Sardar (under preparation).

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Study of the Utilization of Waste Tyres & Li-Ion Batteries from ELV in Automotive Industries & NRPW through Coprocessing in Cement Plants as an Alternative Fuels & Raw(AFR) Materials Promoting Circular Economy.

Abstract:

Purpose: *Global cement production is hoped to rise by 15-30% by 2050 from current level, due to rising global population and urbanization patterns. This increase in production of cement ultimately dominance the CO_2 emission from cement industries and expected to increase by 4% globally (Technology Roadmap, IEA). India is the second maximum producer of cement after China. One ton of clinker required approximately 100 kg of coal and share of energy in total cost of production of cement is 30-40% (IEA, 2006). In recent year, the quest for increasing energy efficiency and reduction in CO2 emission has led cement industry to test and use the waste material as alternative fuel. India propagates 26000 tons of plastic waste every day. The mismanagement of this plastic waste is the main cause of marine littering. In this thesis I have taken Non-Recyclable Plastic Waste (NRPW) and Waste Tyres & Li-Ion Batteries from ELV in Automotive Industries as Raw material for alternative fuel in cement kiln. I have discussed the approach of pre-processing and co-processing of NRPW in cement kiln. The capacity of using NRPW in cement plant is enormous because it can be collected from household as well as industry. The main objectives of the study is to provide statistic data on characteristics and proportion of plastic waste and NRPW generated from some target sectors (household, school, office, hospital, industries, trading and service, and tourism) in West Bengal & Odisha , India and co-processing of waste in cement plants in India.*

Methodology: The Work is based on literature review, Google form survey on perception of people on plastic waste, sampling of plastic waste in dumpsites of West Bengal & Odisha, analysis of information and data collected from cement plants of Odisha and Study of the Utilization of Waste Tyres & Li-Ion Batteries from ELV in Automotive Industries & NRPW.

Findings: Co-processing is the best method we have till now for managing NRPW. The goal is to analyse the mass flow of non-recyclable plastic and optimize the NRPW consumption and waste tyre while maintaining the product quality in kiln. The potential is enormous since today globally 3.8 billion tons of cement produced by cement industries that consumes nearly 380 million tons of fossil fuels and AF. This study has shown the potential Use of ELV Waste like Waste Tyres and Lithium-Ion Batteries Promoting Circular Economy through Coprocessing in Cement Plants as an Alternative Fuels & Raw (AFR) Materials.

Novelty: The practice of co-processing in cement industry for managing NRPW & waste tyre & li-ion batteries conserve natural resources (fossil fuels) and reduces overall cost of production of cement at the same time& this recycling network reduces energy consumption, reduces greenhouse gas emissions, and results in considerable natural resource savings when compared to landfill . Co-processing provides an opportunity for potential utilisation of Waste Tyres & Li-Ion Batteries from ELV in Automotive Industries. Repurposing of waste tyres can made a framework for use in li-ion batteries will ultimately promote circular economy.

Key words: Pre-processing, Co-processing, NRPW, Circular economy, Resource circulation, urbanization, cement plant, utilisation of Waste Tyres and Lithium-Ion Batteries.

INTRODUCTION

CHAPTER 1:

This chapter provides a brief introduction about the situation of plastic waste generation, its management and effect of mismanagement of plastic waste. It also brings to the readers an overall idea of status and significance of co-processing technology for plastic waste management, and utilisation of ELV waste like waste tyre and li-ion batteries before outlining the objectives of the thesis.

CHAPTER 1: INTRODUCTION

1.1 Background :

Globally, 6.3 billion tons of plastic waste were generated globally between 1950 and 2015 out of which only 9% has been recycled, 12% incinerated and the rest has been dumped, landfilled or kept uncollected [UNEP, 2018]. Out of over 300 million tons of plastics produced every year, nearly 8 million tons are dumped into the oceans as plastic waste globally (Boucher et al, 2017), and this will be doubled by 2025 at current rates of consumption and production, if no action is taken up to defence it . Plastics exist in the environment for several hundred years, and eventually find their ways to the oceans. Thus in every one minute one garbage truck is dumping into the ocean. It is estimated that in 2030 this is increase by two per minute and in 2050 this is increase by four per minute of garbage truck if no action is taken. As of now there are over 150 million tonnes of plastics in the ocean that is harmful for marine environment (Davos 2016 | The Guardian) . The disposed waste by ships, boats and the lost or discarded fishing gears also contribute to the marine environment ant it harm the marine environment .

About 300 million metric tons of plastic wastes have been estimated to be generated annually. Based on current population growth and changing consumption habits , municipal waste generation has increased in recent years and tends to increase with the economic development of society.((Yukalang et al., 2017). In this sense, the cement industry has a key role in alternative waste management treatment . The clinker manufacturing process uses raw materials and consumes significant amounts of energy generally provided by fossil fuels; however, fuels from waste mixtures have been developed, such as Refuse Derived Fuel (Güereca et al., 2015). Waste must have certain properties to qualify as RDF, including caloric value, humidity content, and physical criteria. Based on these traits, the valorisation of waste by the cement industry could be an opportunity for both sectors. In this sense, using municipal waste with high combustion heat, such as RDF, seems like a good alternative fuel because some studies have demonstrated improved environmental performance due to its specific characteristics during high temperature operations. According to these results, RDF co-processing (Waste scenario) saves 34 kg of CO_2 equivalent per ton of clinker produced (0.72 kg of CO2 per kg of RDF).(http://www.dtic.mil/docs/citations/ADA119065) .Energy are required for the production process of RDF this cause to emissions. In the cement industry information on energy consumption including secondary fuels are relatively well known. Flourishing fuels like fossil fuels (e.g. coal, oil or natural gas) used in the cement industries. However in recent years low grade fuels such as petrol coke and waste derived fuels (traditionally waste oils, spent solvent, waste tyres) have increased. Co-incinerated animal meals and animal fats are used in cement industry. In addition, the cost for the cement production are reduce by the use of alternative fuels. For evaluate to what extent conventional fuels can be replaced by waste materials such as waste oils, mixtures of non-recycled plastic and paper , used tires , biomass wastes and even waste water sludge that have encouraged for energy costs and environmental concerns for cement companies worldwide to evaluate to what extent conventional fuels can be replaced by waste materials, such as waste oils, mixtures of non-recycled plastics and paper, used tires, biomass wastes, and even wastewater sludge.(Https://Www.Researchgate.Net/Publication/223061452_CoCombustion_of_coal_and_meat_and_bone_meal, n.d.). Global tyre manufacturing was calculated at 20 million tonnes in 2019 and it is increasing about 3.5% per year through 2024. Currently, only 15–20 percent of used tyres are considered for recycling or reuse. Furthermore, 75% to 80% of the used tyres are disposed of in landfills (Kinga Korniejenko et al.2021). Tyres include 46–50% rubber, 22–24% carbon black, 18–28% steel wires (belts and beads), and 5–6% textile overlays (polyester cord fabrics, rayon cord fabric nylon cord fabric, and aramid cord fabric) and also other admixtures (antioxidants, antiozonants, sulfur, zinc oxide, etc.) from this we can reuse it for various recycling treatment (Kinga Korniejenko et al.2021).

The tyres are usually made of rubber, CB, zinc oxide, organic additives and sulphur. After the thermal cracking, the main products structure of about 55% of pyro lytic oil, 15% of pyro lytic gas, 35% of CB and 15% of steel wire (Ruipeng Zhong et al.2019).

1.2 Utilisation of ELV from automotive industries –

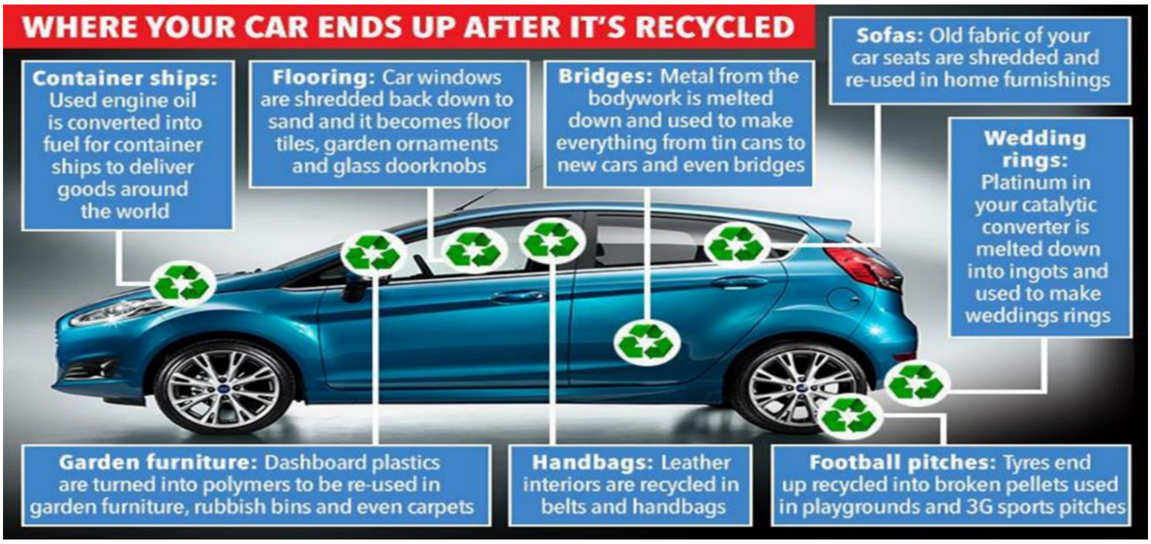


Figure 1: Reuse of different parts of end of life vehicle

In the automobile industry, motor vehicles are no longer suitable when it came to the end of their life thus generating millions of tonnes of waste. I have found that by 2050 the automobile ownership will become 2.5 billion and the generation of End of life vehicle are estimated 100 million that accounts for 4% of total automobile ownership. (S.Sakai et. Al.2013).The increased issue of raw material shortages and waste management challenges have become the new research area thus utilisation of automotive waste an alternative solution towards producing sustainable materials like those can be developed thermal insulation sandwich panels for the needs of creating high performance thermal insulation for buildings.(Yee Choong Wong et.all.2020). For the utilization of ELV in the automobile industry by the modern treatments of sorting, dissolution/precipitation, extrusion, catalytic pyrolysis and plastic upgrading we can magnify ELV management performances by large amount of polymers sent to recycling, small amount of automotive shredder residue sent to landfill can improve of impact of environmental categories like this can reduce carcinogens, non-carcinogens, global warming and non-renewable energy (Filomena Ardolino et.al.2021). From the above figure we can see what the main utilisation are can be used of end of life Vehicle. For the utilisation of ELV we can use 3R policy that are reduce, reuse and recycling. It has been found that in ELV management there is two way to manage the ELV one is recovery and another one is disposal and for again in recovery part we can recover the energy and recycling the material and product by reuse, repair, remanufacturing.

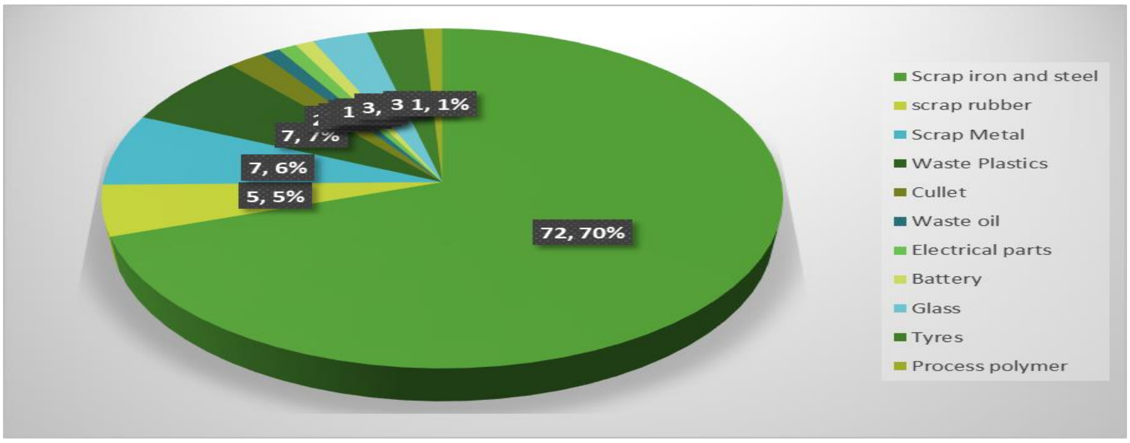


Figure 2: Percentile value of different part utilisation of ELV (Fuli Zhou et.al.2019)

From the above figure we can see that steel and iron are the highest part to be recycled than other used parts in car.

1.3 Utilization of waste tyres & li-ion batteries: Utilization of waste tyre can be made by numerous rubber application such as in agricultural sector, for protection of environment, engineering and construction purpose. Thermal and thermochemical processes such as incineration and pyrolysis, gasification and liquefaction (PGL) is the process from which we can accomplish energy and material recovery from waste tyre (Edison Muzenda, 2014).

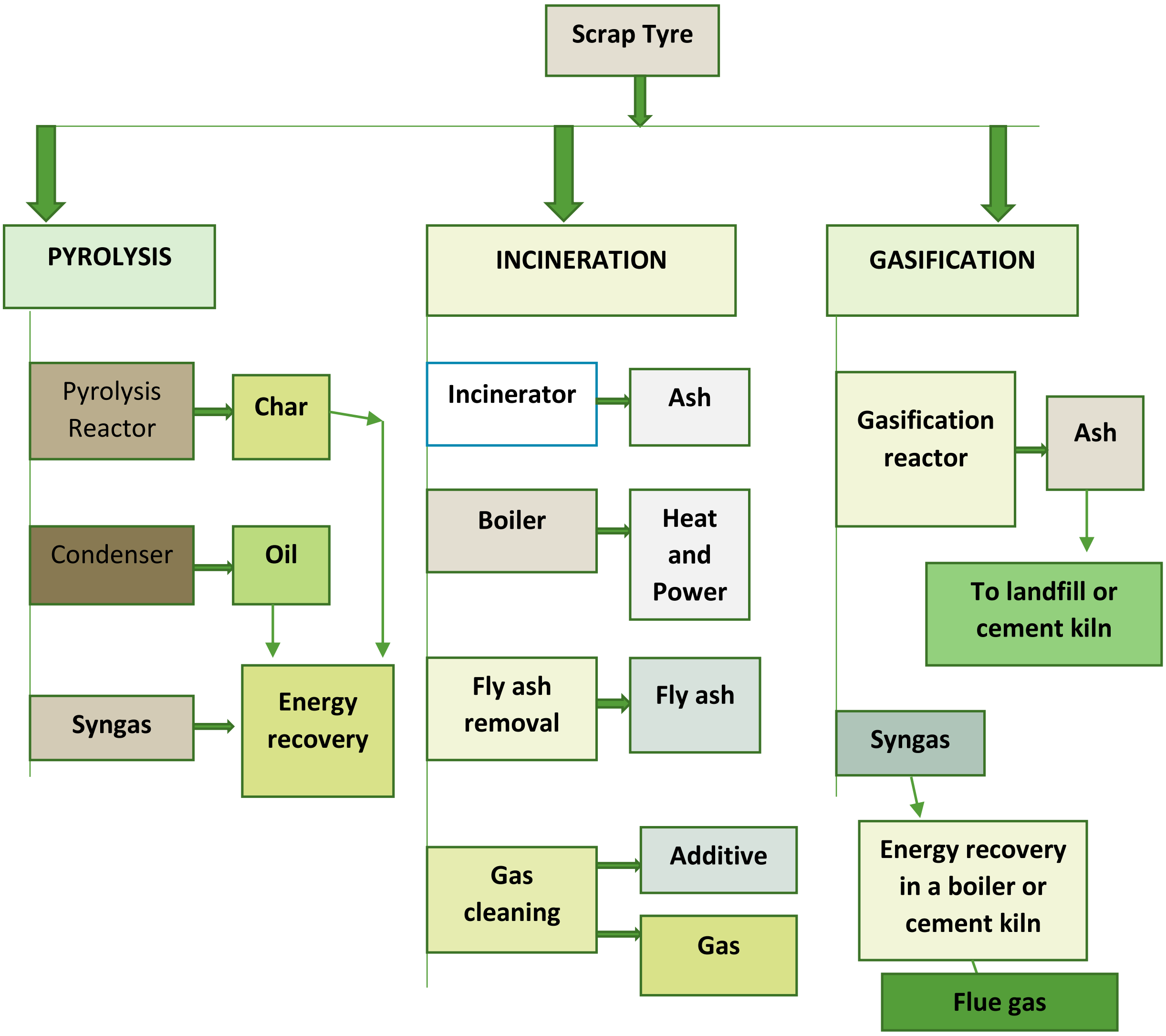


Figure 3: Utilisation of waste tyres

In ELV battery utilisation it has been found that there are several process for recycling such as pyro metallurgy, hydrometallurgy, Bio metallurgy from this Black mass – a new resource obtain by Recycling of LIBs starts with mechanical operation this yields "black mass ", it mainly contains valuable Co, Ni, Mn, Li, but also carbon and many contaminants and Chemical treatments are needed to extract the valuable metals from "black mass".

To create exact circular economy for Lithium ion batteries with a hierarchy of 3 R (reduce, reuse, remanufacturing) opportunities need to addressed particular key research challenges ; automation of disassembly, safety and efficiency in dismantling, regulation of the recycling market, slag, plastics, electrolyte, and anode recycling, clarity of materials waste streams, grade up the recycling processes to industrial level and new chemistries and components are developed by new recycling process(Chen et al., 2019; Sommerville et al., 2020; Yun et al., 2018).

1.4 Use of NRPW and other materials in co processing as alternative fuels :

The analysis is specially focused on the technical, economic, and environmental effects of the uses of five solid wastes, namely, municipal solid waste (MSW), meat and bone animal meal (MBM), sewage sludge (SS), biomass, and end-of-life tyres (ELT), in the cement industry.

1.5 Potential of use of ELV from automotive industries, waste tires and li-ion batteries in Co-processing:

End-of-life vehicle (ELV) recycling is a process that consumes energy and could be an energy source as well. This part of energy recovery builds on many different factors related to the broad and local perspective of ELV recycling. The ELV recycling process energy consumption is lower in relation to energy consumption during the production of new vehicle parts from different energy sources like electrical, fossil. This article assiduity to promote an integrated approach in the analysis of the problem of energy recovery through ELV recycling. Authors aim to explore the ELV recycling process as an energy generator and to present possibilities for its energy recovery. The research analyses are based on the empirical investigation of ELV recycling for developing country, and on defined statistical model presenting the impact of ELV recycling on energy generation, spending, and conservation during one-year intervals. Research results conveyed that the higher ELV generation rates may lead to higher energy recovery, and environmental and socio-economic sustainability and thus by the use of ELV we can contribute to co-processing in cement plant (Vuk Petronijevi´c et al. 2020).

1.6 Status of Co-processing in cement plants :

Unrestrained waste management break down land, ground water and air quality, leading to health risks to humans, animals and the ecosystem. Thus wastes are turn into refused derived fuel and can use as co-processing in cement plants .

Compared to land filling and incineration Co-processing is a more environmentally friendly and sustainable method of waste disposal because of attenuate emissions and no residue after the treatment (Co-processing of non-recyclable hazardous plastic waste in cement kiln (sustainable-recycling.org). The use of waste materials in industrial processes to recover energy and material from them as alternative fuels or raw material (AFR) confer as Co-processing. During the usage of plastic wastes in cement kiln as AFRs, the material and energy value present in them gets fully improve in the cement kiln as replacement to the fossil raw materials and fossil fuels that are legitimately utilized in the kiln. (Amsaveni et al., 2020). For use as an alternative raw material or as a supplementary fuel for energy recovery, substantial factions of the industrial , commercial, domestic and other wastes contain materials have potential . The production of cement in India is more than 300 million tons per annum, for which estimated coal and raw material (Limestone, Iron ore, Clay, Bauxite etc.) requirement are 50 million tons per annum and 450 million tons per annum, respectively.(Manoj Sharma: Cost Management in Cement Sector of India (manojwritings.blogspot.com)

1.7 Scavengers involved in the waste supply chain towards co-processing

Dumpsites are the workplace of many thousand people, a marginalized group of men, women and children who search waste piles to obtain some livelihood. Scavengers are mostly men, their performance was calculated to be 1–7.7% as far as the recyclable diversion rate is considered working informally for themselves, and do not belong to any official body or informal local association.(Al-Khatib et al., 2020) . In order to involved scavengers in the waste supply chain towards co-processing there is highly recommended to the government support through tax stimulant to the private sector in developing countries, providing them impulse, on the job training and establishment to the official waste management sector this analysis is a stepping stone for scavengers . (Al-Khatib et al., 2020)

1.8 Research projects and the Introduction

1.8.1: **Major activities in the research studies** Conduct an extensive literature review to Identify the major sources of non-recyclable plastic waste (NRPW) in India, examples of few major sources are given below: The plastics constitute two major categories: (i) Thermoplastics and (ii) Thermoset plastics. The plastics materials are categorized in seven types based on properties & applications.

Table 1: Types of plastic, Applications and Recyclability

Sr. No	Source Code	Name of plastics	Few Applications
1.	PET	Polyethylene Terephthalate (PET)	Drinking water Bottles, Soft drink Bottles, Food jars, Jelly pickles, Plastics Films, Sheets
2.	& HDPE LDPE	High Density Polyethylene (HDPE) Low Density Polyethylene (LDPE)	Plastics bags ,Food containers, woven sacks, Bottles, Plastics Toys, Milk Pouches & Shopping Bags, Metalized Pouches
3.	PVC	Polyvinyl Chloride (PVC)	Pipes, Hoses, Sheets, Wire, cable insulations, Multilayer Tubes
4.	PP	Polypropylene (PP)	Disposable Cups, Bottle caps, Straws,
5.	PS	Polystyrene (PS)	Disposable Cups, glasses, Plates, spoons, trays, CD Covers, Cassette Boxes, Foams
6.	OTHER	Thermoset, Poly Carbonate (PC), Poly urethane (PU) FRP	CD, Melamine Plates, Helmets, Shoe soles.

1.8.2 Non-Recyclable Plastic Wastes in dumpsites/landfills :

For decrementing plastic waste from dumpsites and landfills diminishing marine plastic pollution from land-based activities in the world environment can play a significant role. Co-fuelling in cement industries can be treat the plastic waste recovered from these dumpsites. Up to 80% energy recovery from waste can target to Cement kilns for valorise plastic waste which is much higher compared to consecutive waste-to-energy plants ("Correction to: Missing Conflict of Interest Statements in Previously Published Articles," 2021). There is a readily available solution to handle the large volumes of solid waste generated thus Cement industries could help in the decreasing of marine plastic pollution with controlled emissions with bountiful stimulant and sound regulations, and a very massive capacity to co-fuel cement production, (Tracking the Ganges River, a highway of plastic waste (mongabay.com)).

1.8.3 Non-Recyclable Plastic Wastes from industries, for example, from paper production :

By mixing used/waste paper with water and chemicals to break it down for the recycling of paper. To strands of cellulose this mixture is then chopped up and heated to break it down called pulp or slurry. For removing any glue or plastic that may still be in the mixture it is then strained via screens. Finally it is cleaned, de-inked, bleached, mixed with water thus it can be made into new recycled paper.

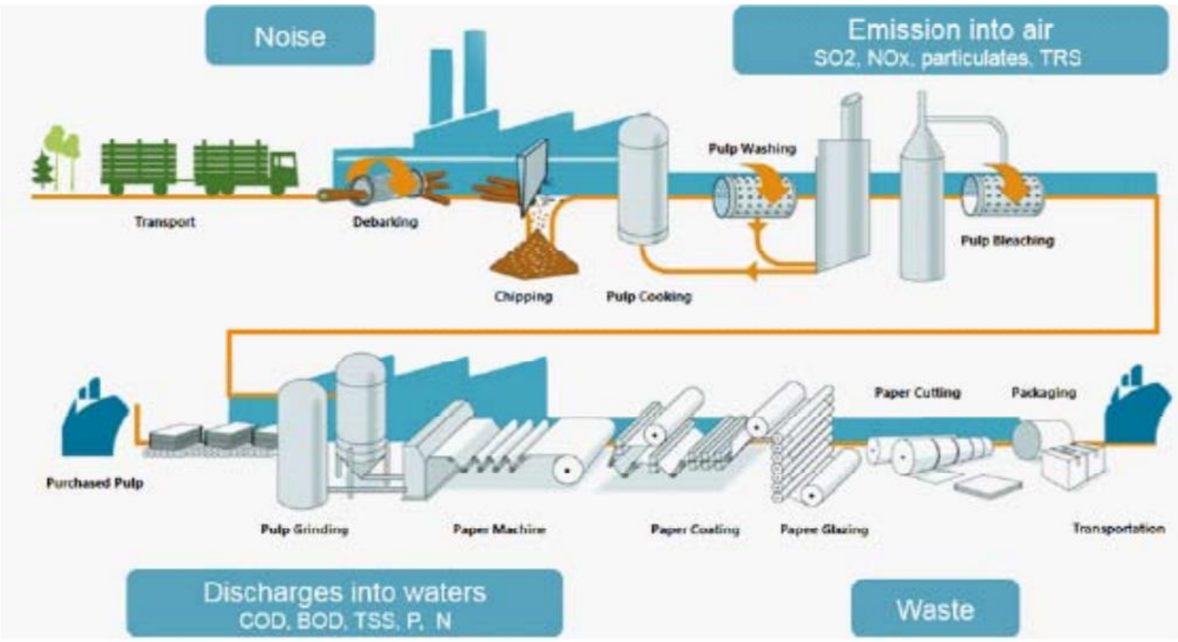


Figure 4: Non-recyclable plastics from paper industries

1.8.4 Non-Recyclable Plastic Wastes in Rivers :

The harmful effects such as flooding and poisoning of the animals in the marine ecosystem caused by plastic wastes generated on land find their way to water bodies such as rivers. There are also chances noxious to human health for the plastics in the marine environment, which are ingested in fish if such fish are consumed. The global occurrence is that leakage of plastic waste into the environment and is not determinate to any particular country. Most leaked plastic waste ends up in oceans with a calculated 8 million tonnes added every year. The ocean is conversant to cause a collapse in marine life around the world for massive plastic waste (Avi sharma et al. 2020). Where the local waste management practices are poor there is a large amount of mismanaged plastic waste that enter in rivers and the ocean and the largest emitters tend to have cities nearby (https://ourworldindata.org/plastic-pollution) . In the below figure seven of the top ten rivers are in the Philippines, two are in India , one in Malaysia in which Philippines alone create 6.4% of global river plastic . Non-recyclable plastic waste can cause the probability of higher chance on flash flood due to high rainfall in the locality area that's why we have to encourage the upstream management such as design for recycling, that push the producers re-consider their products to be collectable, detectable and recyclable to reduce the amount of non-recyclable plastics.(Indradhi Faisal Ibrahim et al.)

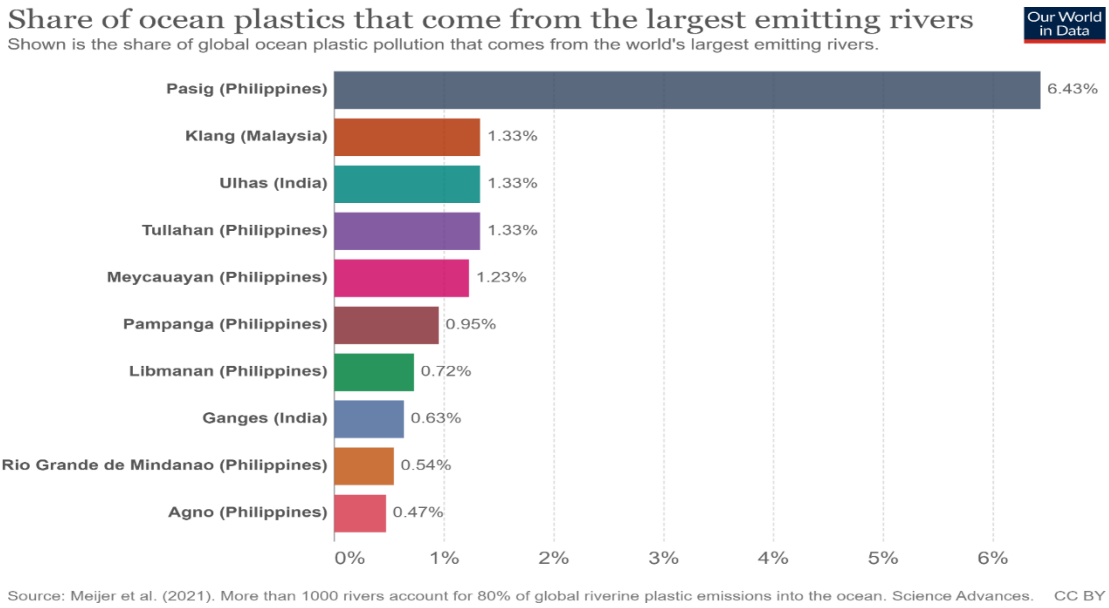


Figure 5: Non-recyclable plastic wastes from largest emitting rivers

1.8.5 Non-Recyclable Plastic Waste from Cities and Municipalities:

The amount of waste collected was reported by all municipalities based on the capacity of their collection vehicles – specifically the ones that go to the disposal site. Assuming that there is 25% loss between first collecting the waste and the amount that is loaded on to the trucks that reach the disposal site, most cities reported this figure within the range of 50% to 85%. Door to door collection was found to be practiced, either partially or fully, practiced across 60% municipalities. 30% of these reported carrying out complete door to door collection. (David hallowes et al.2008).

Figure 6: Non-Recyclable Plastic Waste from Cities and Municipalities

Literature Review

2

This chapter is based on national and international literature reviewed, contains:

- **Global Plastic Production, consumption and source of NRPW**
- **Plastic waste generation and its management in India and globe**
- **Co-processing technology , AFR & RDF production**
- **Co-processing & Circular economy**

2.1 Definition of plastic including non-recyclable plastic waste :

With a polymerisation or poly-condensation process plastics are made from natural materials such as cellulose, natural gas, coal, salt and of course crude oil which is a complex mixture of thousands of compounds and for used it need some process. Plastic production take place with the distillation of crude oil by the distinguishing heavy crude oil into groups of lighter components called fractions that is a mixture of hydrocarbon chains (chemical compounds made up of carbon and hydrogen) that differ in size and structure of their molecules like naphtha is the crucial compound for the production of plastic. Synthetic or bio based plastic are there in the world and Synthetic plastics are executed from crude oil, natural gas or coal and bio based plastics derived from renewable products such as carbohydrates, starch, vegetable fats and oils, bacteria and other biological substances(www.plasticseurope.org).

The material made up of polymer like polyethylene terephthalate (PET), high density polyethylene (HDPE), vinyl, low density polyethylene (LDPE), polypropylene (PP), and polystyrene (PS) resins or multi-materials like acrylonitrile butadiene styrene (ABS), polyphenylene oxide (PPO), polycarbonate (PC) & poly butylene terephthalate (PBT) is known as plastic (CPCB, April 2018). There are recyclable and non-recyclable plastic are available by different types.

Table 2: Types of plastic and its application

Types of plastic	Labelling	Recyclable or not	Applications
Thermoplastics			
High-density polyethylene (HDPE)	2	YES	Gas Pipes, Industrial Wrapping and Film, House Wares, Containers, Toys.
Low-density polyethylene (LDPE)	4	YES	Toys, Coatings, Containers, Cable Insulation, Film, Bags, Pipes
Polyethylene Terephthalate (PET)	1	YES	Synthetic Insulation, Food Packaging, Bottles, Film.
Polyvinyl chloride (PVC)	3	YES	Pipes, Toys, Cable Insulation, Credit Cards, Medical Products, Window Frames, Flooring, Wallpaper, Bottles.
Polypropylene (PP)	5	YES	Battery Cases, Electrical Components, Crates, Car Parts, Film, Battery Cases, Microwave Containers.
Polystyrene (Styrofoam)	6	NO	Thermal Insulation, Tape Cassettes, Disposable Cups, Plates, Electrical Appliances
Others	7	NO	Thermoset plastic, Melamine plates, Helmet
Thermosetting Plastics			
Epoxy resins	7	NO	Car components, Sports equipment's, Boats, Adhesives.
Phenolic (phenol formaldehyde, urea formaldehyde)	7	NO	Electrical appliances, Adhesives, Car-parts.
Polyurethane	7	NO	Furniture foam, Adhesives, appliances, car parts, electrical components, trainer soles.
Furan resins	7	NO	Manufacture of sustainable bio composite construction, cements, adhesives, coatings and casting/foundry resins.

2.2 Global plastic production:

Plastics are applied in a wide variety of products and have extracted other materials that were previously used for the applications that plastics now prevail such as wood, metal, and glass. The production of plastics totalled around 370 million metric tons worldwide in 2019 (Statista, 2021).

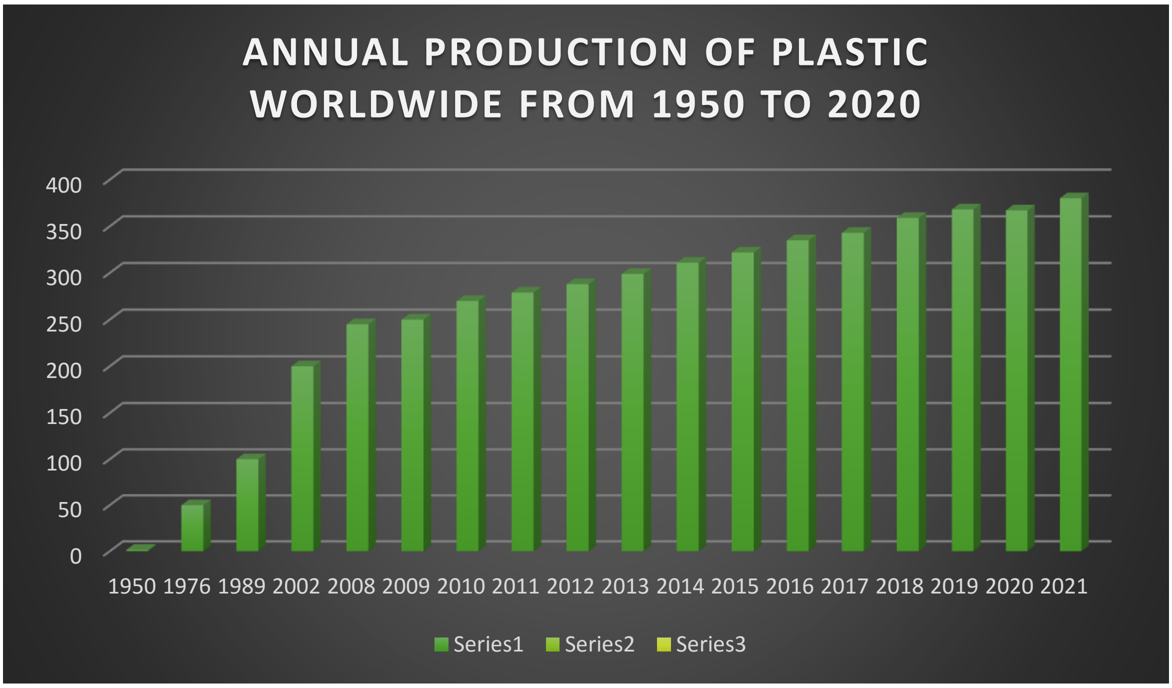


Figure 7: Annual production of plastic worldwide from 1950 to 2020

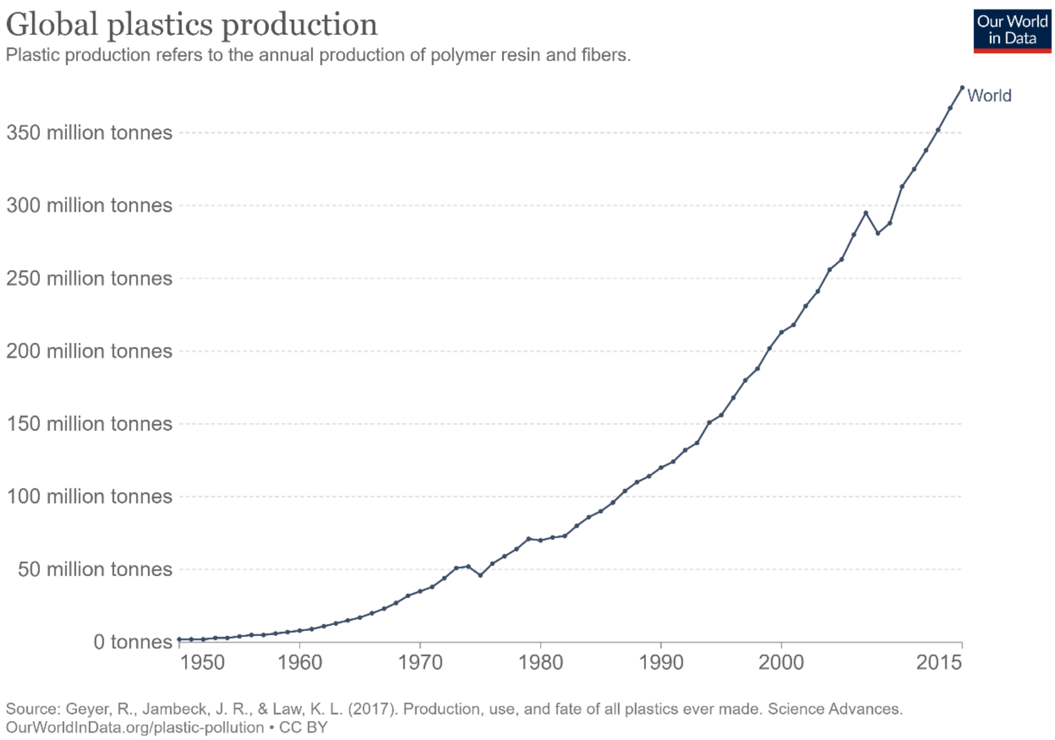


Figure 8: Forecasted value of Global plastic production

2.3 **Plastic production and consumption in India**

For convinced an effective value chain within the country here in India almost 15 large scaled polymer manufacturers, nearly 30,000 plastic processing units, over 7 thousand recycling units, and a host of end-users were developed . In financial year 2019, this driven to the employment of more than 4 million people, with almost 1.7 million skilled labourers. In 2018, the total spending volume of plastic in India was approximately 19 thousand kilotons per annum. During the observed time frame the spending volume multiplied 20 times over. However, the per capita spending of plastic in the country was less than half of the global average.

From 10 million tons in 2013 to 13 million tons in 2017 the Plastic production in India is rising at a rate of 10% annually and increased. Plastic consumption is flourishing at an annual growth rate of 8.4% and increased from 11 million tons in 2013 to 16 million tons in 2017 (CPCB, 2017).

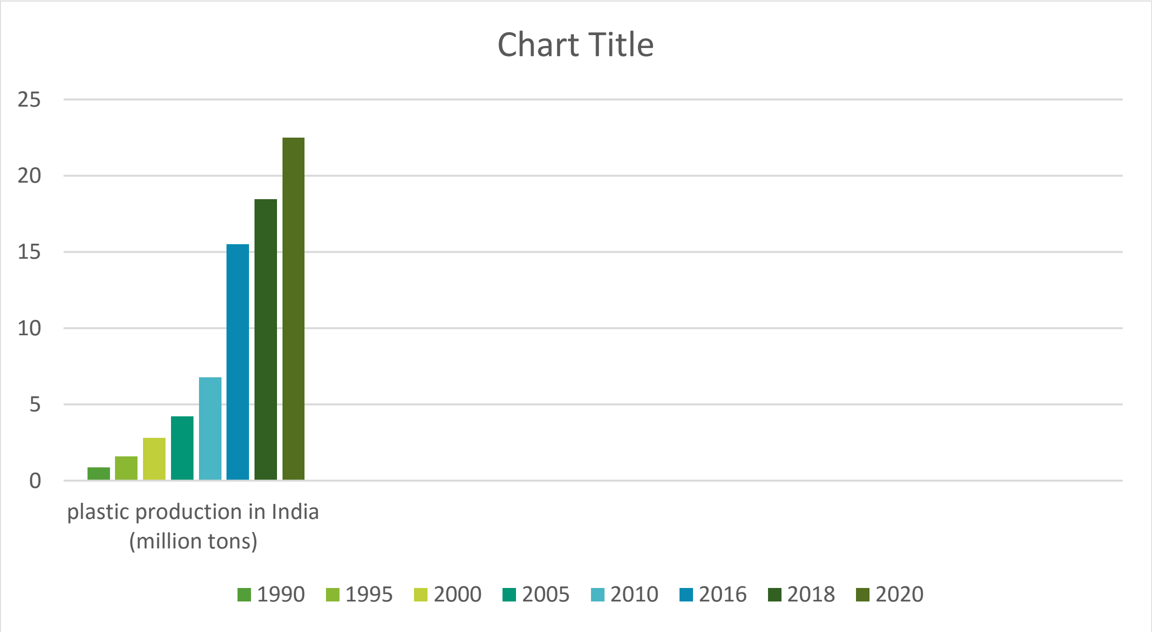


Figure 9: Plastic production in India

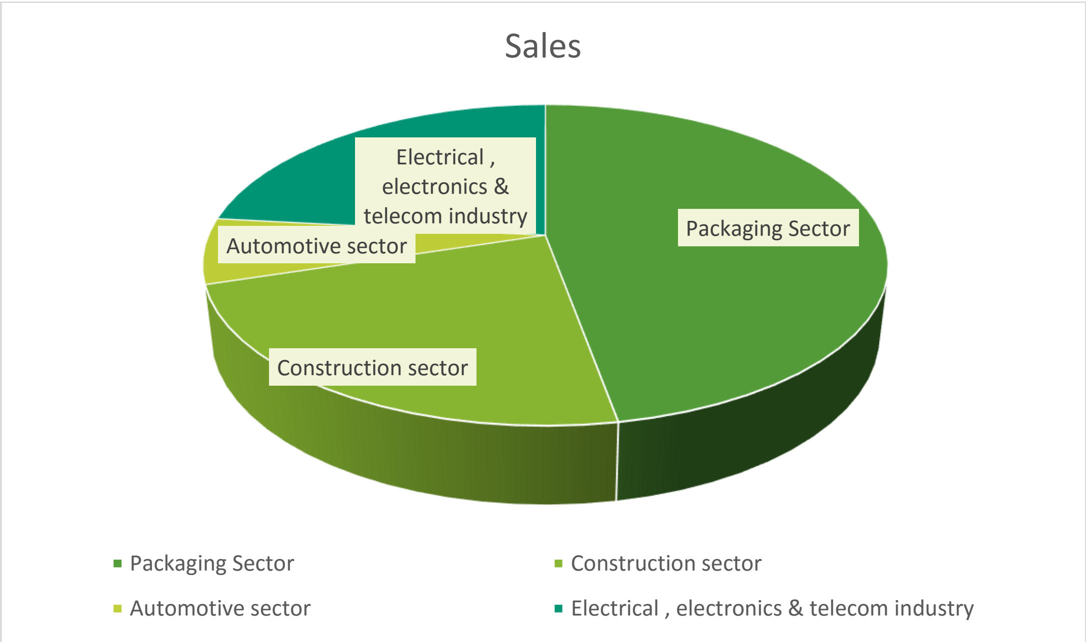


Figure 10: Different sector for consumption of plastic

2.4 Source and application of NRPW

Under four sectors, namely, Composite Waste, Industrial Sector Waste, Municipal Sector Waste and Transportation Sector Waste are the focus was on applicable waste and recycling materials and source of Non-Recyclable plastic waste.

All plastic has a number on the bottom. The Resin Identification code is truly an indicator of a classification system. According to Mercola, the most toxic plastics are polyvinyl chloride (PVC) (3), polystyrene (PS) (6), and other(7) . While is a plastic catch-all for variations that may even contain hazardous by products like BPA and BPS, polystyrene is Styrofoam (so a hot to-go coffee cup or Styrofoam to-go food containers) and is usually found in vinyl flooring or padded play mats for children and is associated with allergies and asthma. Recycling centre should have the capability to recycle these generally non-recyclable plastics, they can be transformed into useful items like egg cartons, vents, speed bumps, cables, panelling and more. This is the general rule to check the bottom of the bottle or container where we should potent to find where the number will be. If it's a 3, 6, or 7, its likely non-recyclable, but like we mentioned, we have to check with our centre. Number 3s are generally single-use plastic wraps, window cleaner and detergent bottles, shower curtains, vinyl piping, flooring, and home siding — anything known as PVC or vinyl. Since 6 is Styrofoam, anything that is a Styrofoam cup, plate, carry-out container, and egg carton made of foam, disposable cutlery, or a CD case generally cannot be recycled. Look out for plastic baby bottles and medical storage containers, plastic cutlery, and toys, Sippy cups, water jugs, sunglasses, Nylon, signs, and electronics that are part plastic that is for 7. When companies were asked about the benefits of using recycled materials, reducing landfill waste was number one at 40% followed by quality at 35% then reduced cost at 28%. For the composition of the plastic waste products to providing detailed data, the results showed that impurities represented 30% (wet weight) of the plastic waste, and that about 77% of the plastic waste was characterised as Low Quality applications, expressing some legislative recovery restrictions(Al-Salem et al., 2009). The overall recycling potential was found by accounting for the level/type of impurities, to be 54% for hard plastics, 60% for plastic films and 80% for PVC waste. The results explained that while varying according to polymer type, the recyclability of "High Quality" plastic waste was 12–35% higher than "Low Quality" applications. Cement Kiln Dust (CKD), silica fume, swine manure, animal fat, soy bean, roofing shingles, citrus peels, sewage sludge, date and oil palm tree fly ash, foundry sand, slag, glass, plastic, carpet, tire rubber, recycled asphalt, recycled concrete, gypsum, and a place to add additional recycled materials being used in the construction industry not listed .

Table 3: Source of non-recyclable plastic

S No.	Sources	Uses
1	Food Packaging	For food packaging of biscuits, namkeen, chips, edible oil, juices Multi-layered films are use
2	Pharmaceutical & cosmetics products	Packaging for packing of medicines, tablets and cosmetics etc. Multi-layered are use.
3	Electrical and electronic goods	Multi-layered

2.5 Plastic waste generation:

As per the research in University of California and Santa Barbara and others, it has been invented that around 8.3 billion metric tonnes of plastic has been produced from 1950 to 2015. Out of this total plastic produced only 12% for incineration (Waste to energy) and 9% goes for recycling and the rest 79% , that is around 6.3 billion metric tons of the produced plastic become plastic waste , which are still dumped in our landfill, oceans & water bodies (CSE,2020).

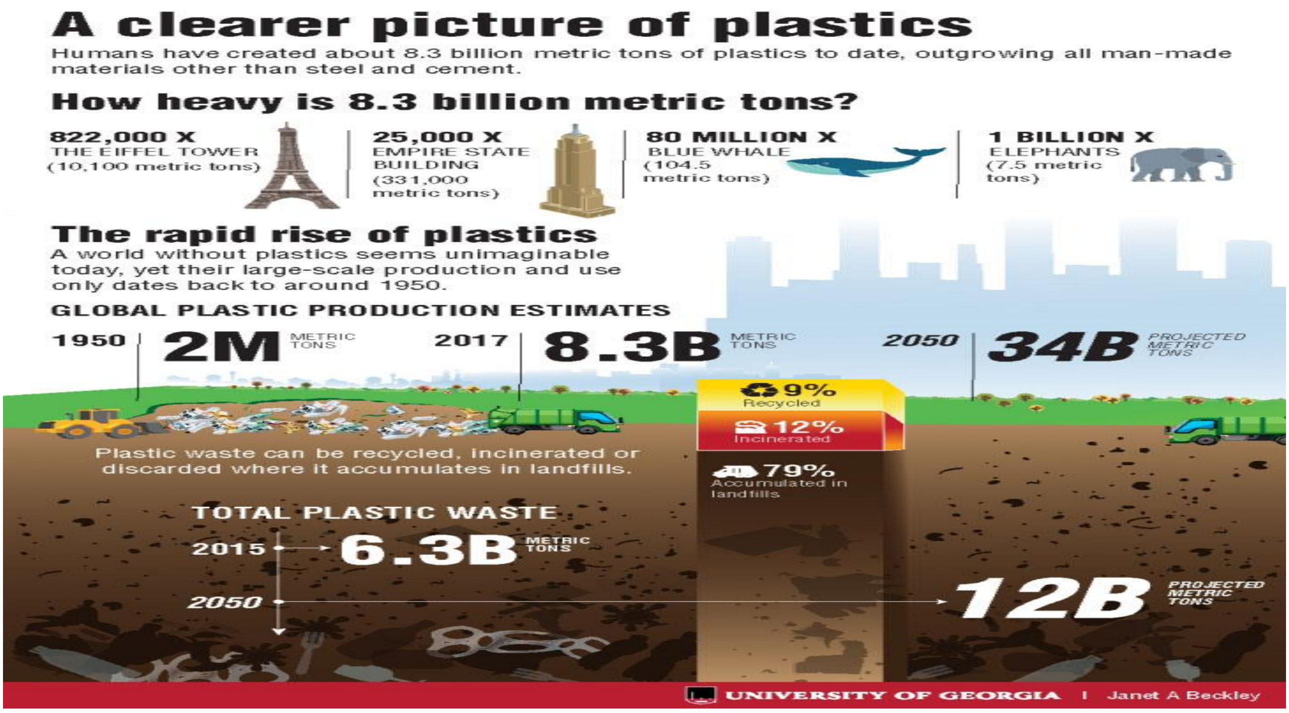


Figure 11: Plastic waste generation (Projected) in world (Source: Julie Cohen, 2017)

2.5.1 Plastic waste generation in India: For impact on solid waste generation in an area economic development, public habits, the degree of industrialization, etc. (UNEP, 2020) are some important parameters,

Solid Waste means and includes solid or semi-solid domestic waste, sanitary waste, commercial waste, institutional waste, catering, and market waste and other non-residential wastes, street sweepings, silt removed or collected from the surface drains, horticulture waste, agriculture, and dairy waste, treated bio-medical waste excluding a hospital or industrial waste, e-waste, battery waste, hazardous and radioactive waste generated in the area under the local authorities. (Guidelines for Disposal of Legacy Waste (Old Municipal Solid Waste), CPCB, 2019). The world generates 2.03 billion tonnes of municipal solid waste annually, with at least 33 percent of that extremely conservatively not managed in an environmentally safe manner. Worldwide, waste generated per person per day averages 0.74 kilogram but ranges widely, from 0.11 to 4.54 kilograms. Though they only account for 16 percent of the world's population, high-income countries generate about 34 percent, or 683 million tonnes, of the world's waste. Global waste is expected to grow to 3.40 billion tonnes by 2050, more than double population growth over the same period. (World Bank, 2022). In 2015 Asia was the largest generator of global plastic waste, generating 82 million tonnes followed by Europe with 31 million tonnes and Northern America with 29 million tonnes, Latin America, the Caribbean, and Africa each produced 19 million tonnes of plastic waste. (Lebreton et al., 2019)

The per capita solid generation in India shows a marginal decreasing trend from 2015 to 2021, (Annual Report 2020-21 on Implementation of Solid Waste Management Rules, 2016, CPCB) indicating increasing awareness among the common people in the county. Under the guidance of CPCB, local authorities (ULBs) are taking action to increase awareness among the citizens to strengthen the waste management structure of their areas. The actions taken to date in some states in India, such as Assam, Meghalaya, Bihar, Himachal, and Odisha demonstrated the viability of such programs by being the top 5 states with the lowest per capita solid waste generation. (CPCB, 2022).

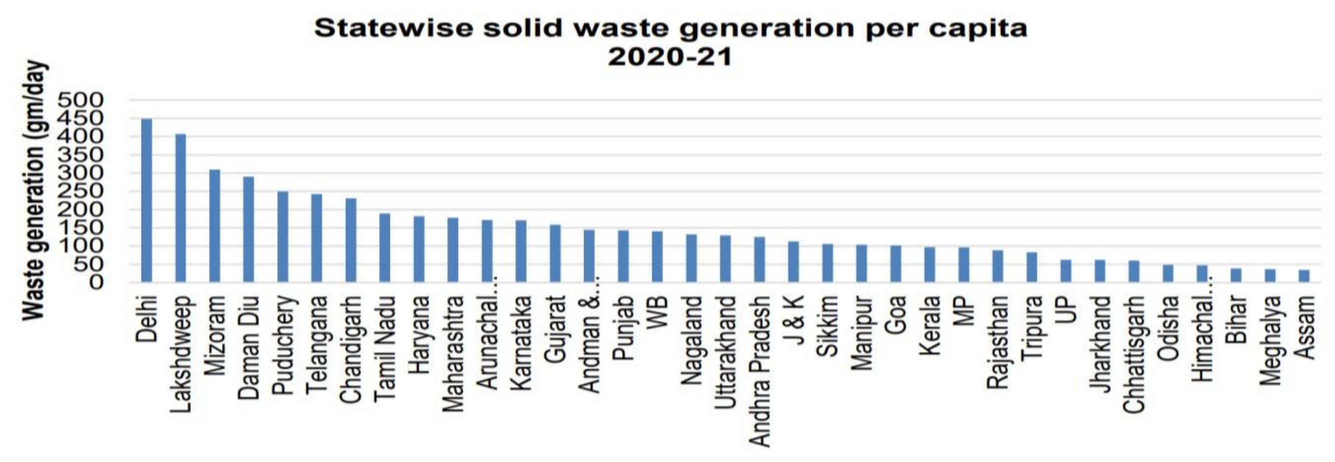


Figure 12: State wise per capita solid waste generation (CPCB, 2022)

2.6 Waste supply chain of towards marine environment waste

Plastic from mismanaged waste at coastlines enter the ocean annually in worldwide it is estimated that 5 to 13 million tonnes (Jambeck et al. 2015). The dumping of garbage, sewage, waste chemicals, and construction debris into the ocean is called ocean dumping. There are many incident where ocean dumping is controlled and regulated. However, tankers and ships dumped hazardous materials being into the sea. They are also being illegally dumped in coastal waters. Crude oil discharge is the main cause of marine pollution are cargo ships both accidentally and deliberately discharge into the ocean. As far as ocean pollution goes, this is one of the primary causes.

→ The dumping of industrial waste is the other reasons for marine pollution. All of which pollute the ocean those products contain PCBs, PAHs, toxins including mercury, and radioactive material.
→ Trash and debris are being washed by Heavy rains and floods into the waters.
→ The world's leading causes of ocean pollution is called "garbage dumping" that is human waste and sewage water that has been partially treated or untreated goes into the ocean.
→ Acid rain which then pollutes the water is carried by the carbon dioxide in the air reaches the ocean and due to fossil fuels being burned automobiles emit carbon dioxide this leads to air pollution.
→ Oil spills are dangerous for marine life and can affect coral reefs that thrive in the ocean it is also the main effects of ocean dumping. In fact they can greatly affect the life cycle. Spilled oil which can block off respiration can be clogged the gills of fish. Marine plants will die because it affects photosynthesis and its process if sunlight is blocked. Also these toxins not only invade the marine life, but they can be harmful for human also. For example, they could get food poisoning if that fish are contaminated and someone were to catch a fish and eat it.
→ The oxygen in the water could be evacuated if garbage is dumped into the ocean thus due to lack of oxygen this results in poor health for marine life. Animals such as seals, dolphins, penguins, sharks, whales, and herring could all die.
→ We can see that sea creatures suffocate or choke by bottles and other plastics including bags. They may eat them thinking those are food. The major causes of death among turtles are Plastic items are one of this. They try to eat them thinking plastic bags look like jellyfish.

The effects of ocean dumping are due to our carelessness. We throw down chemicals to the drain every day such as house hold cleaners that is roughly two thirds of the world's marine lives have been threatened with those chemicals. Not only do we eat fish and other marine life, but so do other animals we have to good to remember that marine life is a part of our food chain and main food source for other fish and bears are Underwater creatures.

There's a lot we can do to save our oceans. The best place to start is to keep them clean and not throw anything into them. It's also a great idea to keep the beaches clean. Garbage on the beach can freely end up in the water. Another thing we have to do is to stop pouring chemicals down the drain such as paint or oil. In other words, conserve water to stop using toxic household products and don't overwater our lawns.
Now that we know the cause and effects of ocean dumping, we will be able to understand that it's just something we shouldn't do. We have to know how much water is worth, until we have none. It's best to remember the causes, consider the animals and always keep them in the back of your mind. We can stop the effects of ocean dumping for good if we work together.

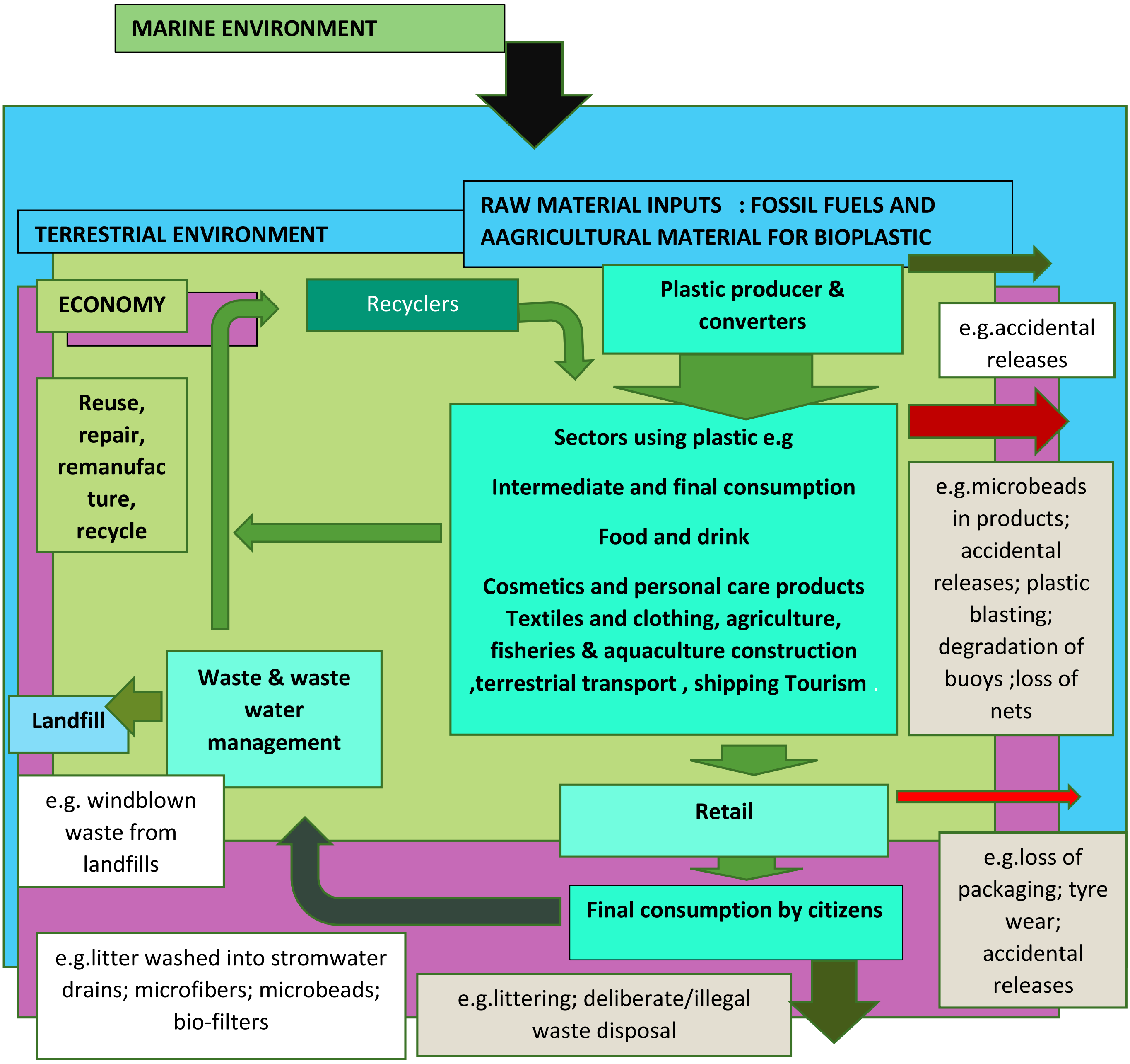


Figure 13: waste supply chain towards marine environment waste

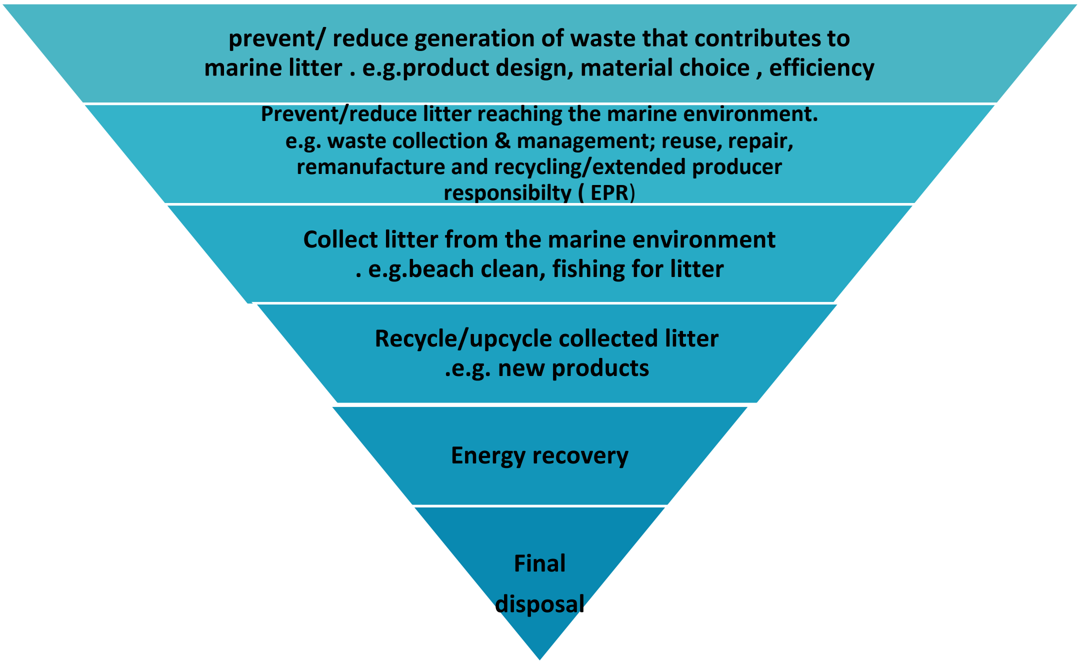


Figure 14: Hierchy process to prevent marine litter

2.7 Plastic waste Management

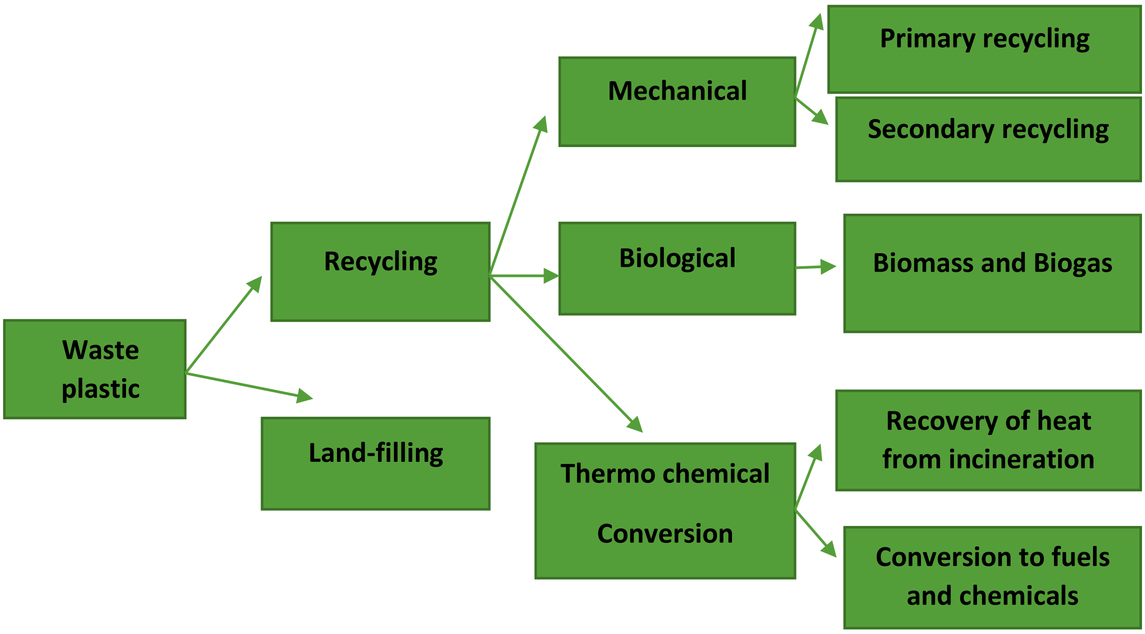


Figure 15: Different process for plastic waste management

2.7.1 Plastic waste management in India

15 million tonnes of plastic generates in India every year. In India, plastic consumption has increased from 5 million tonnes/year in 2005 to 8 million tonnes/year in 2008 and is expected to rise up to 24 million tonnes by 2020 (Singh and Ruj, 2015). The growth rate of plastic consumption is increasing at the rate of 2.5 times the gross domestic product (GDP) growth rate in India (India's GDP increased from 6.7% to 7.2% between 2017 and 2018) (CPCB, 2015a). Out of total plastic wastes generated, 94% are thermoplastics that can be recycled and 6% are thermoset plastics that cannot be recycled. In India individually analysed different phases, such as collection, sorting, compaction, reprocessing and refuse disposal for quantifying the material consumptions and energy as well as the emissions into the environment. The results showed that mechanical recycling was the most favourable for all the collected plastic wastes, and the scenario incineration with energy recovery was the most environment friendly for all the process wastes. The goal of the plastic waste management in India is to study to evaluate the environmental impacts of existing and proposed plastic wastes management scenarios (landfilling, incineration without energy recovery, recycling of PET and PE wastes and incineration with energy recovery) to compare the different plastic waste management scenarios for identification of the best scenario (with least environmental impacts). The functional unit is the waste treatment of one tonne of plastic waste. This study includes two plastics: PET and PE. Hence this study evaluates the impact of the waste treatment of one tonne of PET, and separately evaluates the impact for the waste treatment of one tonne of PE.

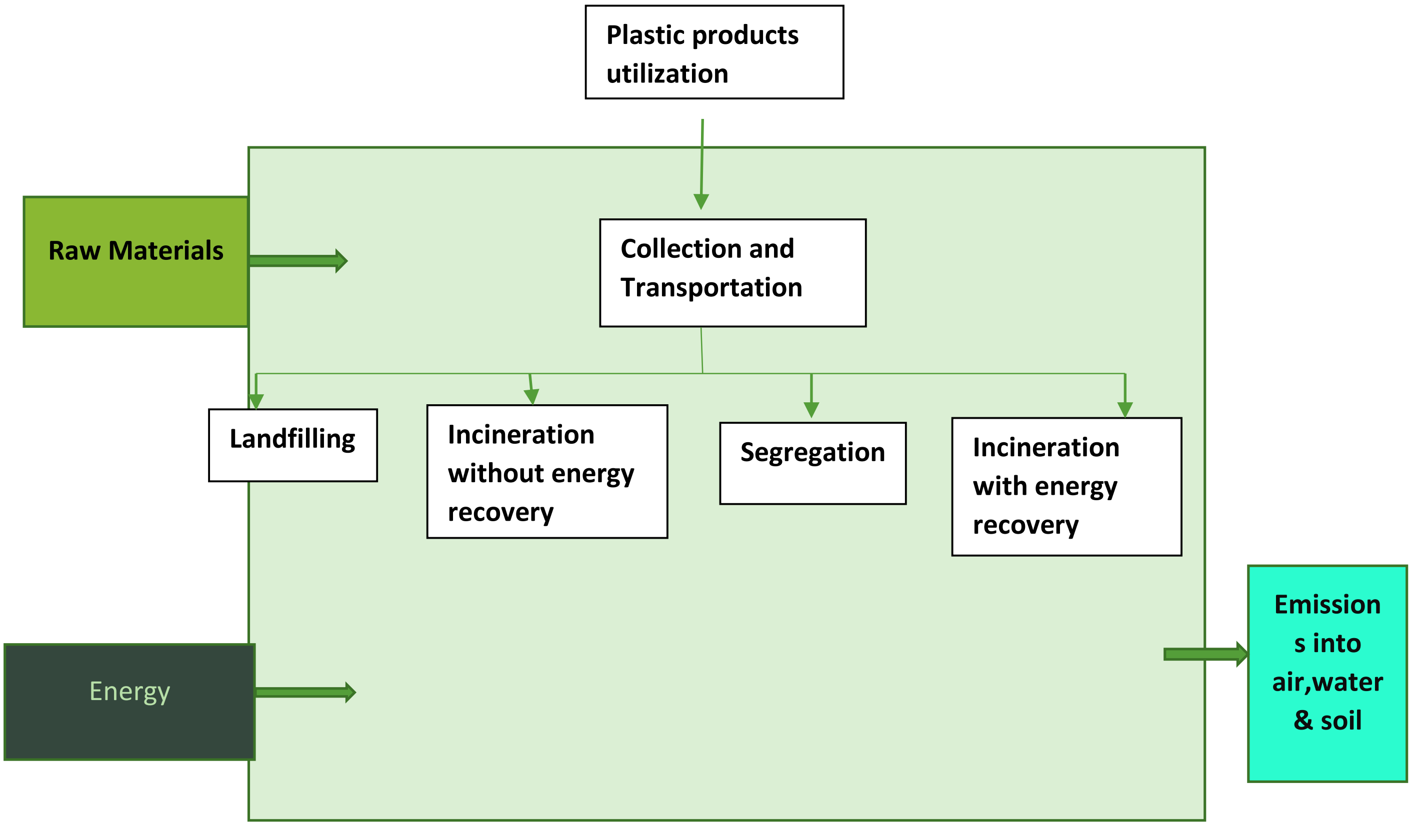


Figure 16: Pathways towards plastic waste management

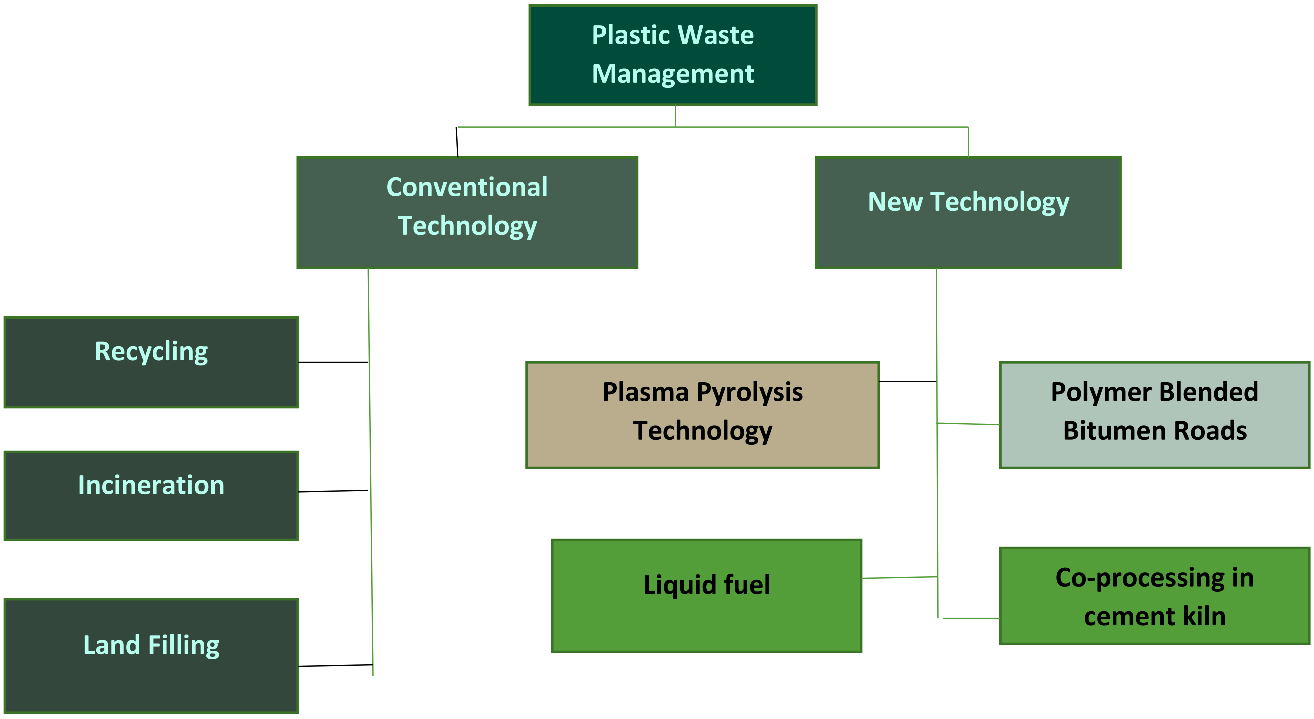


Figure 17: Conventional and new technology of plastic waste management

2.8 **Co-processing** :

Co-processing is the use of waste as AFR in resource and energy-intensive industries such as cement industry. As a sustainable solution to the management of wastes from industrial sources, municipal sources, and agricultural sources, the technology practiced worldwide is Co-processing in cement kilns. For conservation of natural resources, curbing the global CO_2 and GHG emissions and reducing the landfills possibilities AFR from waste definitely contribute reducing the cost as well as the amount of fossil fuel. To conserving natural resources and to implement 3R and circular economy concepts on large scale Co-processing promotes curbing the climate change impacts and global warming. Large scale employment can be provided by Co-processing like other waste management initiatives has potential. A sustainable solution for industrial wastes are developed if we used it in cement kiln thus Co-processing provides because the waste is used as fuel as well as the raw materials leaving no residue to be disposed to landfill. Compared to MSWI this is one of the advantages of co-processing, that produce 20–30% ash, slag, flue-gas cleaning products, etc. Combustible parts of the waste and the raw materials are substitute the fossil fuels, such as Silica and Iron are replaced by non-combustible parts of the waste (Ash) which in turn acts as substitute raw material. The highest value of energy efficiency in cement kiln is that the instant use of energy released without any losses. The unfavourable impact on the environmental negligible. For several benefits the cement industries in several countries are induced to realize the potential of use of wastes as alternative fuels and raw material (AFR) in cement kilns. From the current level of less than two-digit percentage Indian cement industries have taken a target to reach a 25% thermal substitution rate (TSR) by 2025,. It has been calculated that to achieve 25% TSR at 2025, Indian Cement Industry will require 7.08 million TOE of energy from Alternate fuels. While "TOE" is expanded as ton of oil equivalent (TOE), a unit of energy. TOE is the amount of released energy by burning one ton (1000 kg) of crude oil. According to the European Composites Industry Associate (EuCIA) the cost of virgin materials to produce GFRP is very low and hence, pyrolysis and mechanical processing of GFRP is not durable. In a cement kiln the co-processing of GFRP is being practiced as a stable option. The cost of co-processing is still unknown, however, is calculated to be more than landfilling.

2.8.1 Co-processing of waste in cement kiln :

Terms & Definition related to Co-processing of Waste in Cement Kiln

Materials related Terms & Definition	Different types of materials are involved to co-processing and associated activities. Those are associated with the demand side of a cement plan are Alternative fuels and raw materials (AFR), refuse derived fuel (RDF), etc., while Cement, clinkers, Concrete, etc., on the other hand, Biodegradable waste, carry bag, NRPW, plastics, etc., are associated with the supply side of cement plants are those materials-related terms which are associated directly with the co-processing are.
Process & system related Terms & Definition	Several processes and systems are related to co-processing and associated activities. Pre-processing, Alternate use, Calcination, Clinkering, environmentally sound technologies while environmentally sound management, solid waste management (SWM), Trans-boundary movement, Sustainable Development are system-related terms are the process-related terms associated with the co-processing.
Legal and permit related Terms & Definition	The terms, such as Authorization, Consent, extended producer responsibility (EPR), Registration, Prescribed authority, and Tipping (or Gate) Fee are day-to-day relation to the co-processing and associated activities. For the awareness of each the permission for the process, compliance to the respective limits and parameters.
Infrastructure related Terms & Definition	For effective co-processing of wastes in cement plant necessary infrastructure are Kiln, Co-incineration plant, Facility, Pre-calciner, Rotary kiln, etc.
Stakeholder Related Terms & Definitions	For great impact on the quality of co-processing and associated activities the contractor, transporters, waste generators, etc., are very important stakeholders.

2.8.2 Alternative fuel and raw material (AFR)

To replace a portion of the virgin natural resources it uses with waste and by-products from other processes there has many amenities in the cement industry. Depending on their properties these may be used as raw materials, fuels, or as constituents of cement. Alternative fuels and raw materials should meet quality specifications in the same way as conventional fuels and raw materials.

a. **Alternative Raw Material use** : Replacing raw materials such as clay, shale and limestone the selected waste and by-products containing useful minerals such as calcium, silica, alumina and iron can be used as raw materials in the kiln.

b. **Alternative fuel**: Replacing a portion of conventional fuels, like coal the selected waste and by-products with recoverable calorific value can be conduct as fuels in a cement kiln. With the target of ensuring a uniform source with near constant thermal properties in most cases, a specific pre-processing of the waste will be carried out in order to economically provide an engineered alternative fuel for the cement process, which usually includes a homogenization process. The alternative fuel produced keeps the status of the input wastes after the pre-processing, and is managed by waste regulations.

c. **Alternative raw material and fuel** : Because some materials have both useful mineral content and recoverable calorific value, the distinction between alternative fuels and raw materials is not always clear. For example, sewage sludge has a low but significant calorific value, and the ash from its combustion contains useful minerals for the clinker matrix. For this specific case, these wastes must be treated as a fuel and processed in a high-temperature environment where the organic phase is completely destroyed .

d. **Waste or by-product cement additives** : These materials can be used with clinker to produce different types of cement. They may help to control the setting time of the cement (synthetic gypsum); they may have cementations properties in their own right (blast furnace slag); or they may affect the consistency of the cement mortar. The use of these alternative constituents is extremely important in reducing the environmental impact of cement production. They can reduce the quantity of energy-intensive clinker required for each tonne of cement, further reducing CO2 emissions per tonne.

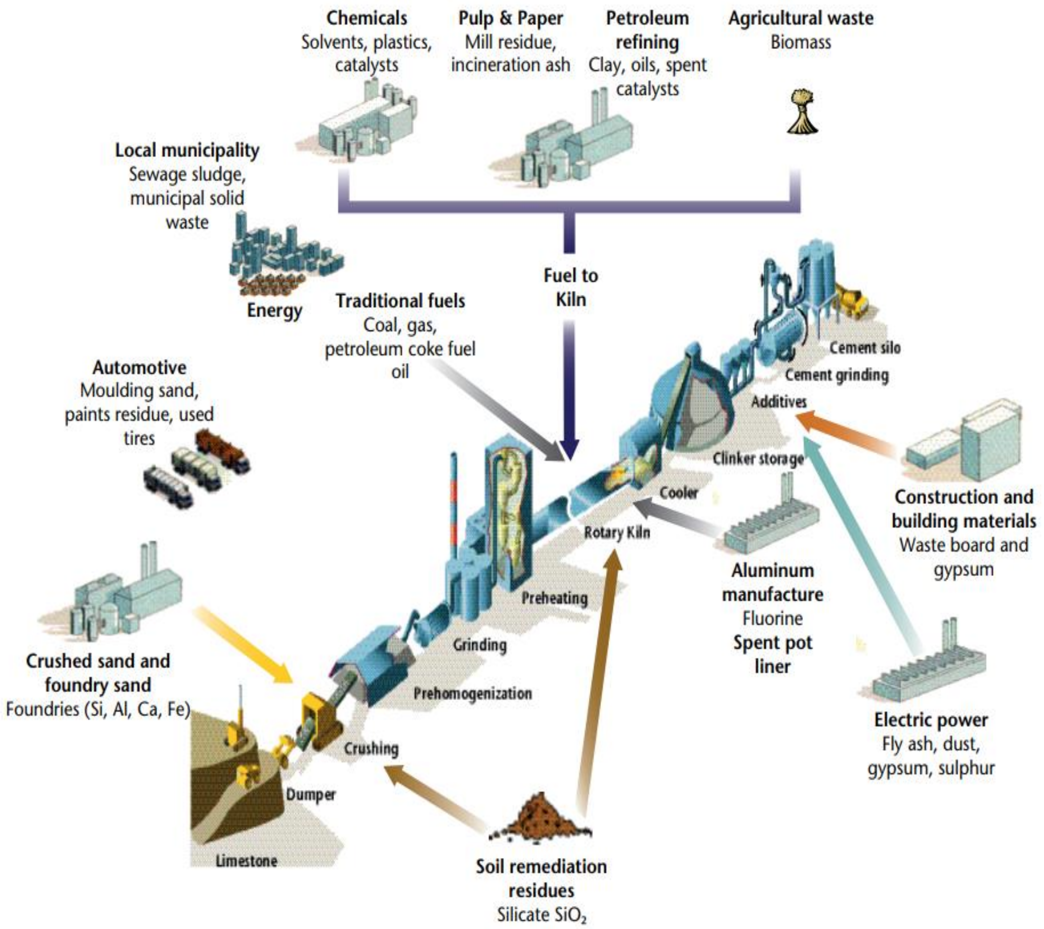


Figure 18: Alternative fuel & raw material used in cement industry

There are many alternative fuel & raw material are there that can be turned into cement. Those are **Hazardous Waste (HW).**

- For Cement Industry growing emission standards using HW.
- For selected categories of HW recommend exemption of emission trials.
- For co processing suggest steps to increase availability of HW by including some part of land-fillable HW.
- For HW pre-processing units we have to develop guidelines for cement industry.
- Inventory data base on software platform facilitate availability of HW in all relevant states.
- To include co-processing of HW in Cement plants it has been suggest amendments to existing HW rules as a 4th option of HW disposal.
- Based on viability gap funding for HW Pre- processing units for cement Industry, encouraged central/state subsidy.

Residue Derived Fuel (RDF) from Municipal Solid Waste (MSW):

- Namely technical, institutional and financial that addresses all the pillars of sustainability setting up a demonstration project in a public private partnership mode.
- Under their waste to energy scheme RDF co-processing inclusion by MNRE.
- By partly reading the menace of MSW RDF use for co-processing to be acknowledged as a CSR activity, which would unlock finances for this action that will have major societal benefits.

Used Tyres:

- Through with used tyres recommend ban on current practices of that create huge environment pollution.
- For co-processing it is recommend free import of tyre chips and rubber waste.

Biomass :

- For utilizing surplus biomass it has to represent to MNRE for including biomass co-processing in cement industry in their action agenda.
- The cement industry as CSR activity Captive/neighbourhood should be carried out energy crop plantation.

Industrial Plastic Waste :

- Plastic waste co processing in cement plants in other states of India encouraged by the Replicate Gujarat model.
- Normalization of policy with regard to categorization of plastic waste that facilitates its transportation across states.
- Fly ash : Policy amendments to increase fly ash usage in cement industry to 40% from the present level of 35%.

Slag:

- As raw material Pre-sorted and sized LD slag from steel plants are used for AFR.

2.8.3 Guidelines for use of alternative fuel and raw material in cement kiln :

Key performance indicators: Key performance indicators (KPI) provide a measure of how companies are moving toward more eco-efficient use of fuels and raw materials. The measures below are the ones that CSI member companies have committed to report on. KPIs have also been agreed upon by CSI member companies for other key areas identified in the CSI Charter, including those for emissions monitoring and employee health and safety.

a. Air emissions: Refer to CSI Guidelines for Emissions Monitoring and Reporting in the Cement Industry.

b. Energy KPIs:

Specific heat consumption for clinker production: total heat consumption of kilns divided by the clinker production, in mega joules per metric tonne of clinker (MJ/t).

Alternative fuel rate (kiln fuels): energy contained in consumed alternative fuels divided by the total heat consumption of kilns (%).

Biomass fuel rate (kiln fuels): energy contained in consumed biomass fuels and biomass content of mixed fuels divided by the total heat consumption of kilns (%).

c. **Raw material KPI** :
Alternative raw materials rate: consumption of alternative raw materials, as a percentage of total raw materials for cement production (calculated on a dry basis).

Clinker/cement (equivalent) factor: calculated based on total clinker consumption and cement production (%).

2.9 Production of Refused Derived Fuel use of Refused Derived Fuel as Alternative Fuel & Raw materials :

RDF stands for Refuse Derived Fuel. From combustible components that the industry calls Municipal Solid Waste – MSW for short this fuel is produced. For finally burned to produce electricity this waste, usually taken from industrial or commercial sites, is shred, dried, and baled. Refuse Derived Fuel is a renewable energy source that assure waste simply isn't thrown into a landfill and instead, put to good use. The World Business Council for Sustainable Development explains: "Selected waste and by-products with recoverable calorific value can be used as fuels in a cement kiln, replacing a portion of conventional fossil fuels, like coal, if they meet strict specifications. To provide 'tailor-made' fuels for the cement process" sometimes it can only be used after pre-processing. RDF has many facets, meaning it can be further specified into SRF (Solid Recovered Fuels) and, AF (Alternative Fuels) and TDF (Tyre Derived Fuels),.

The materials are processed for the RDF is 'combustible components' that can be processed for RDF. Such components include non-recyclable plastics, paper cardboard, labels and generally 'corrugated materials. The variety of materials able to be processed and turned into Refuse Derived Fuel means that this practice poses huge environmental benefits, as less and less fossil fuels will be required in coal fired power plants, lime plants or cement plants.

Size screening, coarse shredding, bag splitting, shredding, Magnetic Separation, and refining separation are the production steps are involved in RDF.

2.10 Pre-processing of waste :

There are several techniques that are utilized for waste pre-processing. These include the following:

(a) To comply with the desired level of composition, heat content, and/or viscosity it has to Mix of liquid wastes.
(b) Via shredding, crushing, shearing, etc. bulky combustible wastes and packaged wastes are processed.
(c) Wastes are mixing in a bunker.
(d) To produce refuse-derived fuel (RDF) it has to processing of source segregated combustible waste and/or other non-hazardous waste.

2.11 LITERATURE REVIEW

Literature review of Potential of plastic waste generation from ELV

1: **Giovanni Francesco Cardamone (2012)**: The main objective in this paper is management option of ELV plastic in Europe. Those are ELV dismantling, ELV shredding, Post shredding treatment and the other innovative options for the management of ELV plastics are creasolv® process, extruclean process and by plastic upgrading process . In this paper mainly in terms of Carcinogens, Non-Carcinogens, Global Warming and Non-Renewable Energy midpoint categories the Life Cycle Impact Assessment indicates that the proposed new recycling scheme could strongly improve the environmental performances of ELV plastics management. Their potential influence improved of 138%, 100%, 42% and 114%, respectively. This means that plastics from end-of-life vehicles could be managed in a sustainable way, by using the analysed novel options, appropriately combined in an efficient management scheme.

2: **I. Vermeulena (2011):** Recycling of ELVs is not a recent concern, scrap cars have been recycled on an industrial scale for many decades and long before any national or European legislation was enacted . The recycling rate of ELVs has always been high in comparison to other consumer products, due to their high metal content (of about 70%), making recycling economically feasible. The environmental impact of the non-recycled fraction of an ELV should nevertheless not be overlooked, as it often exhibits hazardous characteristics due to the presence of spent oils and lubricants, heavy metals, persistent organic pollutants (POPs), etc.

Primary recovery techniques, mostly of mechanical or physical nature, are capable of recycling up to 75% of the ELV components, leaving a residual 25%, called automotive shredder residue (ASR). The review demonstrated that enhanced recycling and recovery of ELVs, possibly in combination with incorporation of ASR into products, will allow to meet the European 85% target for reuse and recycling. Moreover, the 95% reuse and recovery target will be met by applying in addition thermal incineration techniques or emerging technologies such as pyrolysis or gasification. Compared to present landfill practice with environmental benefits all these treatment methods were found.

3: **Yang Li (2020):** The demand of the supply of recyclable resources from End-of-Life Vehicles (ELVs) become driving society because the contradiction between limited resources and rapid development in the automobile industry. To have an overall understanding of the end-of-life (EOL) vehicle population, what and how they can convenience from ELV recycling for vehicle producers it has become an urgent need for vehicle recycling policymakers.

In this paper the results display that more than 19.1 million tons of recyclable steel and 6.2 million tons of plastics can be recycled in 2030. An introduction of recycling policy instruments leading by vehicle producers may reduce the government expenditure on promoting legal vehicle recycling such as the deposits to vehicle producers for recycling the end of life vehicle thus reduce their production costs .

4: **A Merkisz-Guranowska (2018):** In this paper discussed about the waste from end-of-life vehicles can be economically reused or forwarded for disposal. The UE 2000/53/EC directive imposes a recovery rate from end-of-life vehicles on the level of 95% of their weight and a recycling rate on the level of 85%. Changes in the material structure of vehicles observed in recent years indicate a gradual replacement of ferrous metals traditionally used in the automotive industry with plastics and composites, which mainly results from the need to reduce the vehicle weight, fuel consumption and CO_2 emission.

The conditions for maintaining high recovery and recycling rates for the ELV are as follows: deeper dismantling at the treatment facilities, improvement of technologies of light fraction segregation after shredding, i.e. mixed fraction of waste obtained after shredding of the body at an industrial shredder and separating of the metal fractions, investment in technical infrastructure like plastic processing facilities (mixed plastics in particular, as is the case for many vehicle subassemblies) as well as facilities processing composites and carbon fibres.

5: I. Vermeulena (2011): This paper was dedicated for How Current landfilling practice will be limit by the treatment of ELV that is related to Automotive Shredder Residue (ASR) . In ASR 25% are recycled and 75% of the ELV components are recycled by primary recovery techniques. The use of thermo-chemical process like pyrolysis or gasification are applied for further reduction of ASR and also incineration and thus its application in waste to energy plants in cement kilns or in metallurgical processes is possible for environmental impact .

6: **Yee Choong Wong (2018):** In this paper tells about the subjects of global concern are maintained by End-of-Life (ELV) waste management and its immeasurable environmental impacts. The study proposes a framework that convert the ELV waste from automotive to construction industries to promote circular economy thus improve ELV recyclability. This concept was enlarge on the basis of present ELV policies and legislation , processing framework, waste management and recycling possibilities for converting ELVs into building products.

7: **Giovanni Francesco Cardamone (2021)**: In this paper the study analyses novel treatments of sorting, dissolution/precipitation, extrusion, catalytic pyrolysis, and plastic upgrading, which could contribute to define a sustainable ELVP management scheme. The new scheme greatly enhances ELVP management performances, by hugely increasing annual amounts of polymers sent to recycling (from 26 kt/y up to 509 kt/y), drastically decreasing residues to be sent to combustion or landfill (from 984 kt/y down to 232 kt/y), and improving the impact of main environmental categories. Carcinogens, Non-Carcinogens, Global Warming and Non-Renewable Energy reduce of 138%, 100%, 42% and 114%, with reference to the current scenario.

The recovery of PE in fuel tanks by a supercritical extrusion process and the treatment of residues and non-target polymers by a catalytic pyrolysis process also contribute to improve the environmental performances. A sensitivity analysis quantifies the role of some key parameters, indicating that the results could be affected by energy consumption of dissolution/precipitation process, oil yield of catalytic pyrolysis treatment, but also by the substitutability factor utilised to quantify the avoided burdens associated to the recycled polymers.

2.12 Research gap:

As per the literature review I have found that there are still some points to be discussed are as follows:

- Method of segregation and collection of NRPW from dumpsite as well as from household and market.
- Potential of dumpsites for NRPW as raw material for co-processing in cement kiln.
- A definite business model for conversion of NRPW into RDF is not reviewed till now .
- No definite supply chain for marine littering .
- Automatic & intelligent recovery system
- Efficiency & Safety disassemble
- The lack of recovery process in terms of slag, electrolyte & anode for Li-ion batteries.
- The Development of recycling methods for new batteries which have various components for li-ion batteries.

2.13 Research questions :

1. Which residuals are used and out of which process do the waste materials come from for co-processing?
2. Which pollutants do the waste contain in co-processing?
3. The data of the used waste (calorific value, water content, heavy metals, chlorine content, PCB, etc.).
4. Is the statements reliability durably guaranteed in co-processing ?
5. Is a constant quality within a certain spectrum possible in co-processing?
6. What is the expected emissions (PCB, Dioxin/Furan, heavy metals) in co-processing ?
7. How is the enrichment of harmful substances in clinker or cement ?

8. How we can enhance the ground realization of the potential and introduced policies to encourage the development of co-processing still remains in the nascent stage with Thermal Substitution Rate (TSR) reported at less than 1% ?
9. What are the economic feasibility, industry perspective and proposes menu of business models for turning co-processing into a sustainable business case ?
10. What is the emissions and product quality of in the cement manufacture during co processing were presented ?
11. How the co-processing in cement plant is highly robust process as mentioned from the analysis and also the auxiliary technology requirement is less thus making the process a sustainable waste disposal and carbon mitigation process ?
12. How will the cement industry be able to further reduce the environmental footprint of its operations and its products in their final application and guarantee the safety of the workers and populations living near the plants?
13. Which wastes are used as alternative raw materials?
14. Does using wastes as alternative fuels and raw materials have any effect on cement quality?
15. Does using wastes as alternative fuels and raw materials have any effect on concrete properties ?
16. How to design a recycling network model to reduce costs and carbon dioxide emissions?
17. How do different factors affect the optimal location of facilities in the recycling network?
18. How to further reduce costs to promote recycling of waste tires and used batteries based on the designed recycling network model?
19. How to integrate black mass into a circular economy of waste tire and lithium-ion batteries

2.14 OBJECTIVES:

- Evaluated current plastic waste problems and management practice in the pilot demonstration area (and country if possible), including possible environmental impacts of current plastic waste management practice. This is already partly in place, done by SINTEF.
- Evaluated the feasibility/environmental benefits of using local cement industry to recover energy/co-process NRPW compared to current plastic waste management practice in the pilot demonstration area.
- Estimated t/y of NRPW co-processed in pilot sites in 2022 compared to current plastic waste management practice (year 2019/2020) and provide an estimate of future co-processing potential by scaling up the practice to all cement plants in the country.
- Estimated t/y coal saved by co-processing of NRPW in the pilot site(s) in the year 2022 compared to baseline (year 2019/2020) and provide an estimate of future potential by scaling up the practice to all cement plants in the country.
- Documented the number of cement plants co-processing NRPW in the country by 2022 and provide an estimate of future potential by involving all "feasible" cement plants.
- Evaluated the future need for other waste streams in the Pilot demonstration area to ascertain sustainability for companies starting with co-processing of wastes
- Potential of plastic waste generation from End of life Vehicle.

CHAPTER 3:

This chapter is based on literature review on circular economy and relation with co-processing

- Definition of circular economy.
- Co-processing of plastic waste in cement plant –A transition to circular economy.
- Circular economy model for plastic waste management through co-processing technology.

CO-PROCESSING A TRANSITION TO CIRCULAR ECONOMY

3. **CO-PROCESSING A TRANSITION TO CIRCULAR ECONOMY**:

3.1 **Introduction**

The circular economy is most frequently depicted as a combination of reduce, reuse and recycle activities. The main aim of the circular economy is considered to be economic prosperity, followed by environmental quality; its impact on social equity and future generations is barely mentioned. Circular economy an industrial system which is restorative or regenerative by intention and design. It replaces the 'end-of-life' concept with restoration, shifts towards the use of renewable energy, completely remove the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models." The Circular Economy is aiming at a closed loop chain, eliminating all resource inputs and waste and emission leakages of the system, the goals of sustainability are open-ended and different authors address a considerable multitude of goals, that also shift depending on the considered agents and their mode of interests.

3.2 **Definition of circular economy**:

A circular economy is an alternative to a traditional linear economy (make, use, dispose) in which we keep resources in use for as long as possible, extract the maximum value from them whilst in use , then recover and regenerate products and materials at the end of each service life. Circular economy (CE) is important towards sustainable development, resources circulation and conservation, involving closing of material loops and cascading used resources , to prevent waste occurrence , and transforming the resulting residual streams into new (secondary) resources .

A circular economy describes an economic system that is based on business models which replace the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes, thus operating at the micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, nation and beyond), with the aim to accomplish sustainable development, which implies creating environmental quality, economic prosperity and social equity, to the benefit of current and future generation.

The Circular Economy as "an industrial economy that is restorative or regenerative by intention and design (Ellen MacArthur).

Circular Economy as the "realization of [a] closed loop material flow in the whole economic system" (Geng and Doberstein).

"A circular economy is one that is restorative by design, And which aims to keep products, components and materials at Their highest utility and value, at all times" (Webster (2015: 16) .

Circular economy is a systems-level approach to economic development and a paradigm shift from the traditional concept of linear economy model of extract-produce-consume dispose-deplete (epcd2) to an elevated echelon of achieving zero waste by resource conservation through changed concept of design of production processes and materials selection for higher life cycle, conservation of all kinds of resources, material and/or energy recovery all through the processes, and at the end of the life cycle for a specific use of the product will be still fit to be utilised as the input materials to a new production process in the value chain with a close loop materials cycles that improves resource efficiency, resource productivity, benefit businesses and the society, creates employment opportunities and provides environmental sustainability (Ghosh S.K, 2019).

Circular Economy as a regenerative system in which resource input and waste, emission, and energy leakage are minimised by slowing, closing, and narrowing material and energy loops. This can be achieved through long-lasting design, maintenance, and repair, reuse, remanufacturing, refurbishing, and recycling.

3.3 Plastic Waste & Circular Economy

Society needs to stop thinking of plastic as 'waste,' but as a renewable resource that needs to be disposed of correctly. A circular economy is restorative and regenerative by design. This means materials constantly flow around a 'closed loop' system, rather than being used once and then discarded. In the case of plastic, this means simultaneously keeping the value of plastics in the economy, without leakage into the natural environment. But this is easier said than done. The Ellen MacArthur Foundation reported that more than 40 years after the launch of the first universal recycling symbol, just 14% of the plastic packaging used globally is recycled, while 40% ends up in landfill and 32% in ecosystems (with the remaining 14% used for incineration or energy recovery). To move society away from the "take, make, dispose" mind-set that has long-informed business models, a fundamental rethink is required. This will involve improving recycling, promoting reuse, creating a market for recycled materials and redesigning products with end of life in mind.

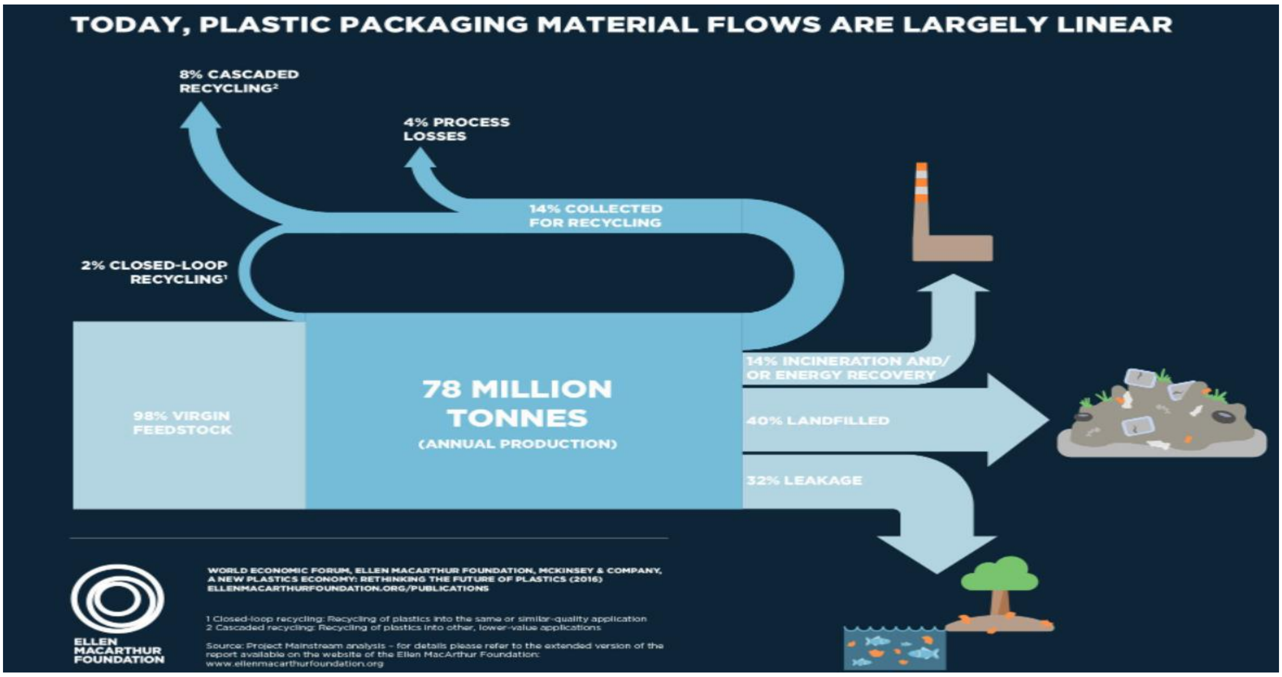


Figure 19: The linear plastic system (Ellen MacArthur Foundation 2017)

Now the question is how do we create a circular economy for plastic? We have to made several plans like beach clean up the waste already in our environment but they are far from enough. Even if we manage to clean up the current plastic in the environment, more plastic leaks into it every day . Every minute , one garbage truck of plastic waste enters the world's oceans. We need to stop plastic leaking into the environment. So we need a systemic approach to create a system that works in practice without loss of economic value and no plastic waste or pollution. We need to rethink the way we make, use, and reuse plastics essentially redesigning the system in which the material is used. Also we can ban all plastic and replace it with another material, such as glass, paper or aluminium. In some cases banning plastics can be a solution, but substitution of plastic with other materials can lead to significant negative, unintended consequences, such as increased carbon emissions, water use, and food waste. In every case, we must take a holistic approach, looking at the whole system in which a material is used, from sourcing and production to use and after use.

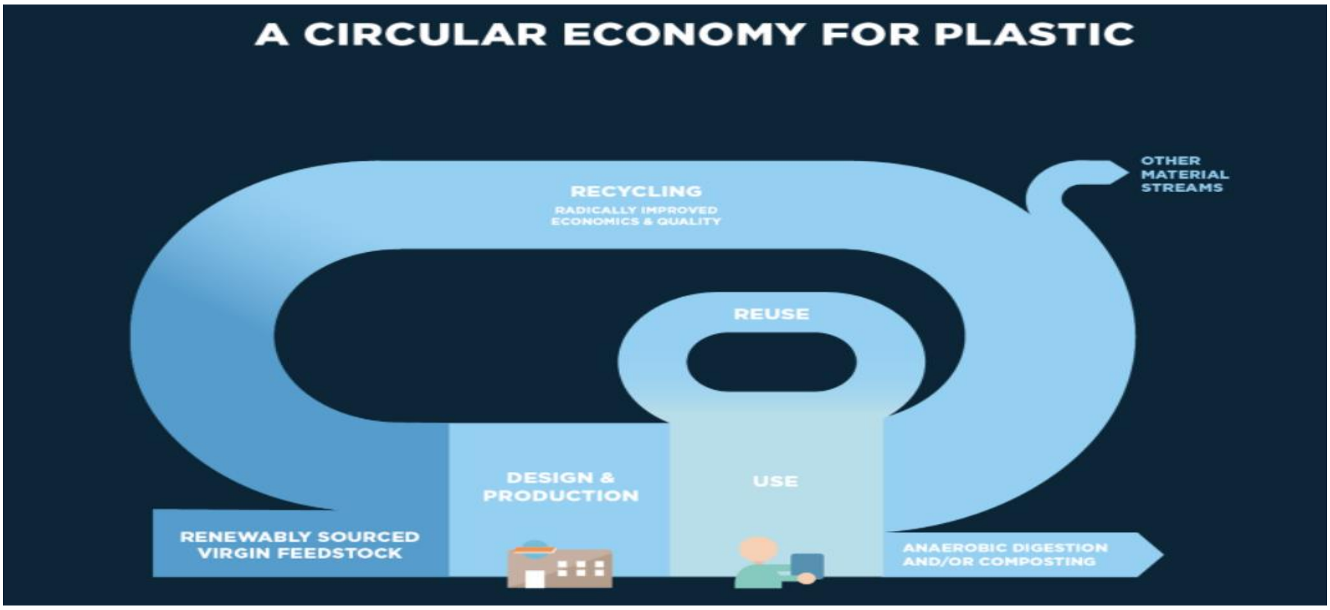


Figure 20: A circular economy model for plastic (Ellen MacArthur Foundation 2017)

3.4 Co-processing of plastic waste in cement plant – A transition to circular economy .

A resource-efficient circular economy for plastics is one that minimizes wasteful use of plastics, produces plastics from renewable sources, is powered by renewable energy, reuses and recycles plastics within the economy without leakage to the environment, and generates no or minuscule waste or emissions.

To enable this, the GOI through its Plastics Waste Management Rules, 2016 has mandated Extended Producer Responsibility (EPR) that incorporates circularity by making manufacturers of products responsible for collecting and processing their products upon the end of their lifetime. The objective of EPR is to minimize the total environmental impact of waste materials from a product and encourage manufacturers/ brand owners to create markets for reuse or recycling of materials. Although there have been collaborative initiatives in existence such as the United Nations Development Programme (UNDP) India, in partnership with Hindustan Coca-Cola Beverages Private Limited (HCCBPL), which encourages sustainable plastic waste management practices and fosters a move towards circular economy in 50 cities and towns in India . Different types of plastic are used in various sectors, such as for domestic and industrial purposes, and as a result, plastic waste is generated. This generated plastic waste is regularly collected on a regular basis by industries, municipal authorities, and rag pickers before being sent to a cement plant for co-processing thus helping to form a circular economy. Reuse of plastic waste for co processing in cement plant promotes circular economy.

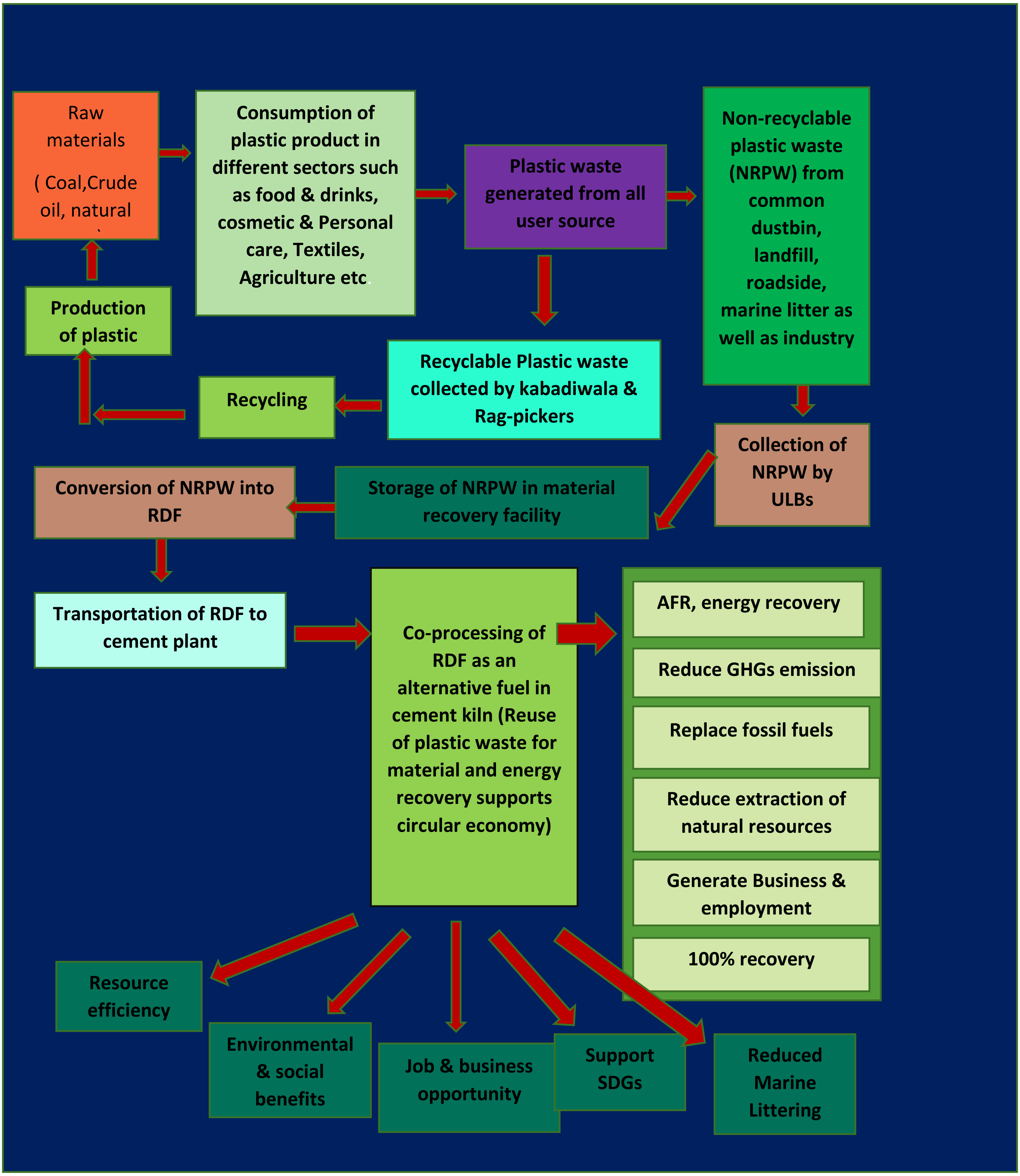


Figure 21: Circular Economy model in plastic waste management trough co-processing in cement plant.

Field study and data collection

4

This chapter is based on

Experimental work. It includes

- **Online and offline Survey with the scavengers in (informal) waste management (environmental, economic, social and health & safety aspects).**
- **Sampling of plastic waste**

Different municipalities of Kolkata and Odisha

- **Data collection on status of co-processing of non-recyclable plastic waste in cement kiln during visit to the cement plant s in Odisha**
- **Testing of collected samples from dumpsites.**

4. CHAPTER 4 FIELD STUDY AND DATA COLLECTION :

4.1 Interviews with scavengers in (informal) waste management (environmental, economic, social and health & safety aspects)

Scavenging is a source of income for most unskilled people in the developing countries. Questionnaire was structured to extract information that included perceptions of scavengers about their activities, health implications of scavenging, monthly income, and behavioural norms. Many people in developing countries make a living by gathering recyclable material that has been refused by others , a practice called scavenging or waste picking.

Valuable items are recovered from discarded solid waste. International Labour Organisation (ILO) defined scavenging as physical selection of recyclable matter from muddled waste discarded at landfills, dumpsites, and places where waste is collected. Poverty caused by unemployment in developing countries leads to scavenging . Our study of meaning making in the face of intractable dirty work examines rag pickers in Mumbai, India, who handle and dispose of garbage, and are further tainted by belonging to the lowest caste in Indian society, and living in slums. These rag pickers constructed both an overarching sense of helplessness rooted in the intractability of their situation, and a set of positive meanings—survival, destiny, and hope—rooted in specific facets of their lives and enacted through distinct temporal frames . How do people engaged in intractable dirty work at the intersection of multiple sources of taint make and manage meanings of their work and lives?

By talking with and observing rag pickers in Kolkata, we gained considerable insight into how people make meaning of their work and lives in the context of intractable, intersecting sources of taint.

The question arises as to how the jobs for rag pickers are created and what service they are rendering to the society. The jobs for rag picker originate from the incumbency of the citizens, who do not care to separate the recyclable and non-recyclable materials from their domestic waste. These rag pickers pick up the useful material and take it to the trash men, who forward it ahead to be recycled. Rag pickers make the recyclable material available to the factories at throw away price while its import could involve a lot of foreign exchange. Also the manure from the separated waste is of better quality. People consider the rag pickers a nuisance but these poor fellows are rendering great service to us by making our waste degradable.

4.2: Methodologies adopted for interview :

The snow ball method intended to gather information on the role of rag pickers in waste reduction, and to find out their socio - economic status, health and hygienic problems was followed10. The survey was conducted among waste pickers in the corporation area during September - December, 2009. For this a structured interview schedule was devised. One hundred and fifty out a total of about 950 rag pickers involved in the activity were randomly selected and interviewed**.**

Activities carried out:

The OPTOCE team has prepared a questionnaire based on the requirements for our study in the OPTOCE project. The questionnaire is for information regarding the status of socioeconomic and health conditions of the scavengers or helping persons working in waste handling and processing facilities like MRF & MCC in major cities in Odisha. OPTOCE team visited waste handling and processing facilities like MRF & MCC in mentioned cities in Odisha. The team discussed with the municipal officers regarding the facilities such as safety equipment, working tools, health cards, and daily wages, provided to the people working in those facilities. The team also analyses the working environment, the amount of physical activity needed, and problems at the working site. OPTOCE team gathered detailed data regarding the socio-economic and health and safety condition of the scavengers working at those sites through the questioner base detailed interview of the scavengers.

Questionnaire prepared for data collection during visiting SWM facilities in different cities in Odisha.

Personal questions	Social questions	Economical questions
• Name • Age • Gender • Education • Marital status • Engagement in occupation (Years) • Daily working time	• Faced discrimination due to work (Yes/No) • problems faced at the working site • Working environment	• Average monthly income • Engagement in any other occupation. • Getting any welfare schemes from Govt, Pvt, NGO • Averagely monthly expenditure on medication

Health questions	Health questions	Health questions
• Injury during work • Type of injury • occurrence of sick leave • occurrence of work accidents • Any musculoskeletal symptoms • any general illness	• Any respiratory illness • Any dermatological problems/skin diseases • Any infectious diseases • Any cardio-vascular illness • Any mental health disorder (depression & anxiety)	• any kind ofaddiction • Attended any health check-up camp • have health insurance, health card • Getting maternity leave (For women) • Uses ofpersonal protective equipment during work

4.3: Study on the socio-economic and health aspects of Scavengers, in the waste handling processes

- **4.3.1: Socio-economic aspect**

Gender- In this occupation, the male proportion is always high than the female. Especially, in the study area, Sambalpur, the female waste pickers or helpers are mainly observed otherwise, the proportion of males is high in other sites. As shown in Table 01 among the total interviewed 59 scavengers there are 37 scavengers are male and 22 women scavengers.

So, the gender ratio of total interviewed scavengers is,

- **37: 22 = 1.68, approx. 2**
- This means there are 2 men working as formal scavengers or helping persons,wherein there is 1 female worker.

Table 01 shows the proportion of male and female scavengers working in Waste managementfacilities in different cities in Odisha. In fig 1. The gender ratio for each city is shown.

Table 4: shows the proportion of males& females among scavengers

Location of the interview	**No of interviews of scavengers**	**Male**	**Female**
Bhubaneswar	8	5	3
Angul	5	4	1
Cuttack	10	7	3
Berhampore	7	7	
Sundargarh	6	4	2
Rourkela	7	7	
Keonjhar	6	3	3
Sambalpur	10		10
Total	**59**	**37**	**22**

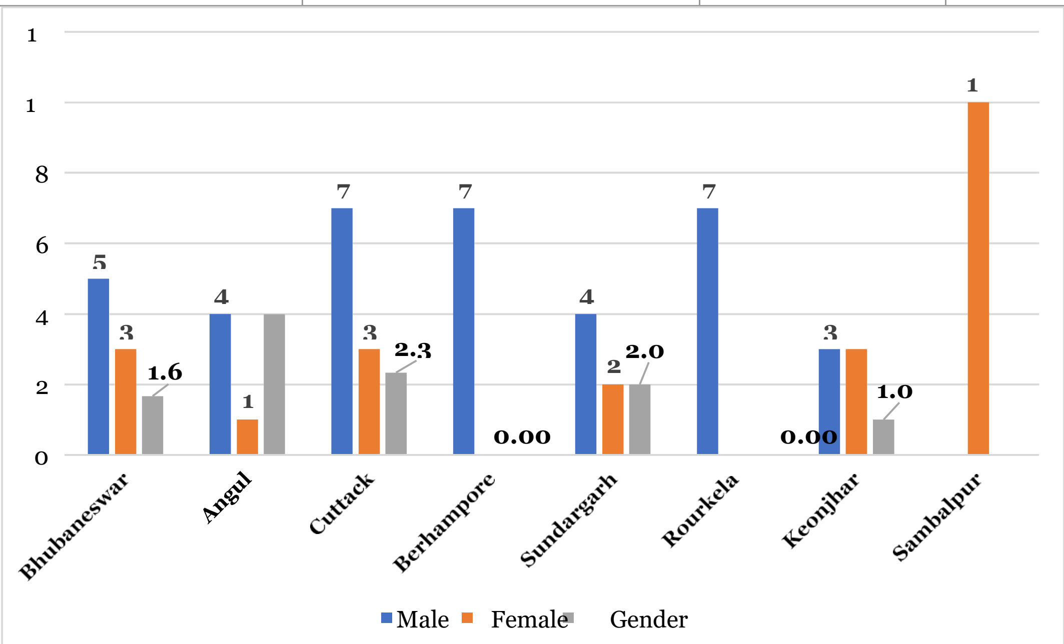


Figure 22: Gender ratio in different cities in Odisha field visit

Age-group- In these studies, it is found that teenagers below 18 years are also engaged in this job due to poverty and family size. In Bhubaneswar below 18 years of age, scavengers are also engaged in the waste management and handling process, mostly in the major cities, the >30 age group people are engaged in this waste picking. It is also observed, that above 50 aged helping persons are alsoengaged in the sites. Table 2 is showing the detailed data of different age groups of helping persons working at PW management sites.

Table 5: Shows the age-group of scavengers

Location of the interview	No. of interview of scavengers	Age groups		
		< 30 years	30-50 years	>50 years
Bhubaneswar	8	2	5	1
Angul	5	1	4	
Cuttack	10	5	3	2
Berhampore	7	3	3	1
Sundargarh	6	2	4	
Rourkela	7	1	5	1
Keonjhar	6		2	4
Sambalpur	10	2	6	2

Education - As this job is not required as such no education criteria, the engaged maximum peopleare illiterate or primarily educated. In study areas, it has been observed that the no of illiterate is also high while only 1scavenger got an opportunity in secondary education. They are mainly engaged for their family responsibility and large family size while there is not required such education in this job. In this case, a major issue is notable that despite being a megacity, there is a lack of gettingopportunities for education among waste pickers in Odisha. The details of the educational qualification of waste pickers involved at waste management facilities are given in table 03.

Table 6: shows the literacy ratio among scavengers in various sites

Location of the interview	No of interviews with scavengers	Education		
		Illiterate	Primary education	Secondary education
Bhubaneswar	8	2	6	
Angul	5	1	4	
Cuttack	10	6	4	
Berhampore	7	4	3	
Sundargarh	6	3	3	
Rourkela	7	2	5	
Keonjhar	6	4	2	
Sambalpur	10	2	7	1

Average income - Among eight sites, the average monthly income of waste pickers is around 6000- 6500rs. Due to contractual jobs, the fixed-wagesare not sufficient at all for scavengers. Workers engaged through the initiative “Mission Sakti” from self-help groups are paid 7500/- as monthly wages and can be seen working in MRF & MCC of Sambalpur. Table 04 shows the average monthly income of waste pickers or scavengers in the surveyed cities in Odisha.

Table 7: shows the average income of scavengers in various sites

Sl no	Location of the interview	Average income 5001/-7000/-	Average income 7500/-
1	Bhubaneswar	4	
2	Angul	5	
3	Cuttack	6	
4	Berhampore	8	
5	Sundargarh	1	
6	Rourkela	1	
7	Keonjhar	3	
8	Sambalpur		10

4.3.2 MEDICAL EXPENSES AND WELFARE SCHEMES

Due to getting involved in unhygienic and unhealthy jobs, the medication expenses are getting regular and high. The average expenses are around 250-500Rs in most of the sites. During COVID, the vaccination of scavengers was done free of cost.

- **HEALTH ASPECT Physical hazards-**

In the physical hazards, the most common diseases are respiratory diseases and musculoskeletal symptoms among waste pickers. In most of the sites, skin diseases and injuries are not that common because of using protective equipment such as vests and gloves by the waste pickers, the physical weakness is about 60% which is a high range due to involvement in the physical hard-working job. Addiction to smoking and tobacco consumption is also found in the survey. In table 05 and Fig 02, the numbers of occurrences for each disease and injuries for each city are mentioned in detail.

Table 8: shows the condition of the different health aspects of scavengers in various sites

Sl no.	Survey area	Health impact				
		No. Of scavengers served	Injury	Musculoskeletal symptoms	Skin diseases	Addiction
1	Bhubaneswar	8	2	5	2	3
2	Angul	5	1	3	0	2
3	Cuttack	10	3	6	2	3
4	Berhampore	7	2	4	1	5
5	Sundargarh	6	2	3	2	5
6	Rourkela	7	1	5	1	6
7	Keonjhar	6	2	4	0	3
8	Sambalpur	10	1	4	2	3

4.4 Sampling of plastic waste in different dumpsites in Kolkata and Odisha:

In brief, we found that the Kolkata rag pickers engaged in meaning making about three central intersecting sources of taint: their work, their caste, and the place they live. This meaning making involved both the construction of an overarching sense of helplessness rooted in the intractability of their situation and a set of positive meanings—survival, destiny, and hope—rooted in specific facets of their lives and enacted through distinct temporal frames. The rag pickers were unable to reframe their exceptionally oppressive situation as only positive. Instead, they held negative and positive meanings simultaneously, combining them in a way that enabled them to carry on.

SAMPLING OF PLASTIC WASTE IN DIFFERENT DUMPSITES IN WEST BENGAL AND ODISHA

A sampling of municipal solid waste at five different dumpsites (Baruipur, Maheshtala, Berhampur, Murshidabad in West Bengal:

Coning and quartering method [IS 436-1-1 (1964)] is used for sampling of mixed solid waste.

Coning and quartering method: The reduction in size of a granular or powdered sample by forming a conical heap which is spread out into a circular, flat cake. The cake is divided radically into quarters and two opposite quarters are combined. The other two quarters are discarded. The process is repeated as many times as necessary to obtain the quantity desired for some final use (e.g., as the laboratory sample or taste sample).

1. A definite amount of 64 kg fresh solid waste is to be collected.

2. Samples from all heterogeneous sampling points shall be mixed thoroughly.[Initially the fresh waste consists concentration variations in different points; they are to be mixed well to get almost equal concentrations in different points of waste collected]

3. The sample is placed on a clean plain surface in the form of heap. [Each cell was brought to a sorting table—a 4' x 8' sheet of plywood with 2" x 6" x 8' rails] (Ref: A Sampling Protocol for Composting, Recycling, and Re-use of Municipal Solid Waste; Martin J.H.; et al.)

4. The total amount of waste taken for sampling are to be divided into 4 parts, using straight lines, perpendicular to each other, where each possesses similar weight (16 kg each)

5. Waste from opposing corners of the divided heap is removed to leave half of the original sample. The remaining portions (16+16 = 32 kg) are to be thoroughly mixed.

6. The mixed waste is to be separated into 4 parts (8 kg each) in similar fashion and 2 diagonal portions are taken removing other 2 portions.

7. Remaining portions (8+8= 16kg) are to be mixed well.

8. New samples are to be placed in fresh containers.

9. The amount of plastic waste is to be separate from total mixed waste of 16 kgs and weighed properly. And the plastic wastes are to be sorted into different container.

10. Weighing: Before and after washing & cleaning.

11. Plastic wastes are to be washed and dried properly to segregate the residues and impurities. After dried up completely, plastic waste is to be weighed and residue fraction can be measured from plastic waste.

12. After sorting out the plastic waste, they are to be identified and separated further according to 7 different categories of the plastics (PET, HDPE, PVC, LDPE, PP, PS & OTHER) and non-recyclable plastics.

13. Take the proper amount of each category of plastic waste, and fraction of each category waste is to be determined from a certain plastic waste.

14. Few clear videos and photos are to be captured of the overall sampling and segregation procedure.

15. All the packets of cleaned plastics are to be kept with label and date, location for testing.

16. These collected plastics will be taken to the lab for different testing.

17. All the records and photos with references are kept and written in the research log book of each researchers with date, location, contact person's details and other details.

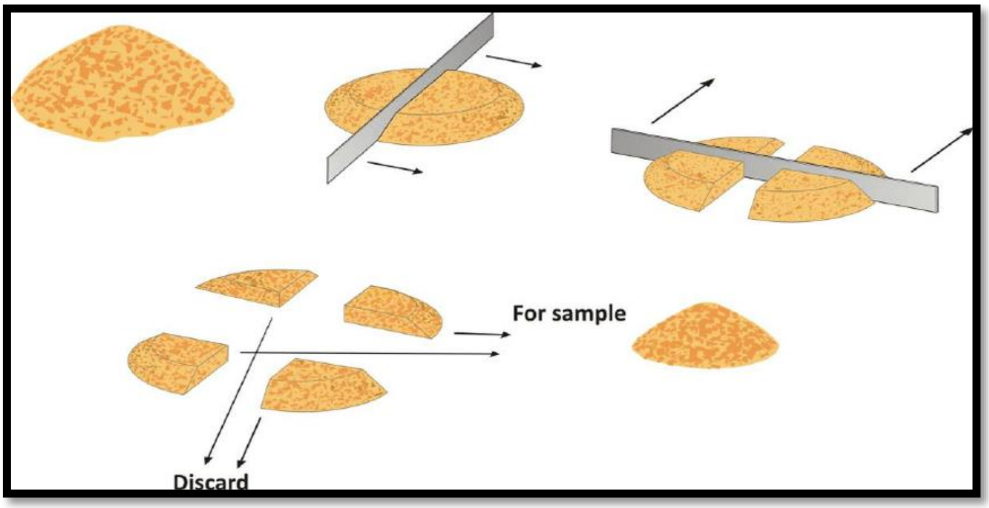


Figure 23: Coning and quartering method [IS 436-1-1 (1964)] is used for sampling of mixed solid waste

Sampling Tools & Equipment:

- ❖ Weighing Machine (100 kg precision)
- ❖ Digging Hoe (Kodal)
- ❖ Containers
- ❖ Gloves for waste handling
- ❖ Labours

4.4.1 Sampling at Baruipur dumpsites of West Bengal

- **Location of the Dumpsite:** kirtonkhola, ward-08, Baruipur, 19 km from Jadavpur university
- **Age of Dump site:** Over 60 years
- **No. of words covered:** 17 (Baruipur municipalities)
- **Types of waste compositions:** Mixed waste
- **No. Of scavenger/waste pickers(Formal/Informal):** 110 (20/90)
- **Area of dumpsite:** 2.03 acre
- **Total solid waste accumulated daily:** 33 to 34 tons
- **Types of vehicles- used for disposal of waste:** Tractors, Lorry, Dumper, compactor, paddle tricycle, battery operated tripper, and fuel operated tripper

Sampling Procedure of plastic waste at the dumpsite:

- 64 kg of mixed solid waste is taken from 2 different places for sampling.
- Total waste (64 kg) is divided into 4 square parts having equal amount of wastes and mixed well.
- 2 diagonals are taken from them and are mixed properly.
- Again, 32 kg of waste is taken and divided into 4 square parts having equal amount of wastes and mixed well.
- 2 diagonals are taken from them and are mixed properly.

- Again, 16 kg of waste is taken and divided into 4 square parts having equal amount of wastes and mixed well.
- 2 diagonals are taken from them and are mixed properly.
- Plastic waste from total 8 kg of mixed solid waste is separated and weighed properly.
- 2 sampling of plastic waste had been taken from mixed solid waste.
- Quantity of plastic waste from
    - Mixed waste #sample-01 (8.5 kg): 2.5 kg
    - Mixed waste #sample-02 (4 kg): 0.5 kg

Researcher at Baruipur municipality

Taking fresh waste for sampling

Total 64 kg of mixed solid waste was mixed well for sampling and placed in a clean fresh surface

The mixed solid waste taken divided into 4 parts having each 16 kg

Waste from opposing corners of the divided heap was removed to leave half of the original sample

The remaining waste was mixed thoroughly again placed in a clean fresh surface

The mixed waste was divided into 4 parts in similar fashion, each having 8 kg

Similarly divided into 4 parts each having 4 kg

Wastes from opposite corners were mixed & plastic wastes are separated

Figure 24: Sampling Procedure of Plastic Waste at Baruipur Dumpsite

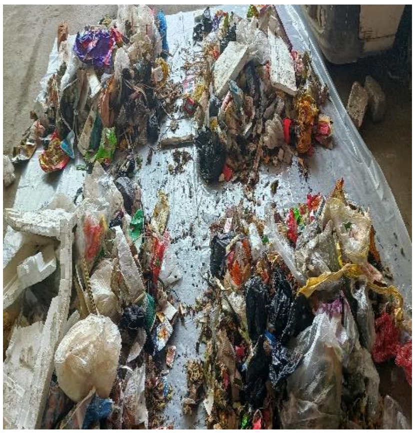
4.4.2 Sampling at Maheshtala dumpsites of West Bengal

- **Location of the Dumpsite:** Budge Budge Trunk Rd, Balarampur, Maheshtala, West Bengal 700140
- **Age of Dump site:** 16 years
- **Area of dumpsite:** 49 bigha
- **No. of words covered:** 35
- **Total solid waste accumulated daily:** 180 metric ton
- **Waste composition:** Mixed waste, kitchen garbage
- **Types of vehicles:** Paddle Tri-Cycle, Tractor, Eicher car, Tata 407, Ashok ley land, Tata ACE, JCB, JCB Hydra, Excavator, Tata V30, Dumper, Hyva compacter, Tri Cycle van.
- **No of scavengers working at the dumpsite:** 19 (Informal)

Sampling Procedure of plastic waste at the dumpsite:

- **Quantity of plastic waste from**
  - **Mixed waste #sample-01 (4.5 kg): 1 kg**
  - **NRPW #plastic waste (1kg): 0.85kg**

Total 64 kg of mixed solid waste was mixed well for sampling and placed in a clean fresh surface



The mixed solid waste taken; divided into 4 parts, each having 16 kg

Waste from opposing corners of the divided heap was removed to leave half of the original sample

The sample was mixed thoroughly again placed in a clean fresh surface

The mixed waste was separated into 4 in similar fashion

Diagonal portions were taken removing other 2 portions.

Figure 25: Sampling Procedure of Plastic Waste at Maheshtala

4.4.3 Waste Sampling at Lalbag Murshidabad dumpsites of West Bengal

- **Location of the Dumpsite:** Lalbag municipality Murshidabad
- **Age of Dump site:** 3 years
- **Area of dumpsite:** 5 acre
- **No. of words covered:** 16
- **Total solid waste accumulated daily:** 32 metric ton
- **Waste composition:** Mixed waste, kitchen garbage
- **Types of vehicles:** Paddle Tri-Cycle, Tractor, Eicher car, Tata 407, Ashok ley land, Tata ACE, JCB, JCB Hydra, Excavator, Tata V30, Dumper, Hyva compacter, Tri Cycle van.
- **No of scavengers working at the dumpsite:**

Sampling Procedure of plastic waste at the dumpsite:

- **Quantity of plastic waste from**
  - **Mixed waste #sample-01 (4 kg): 0.495 kg**
  - **Mixed waste #sample-02(4 kg): 0.685 kg**

Figure 26: Sampling Procedure of Plastic Waste on Mursidabad Dumpsite

Figure 1: Fresh waste taking for sampling

Figure 2: Total 64 kg of mixed solid waste was mixed well for sampling and placed in a clean plane surface

Figure 3: The mixed solid waste taken; divided into 4 parts, each having 16 kg

Figure 4: Waste from opposing corners of the divided heap was removed to leave half of the original sample

Figure 5: The sample was mixed thoroughly again placed in a clean fresh surface, total weight is 32 kg

Figure 6: The mixed waste was separated into 4 in similar

Figure 7: Waste from opposing corners of the divided heap was removed to leave half of the original sample

Figure 8: The sample was mixed thoroughly again placed in a clean fresh surface, total weight is 16 kg

Figure 9: Again the mixed waste was separated into 4 in similar

Figure 10: Waste from opposing corners of the divided heap was removed to leave half of the original

Figure 11: The sample was mixed thoroughly again placed in a clean fresh surface, total weight is 8 kg

Figure 12: Again the mixed waste was separated into 4 in similar

Figure 13: Wastes from opposite corners were mixed & plastic wastes are separated

Figure 13: The plastic waste separated was collected, labelled and weighed












4.4.4: Sampling at Berhampur dumpsites of West Bengal:

- **Location of the Dumpsite**: Berhampur
- **Age of Dump site**: 30 years (Approx.)
- **No. of words covered**:
- **Total solid waste accumulated daily**: 120 TPD

Types of vehicles- used for disposal of waste: Tractors, Lorry, Dumper, Pay Ladder

Sampling Procedure of plastic waste at the dumpsite:

- 64 kg of mixed solid waste is taken from 2 different places for sampling.
- Total waste (64 kg) is divided into 4 square parts having equal amount of wastes and mixed well.
- 2 diagonals are taken from them and are mixed properly.
- Again, 32 kg of waste is taken and divided into 4 square parts having equal amount of wastes and mixed well.
- 2 diagonals are taken from them and are mixed properly.
- Again, 16 kg of waste is taken and divided into 4 square parts having equal amount of wastes and mixed well.
- 2 diagonals are taken from them and are mixed properly.
- Plastic waste from total 8 kg of mixed solid waste is separated and weighed properly.

2 sampling of plastic waste had been taken from mixed solid waste

- **Quantity of plastic waste from**
- **Mixed waste #sample-01 (4 kg):** 0.42 kg
- **Mixed waste #sample-02(4 kg):** 0.435 kg

Figure 1: Overview of Berhmpore dumpsite

Figure 2: Disposal of fresh waste at dumpsite

Figure 3: Fresh waste taking for sampling

Figure 4: Total 64 kg of mixed solid waste was mixed well for sampling and placed in a clean plane surface

Figure 5: The mixed solid waste taken; divided into 4 parts, each having 16 kg

Figure 6: Waste from opposing corners of the divided heap was removed to leave half of the original sample

Figure 7: The sample was mixed thoroughly again placed in a clean fresh surface, total weight is 32 kg

Figure 8: The mixed waste was separated into 4 in similar

Figure 9: Waste from opposing corners of the divided heap was removed to leave half of the original sample

Figure 10: The sample was mixed thoroughly again placed in a clean fresh surface, total weight is 16 kg

Figure 11: Again the mixed waste was separated into 4 in similar fashion

Figure 12: Waste from opposing corners of the divided heap was removed to leave half of the original sample

Figure 13: The sample was mixed thoroughly again placed in a clean fresh surface, total weight is 8 kg

Figure 14: Again the mixed waste was separated into 4 in similar fashion

Figure 14: Waste from opposing corners of the divided heap was removed to leave half of the original

Figure 15: Wastes from opposite corners were mixed & plastic wastes are separated

Figure 16: The plastic waste separated was collected, labelled and weighed

Figure 27: Sampling at Berhampur dumpsites of West Bengal

4.4.5: Sampling Procedure of Plastic Waste on Angul dumpsite:

Quantity of plastic waste from:
Non-recyclable plastic waste from 8.275 kg: 0.8 kg
Recyclable plastic waste from 8.275 kg : 7.475 kg

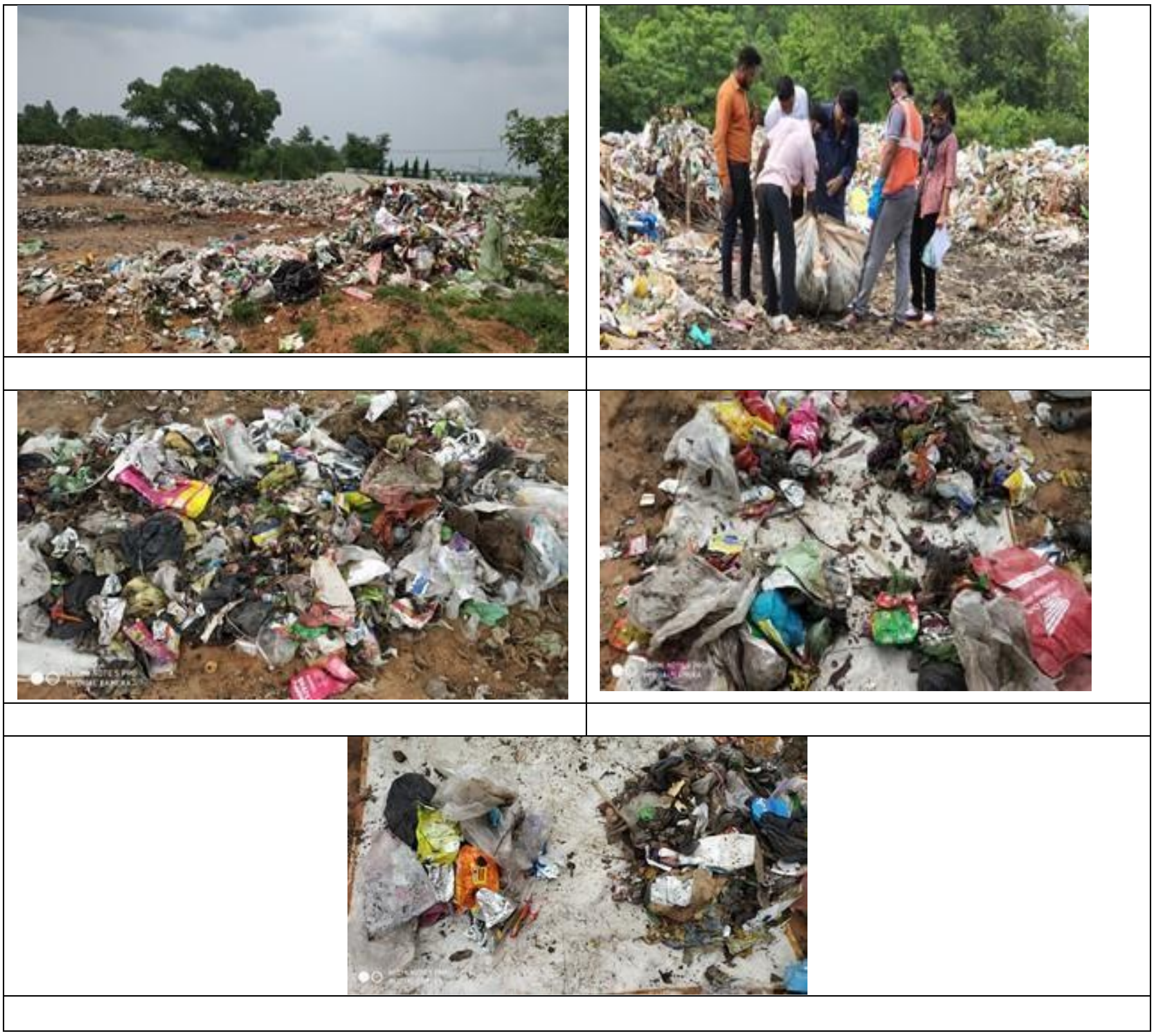


Figure 28: Sampling Procedure of Plastic Waste on Angul Dumpsite

4.4.6: Sampling Procedure of Plastic Waste on Bhubeneswar Dumpsite

Quantity of plastic waste from:

Non-recyclable plastic waste from 8.275 kg: 1.42 kg Recyclable

Plastic waste from8.275kg : 6.855kg

Sampling 2:

Quantity of plastic waste from:

Non-recyclable plastic waste from 7.925 kg: 0.9 kg Recyclable

Plastic waste from7.925kg : 7.025kg

Overview of Bhubaneswar dumpsite

Disposal of fresh waste to the dumpsite

Collection of 64 kg of mixed Solid waste and placed in fresh surface

Sampled waste was divided into 4 parts

Diagonal portions were taken removing other 2 portions

NRPW collected

Figure 29: Sampling at Bhubeneswar dumpsites of Odisha

4.4.7: Sampling Procedure of Plastic Waste on Keonjhar Dumpsite

64 kg mixed waste taken

Divided into 4 parts

Diagonals part are taken

Diagonals part were again mixed

Again divided by 4 parts

Diagonal part taken

Mixed and plastic waste are separated

NRPW collected

Figure 30: Sampling Procedure of Plastic Waste on Keonjhar Dumpsite

4.4.8: Sampling Procedure of Plastic Waste on Sundargarh Dumpsite:

Total 64 kg of mixed solid waste was mixed well for sampling and placed on a clean fresh surface

Mixed waste is divided in 4 equal parts each having 16 kg

Waste from opposing corners of the divided heap was removed to leave half of the original sample

Diagonal portions were taken removing other 2 portions and mix well

Wastes from opposite corners were mixed & plastic wastes are separated

The plastic waste separated was collected, labelled, and weighed

Figure 31: Sampling Procedure of Plastic Waste on Sundargarh Dumpsite

4.5. Result of sampling at dumpsites in Kolkata and Odisha

Table 9: Data for sampling of waste at sixteen different dumpsites in West Bengal and Odisha

Sl. No.	Location of the dumping ground with GPS	Date of Visit	Sample No.	Type of the fresh solid waste taken	Weight of NRPW in 16 kg of solid waste	Weight of NRPW in 64 kg of solid waste	Average weight of NRPW in 64 kg of solid waste (Kg)
1.	Promodnagar [22.646, 88.369]	21.12.2020	1	Mixed	0.3	4.8	7.015086 Kg (10.96%)
			2	Mixed	0.325	5.2	
2.	Baidyabati [22.788, 88.317]	22.12.2020	1	Dry	0.45	7.2	
			2	Mixed	0.268	4.3	
			3	Mixed	0.316	5.06	
3.	Budgebudge [22.473, 88.189]	11.01.2021	1	Mixed	0.305	4.08	
			2	Mixed	0.277	4.44	
4.	Sonarpur-Rajpur [22.422, 88.425]	14.01.2021	1	Mixed	0.212	3.4	
			2	Mixed	0.237	3.8	
			3	Mixed	0.237	3.8	
			4	Mixed	0.277	4.4	
5.	Dhapa [22.538, 88.422]	18.01.2021	1	Mixed	0.362	5.8	
			2	Mixed	0.33	5.28	
6.	Baruipur [22.35, 88.43]	23.03.2022	1	Mixed	0.48	7.68	
			2	Mixed	0.453	7.248	
7.	Maheshtala [22.51, 88.25]	29.03.2022	1	Mixed	0.562	8.992	
			2	Mixed	0.536	8.576	
8.	Berhmpore [24.124, 88.261]	09.04.2022	1	Mixed	0.42	6.72	
			2	Mixed	0.435	6.96	
9.	Murshidabad [24.175, 88.28]	09.04.2022	1	Mixed	0.495	7.92	
			2	Mixed	0.685	10.96	
10.	Bhubneshwar (Bhuashani)	21.06.2022	1	Mixed	2.74	10.98	
			2	Mixed	1.817	7.268	
11.	Cuttack (Chakradharpur)	21.06.2022	1	Mixed	2.38	9.52	
			2	Mixed	2.15	8.61	
12.	Berhampur (Mohuda)	22.06.2022	1	Mixed	1.66	6.65	
			2	Mixed	1.65	6.624	
13.	Angul (Panchamahalla)	22.06.2022	1	Mixed	1.54	6.18	
			2	Mixed	1.74	6.96	
14.	Sambalpur (Durgapalli)	23.06.2022	1	Mixed	1.68	6.72	
			2	Mixed	2.25	9.00	
15.	Keonjhar	23.06.2022	1	Mixed	3.06	12.26	
			2	Mixed	1.99	7.97	
16.	Sundargar	25.06.2022	1	Mixed	2.42	9.68	
			2	Mixed	2.62	10.49	

4.6: Co-processing of NRPW in Dalmia Cement Plant at Rajgangpur:

Objective:

The objective of the field study is to provide us an insight knowledge regarding mainly the usage of AFR in the cement manufacturing process and its components, the internal working of the company, and the opportunity to learn practicality through interaction regarding the manufacturing, quality control, packaging in the plant, etc.

Activity plan with a timeline:

Sl. No.	Activities	Timeline
1	**The questionnaire was prepared for data collection during a visit to cement plants**	June, 22
2	**Visit Dalima cement plants in Rajgangpur, Odisha for the study of co-processing of AFR in cement kiln**	24 June, 22

Activities carried out:

The OPTOCE team has prepared a questionnaire based on the requirements for our study in the OPTOCE project. The questionnaire is for information regarding the status of pre-processing and co- processing in the cement plant. The questionnaire is circulated to the respective cement plant through e-mail so that they got an idea about our study in their cement plant and the type of data we want to collect during the visit.

OPTOCE team with Prof. Sadhan K Ghosh, Principal Investigator visited the Dalmia cement plant, Rajgangpur, Odisha. Different pre-processing subprocesses are explained to the OPTOCE team and relevant data regarding the pre-processing process and quantification of waste/ RDF processed is gathered. To analyse the status of Co-processing at the Dalmia cement plant, the team surveyed the pyro-processes adopted at the plant. The whole pyro-process (the raw material and fuel to the end product clinker) is explained to the team and PI by the officers present at the plant. Different sections of the plant like the raw material storage section, pre-processing unit, calciner to the kiln operation arealso visited and explained to the team.

4.6.1: Description of cement plant:

Dalmia Cement is a part of the Dalmia Bharat group and is one of the pioneers of cement manufacturing industries in India. It produces 26.5 million tons per annum with 13 cement plants spread across 9 states in India.

Dalmia cement plant in Rajgangpur, Odihsa

- **Location of the Plant:** Rajgangpur, Odihsa
- **Age of the Plant:** 1950 - 51
- **Type of plant:** Integrated cement plant
- **Clinker production capacity**: 400 TPD
- **Quantity of MSW and RDF pre-processed**: 180-190 TPD (Dry waste).
- **The current Thermal substitution rate** (TSR): is around 19%.
- **Product range:** Ordinary Portland Cement (OPC) like 43 and 53 grades;

Portland Slag Cement (PSC);

Fly Ash-based Portland Pozzolana Cement (PPC),Sulphate Resistin

When it comes to sustainability, Dalmia cement is doing its part quite effectively. As a matter of fact, the plant mentioned above is using Alternate Fuels quite efficiently.

Figure 32: picture capture at dalmia cement plant

4.6.2: Questionnaire prepared for data collection during visit to cement plant

Questionnaire on Co-processing of Non-Recyclable plastic waste as Alternative fuel in cement kiln

1. List of material ▯ Input raw material ▯ Primary fuel Secondary fuel ▯ Product ▯ Bi-product	**2. Primary fuel (Fossil fuel)** ▯ **Coal** ● Type of coal used ● Calorific value of coal (MJ/Kg) ● Consumption of coal (ton/hr.) ● Consumption of coal (ton/year) ● Supplier of coal (name & location) ● Total Cost of coal per ton (Transportation included)
3. Secondary fuel (Alternative fuel) ▯ Name of alternative fuel (AF) ▯ Classification of AF (solid/liquid/gas) ▯ Source of AF • Supplier type (Industry/Municipality) • Supplier name • Supplier location • Batch size • Batch type (segregated/mixed) • Way of Transportation from source • Cost of AF • Timing of delivery (continuous over year/irregular/seasonal)	**4. Secondary fuel (non-recyclable plastic waste)** ▯ Source of AF • Supplier type (Industry/Municipality) • Supplier name • Supplier location • Batch size • Batch type (segregated/mixed plastic) • Way of Transportation from source • Cost of AF • Timing of delivery (continuous over year/irregular/seasonal)

5. Total amount of AF consumed (ton/hr.) &(ton/year)	**6. Calorific value of AF (MJ/Kg)**
7. Pre-treatment of AF - Pre-treatment process type (pre-processing) - Energy consumed - Processing cost	**8. Storage of AF** - Storage type - Storage capacity
9. Way of extraction from storage	**10. Way of transportation from storage to the Feeding point**
11. Way of dosing AF	**12. Type of feed point to process the AF**
13. Limiting factor for the utilization of AF	**14. Thermal substitution rate of AF (%)**
15. Energy consumed - Total Energy consumed per ton ofcement produced. - Primary fuel energy consumed per tonof cement produced - Secondary fuel energy consumed per ton of cement produced	**16. Refused derived fuel (RDF)** - Process flow chart - Capacity of RDF plant (ton/day) - Composition of input material for RDF - Plastic (Type, name, and quantity) - Calorific value of input material - Quantity of input material per ton of RDF (waste: RDF) - Composition of RDF - Calorific value of RDF - Type of RDF (grade) - grain size of RDF - Cost of RDF per ton - Investment and operating cost for RDF.

SL.	**AFR's physical and chemical properties**	
	Properties	**Value**
1.	Moisture (%)	
2.	Density (Kg/m^3)	
3.	Bulk density (Kg/m^3)	
4.	PH	
5.	Boiling point (^0C)	
6.	Melting point (^0C)	
SL.	**AFR organic properties**	
1.	Ash content (%)	
2.	Volatile content (%)	
3.	Calorific value (MJ/Kg)	
4.	Carbon (%)	
5.	Hydrogen (%)	
6.	Nitrogen (%)	
7.	Sulpher (%)	
8.	Oxygen (%)	
9.	PCBs (ppm)	

	AFR inorganic properties					
SL.	**Oxides**	**%**	**Halogens**	**%**	**Trace elements**	**%**
1.	SiO_2		F		Cd	
2.	Al_2O_3		Cl		Hg	
3.	Fe_2O_3		Br		Ti	
4.	CaO		I		As	
5.	MgO		CN		Ni	
6.	SO_3		NH_3		Co	
7.	K_2O				Se	
8.	Na_2O				Te	
9.	TiO_2				Cu	
10.	Mn_2O_3				Pb	
11.	P_2O_5				Sb	
12.					Sn	
13.					V	
14.					Be	
15.					Ba	
16.					Mn	
17.					Zn	
18.					Cr	

4.6.3: Study on pre-processing & co-processing in Dalmia cement plant, Rajgangpur, Odisha the pre-processing facility at Dalmia cement plant:

- **Source of NRPW & MSW for Pre-Processing**
  - Supplier type (Industry/Municipality)
  - Supplier name
  - Supplier location
  - Batch size
  - Batch type (segregated/mixed)
  - Way of Transportation from source
  - Cost of AF
  - Timing of delivery (continuous over year/irregular/seasonal)
- **Type of waste received:**
- **Size of RDF/ Waste received:** less than 500 mm
- **Grade of RDF received:**
- **Quantity of waste pre-processed (ton/day.):** 180-190 TPD
- **Pre-treatment process type (pre-processing sub processes involved):** Shredding andDrying
- **Energy consumed:**
- **Calorific value of AF (MJ/Kg):**
- **Machinery used:**
- **Purchase price of RDF/ AF used in cement plant from ULB/ service provider (rs/ton):**
- **Storage type:**
- **Way of extraction from storage:**

These wastes can’t use directly for co-processing as an alternative fuel due to limitations of size andquality. For co-processing samples are taken from each vehicle and get tested.

Table 10: Parameters and testing methods for a sample of waste in the Dalmia cement plant

Sl. No.	Parameters	Unit	Test Method
1	Ash content	%	Muffle Furnace (8500C)
2	Moisture content	%	Oven (1880C)
3	Gross calorific value (GCV)	Kcal/Kg	Bomb calorimeter
4	Chlorine (Cl)	%	Volumetric analysis
5	Sulphur (S)	%	Gravimetric analysis

Figure 33: Picture captured at Dalmia cement plant, Odisha

4.6.4: Flow chart for Pre-processing of Alternative Fuel (AF) in Dalmia cements plant, Rajgangpur, Odisha:

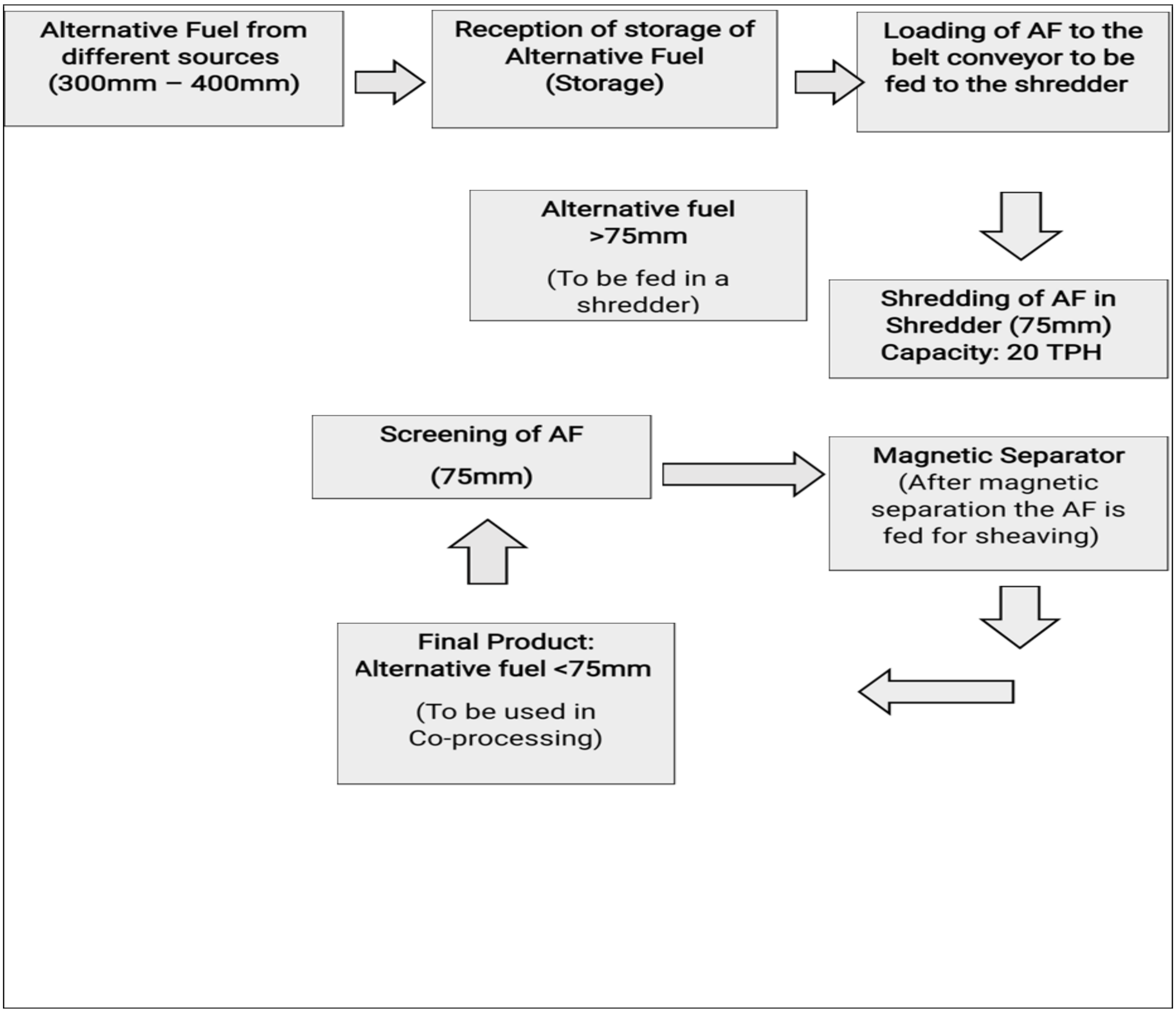


Figure 34: Flow chart for Pre-processing of Alternative Fuel (AF) in Dalmia cements plant, Rajgangpur, Odisha

Co-processing of AF in Dalmia cement plant, Rajgangpur, Odisha:

- Quantity of Municipal solid waste consumed (TPD):
- Quantity of Refused derived fuel consumed (TPD):
- Classification of AF (solid/liquid/gas):
- Total Energy consumed per ton of cement produced:
- Primary fuel energy consumed per ton of cement produced:
- Secondary fuel energy consumed per ton of cement produced

Waste of size less than 75 mm known as alternative fuel or refuse derived fuel are collectedand transfer to the hopper through conveyer belt.

4.6.5: Flow chart for Co-processing of Alternative Fuel (AF) in Dalmia cements plant, Rajgangpur, Odisha

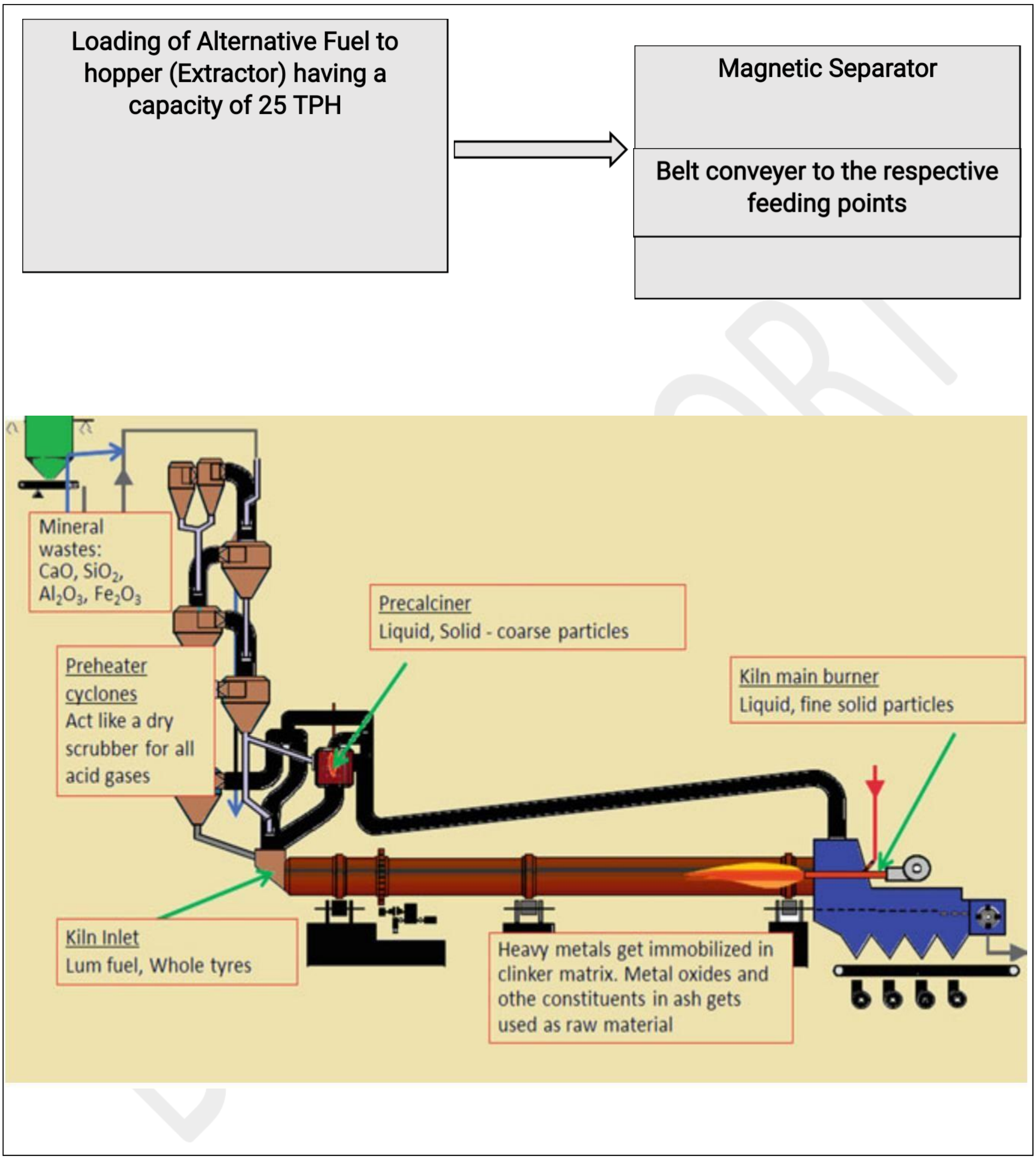


Figure 35: Flow chart for Co-processing of Alternative Fuel (AF) in Dalmia cements plant, Rajgangpur, Odisha

4.7: **Discussion & Conclusion for test result**:

It can be inferred from the test results that, although the waste plastics consist of all the compulsory parameters (GCV, ash content, moisture content, sulphur content) according to the permissible limit mentioned in the CPCB guidelines, due to the presence of the high amount of PVC contents all of the samples cannot be used directly alternative fuel in cement plant. Further, it can be observed that chlorine values of samples have high variation. It indicates the heterogeneous nature of plastic samples in several dumpsites. The plastic wastes from several landfill sites can be utilized as AFR after balancing PVC content of the plastic samples. That can be possible through the segregation of plastic samples according to the identification number mentioned. PVC can be sorted out using its identification code 3.

Main objective of our project is to study the possibility of co-processing of wastes generated and from Bio mining sites at Legacy dumpsites in Odisha, mainly the NRPW which may be converted to cement promoting the circular economy. The second objective is to compare the co-processing with other energy recovery processes from wastes to find the most economic and environmentally friendly process of resource circulation. The third objective is to study the socio- economic, health and environmental aspect of the scavengers involved in the work. According to this, we prepare a questionnaire and the survey was made in different cities wherever the scavengers are available. Our focus was to interview the waste pickers mainly the child scavengers through our survey. The production quantity of clinker and cement in different plants as well as the consumption of coal in Odisha are demonstrated in table 06. Availability of RDF for co-processing will definitely help in reducing the col consumption as well the GHG emission. Concerted efforts in increasing the utilisation of NRPW as RDF in co-processing is always welcome approach towards environmental sustainability.

Table.13 Status of cement production in Odisha

Company	Number of lines *	Clinker Mtpa	Cement Mtpa Est.	Coal Mtpa*
Dalmia	5	5.41	7.49	0.92
ACC	1	1.02	1	0.17
JSW- Shiva	4	2.64	2.59	0.45
Others	2	0.33	1.11	0.06
Total	12	9.4	12.19	1.60
* Specific thermal consumption of 680 kcal/kg clinker and coal CV of 4000 kcal/kg: i.e. each tonne of clinker production requires 170 kg of coal. Note: Ultratech, JK Lakshmi, Nirma, Penna, Ramco, Sagar, Shree Cement have grinding units only. Shiva Cement has approvals to expand prod. By 3 Mtpa clinker; Arcelor Mittal-Nippon steel is looking at an investment of 13.5 billion USD for installing cement capacity of 19 Mtpa.				

Orissa is one of the important cement clusters in India with the cement industry currently producing 9.4 million tonnes per annum (Mtpa) of clinker and 27 Mtpa of cement. With the approved investments, the cement production is expected to reach close to 50 Mtpa in 5-7 years. For clinker production, assuming an average net calorific value of coal of 4000 kcal/kg and specific thermal consumption of 680 kcal/ kg clinker, 1.6 Mtpa of coal will be consumed by the cement industry. By achieving 20% thermal substitution rate or TSR (which Dalmia Rajgangpur plant is achieving at present), 0.3 Mtpa of coal could be substituted. NRPW, if properly segregated, usually should have a higher net calorific value than coal (typically 6000-8000 kcal/kg). However, considering that the waste will have dust/foreign materials and high moisture, especially at dumpsites, the calorific value could be considered equivalent to cement-grade coal (i.e. 4000 kcal/kg). Therefore, for achieving 20% TSR, 0.3 Mtpa of NRPW will be required as alternative fuels. RDF typically has a calorific value in the range of 2000-3000 kcal/kg (low grade RDF). For achieving, 20% TSR utilising RDF, 0.4-0.6 Mtpa of RDF will be required as alternative fuels.

The nine districts in Orissa, covered during the field study, generate 0.4 Mtpa of MSW. With an average yield of 20%, potentially 80 000 tonnes of RDF can be generated. Percent NRPW found during the study was on average 13.27% and therefore annually 53 000 tonnes of NRPW are generated. Additionally, there are four operational dumpsites and three legacy dumpsites in these nine districts with an estimated accumulation of 3.20 Mtpa of MSW (and with the potential to generate 800 000 tonnes of RDF (assuming 25% yield). Considering the availability of NRPW or RDF, the cement industry in Orissa at present has the potential of achieving ……. % TSR.

MOHUA RDF guidelines have specified the different quality of RDF. The proximate analyses of the samples collected by quarter-coning method from the dumpsites reveal the following: CV, Moisture, Cl, Ash etc. Therefore, the quality of segregated combustibles wastes can be categorised as RDF I/II/III as per the MOHUA RDF guidelines. One of the significant solid waste management challenges today are poor segregation at MRF and MCC (meaning poor quality of RDF/SCF and NRPW) and poor uptake of the segregated fractions/combustibles by cement industry and other vendors. There also seems to be a pricing or business model issues around segregated combustibles which stems from the poor quality and inconsistent supplies.

As per the recent NGT order, cities must invest in bio-mining operations to get rid of operational and legacy dumpsites. Out of the nine districts visited, only Rourkela has a bio-mining facility. The study teams recommend that similar bio-mining facilities should be established in other districts and that the SCF/RDF/NRPW be supplied to the cement plants. MRF and MCC can also become important source of NRPW if the operations around segregation of wastes can be improved. With the current and projected clinkering capacity, the study teams also recommend that co-processing should be prioritised as an integrated waste management solution in Orissa. A tripartite agreement, as envisaged in the MOHUA RDF guidelines, between municipalities, RDF producers/bio-mining operators and the cement plants can be established to resolve the logistical and pricing issues. Dalmia-Rajgangpur cement plant has a success case as the plant is currently achieving 19% TSR and has a plan to achieve 100% TSR by 2035. OSPCB as a regulatory authority should showcase its achievements to other cement companies operating in the state, by way of conducting capacity building workshops. The competence at SINTEF, Norway and Jadavpur University and ISWMAW can be utilised for such measures. This may be note that though there were other cement plants which were using the RDF for co-processing, at present only Dalmia-Rajgangpur cement plant id using the RDF in co-processing on wastes. Appropriate measure should be taken to encourage other cement plants. Following are the status of the scavengers with respect to the Social Aspects, Socio-Economic Aspects, Health and Education as aspects of the scavengers in the waste management facilities and dumpsites.

Social Aspects: It has been observed from different collected data that, the new waste management system in Odisha has involved quite a number of scavengers more or less in semi-formal manner from informal types of involvement. Total number of employment generation in MRFs in nine cities is, 33x (40+10+10+10) = 2310. Total no of employment generation in MCC= 35x (40+10+10+10) = 70x35= 2450. Grand total of 4,760. The selling of the separated waste is still to be organised in most of the places, while a part of it sold wherever the scope comes. This gap led to the accumulation of separated wastes in different MRFs. However, the selling of separated waste depends on the efficiency of segregation. More the types of segregated wastes, better is the possibility of selling with better prices. The data of sale of these segregated wastes were not available during our visit. On the contrary, in some of the cities like Jharsuguda, Sundargarh and in the part of Kendujharh, the condition of separated daily waste need to be improved with respect to the storage and effective segregation. It has been also observed that the separated waste in some of the cities like Cuttack, Bhubaneswar and Rourkela, through the segregation is well organised, the availability of vendors including the cement plants for RDF, who will purchase the segregated wastes are yet to be formalised. The separation at Rourkela MRF, Sambalpur, Bhubaneswar and Angul are better than other cities. The availability of effective vendors needs to be explored in all the places.

Socio-Economic Aspects: The scavengers are asked about their economic condition if the NRPW is utilised in cement plant for co-processing. In reply, 90% of the respondents, replied in favour of utilization of RDF in co-processing, which they feel will bring better income for them with sustainability. They responded to be happier if their financial condition is improved by intervention of the cement plant in resolving the waste management problem in state.

Health: The most common occupational health hazards found among the scavengers are respiratory diseases and musculoskeletal symptoms. In most of the sites, skin diseases and injuries are not that common because of using protective equipment such as vests and gloves by the waste pickers. The physical weakness is about 60% which is a high range due to involvement in the physical hard-working job. Addiction to smoking and tobacco consumption is also found in the survey. In general, the health conditions are good. They receive the support of the health schemes of the state and central governments. However, support for the health aspects for their family members are not available. They need to manage by their own.

Education: we interviewed a total of 59 scavengers out of which it was found that 57% got the primary education, 40% are illiterate, and 2% cross the secondary education. Education level of scavengers demonstrated that the people educated in secondary level working as scavenger in a large number. The situation needs to be improved for decent employment generation**.**

Waste Generation Per Capita: It has been observed from our study that the per capita waste generation, in those nine cities varied from 0.205 kg/day (Jharsuguda) to 0.482 kg/day (Raurkela). The population data has been considering from 2011 census. While the population has been increased in last 11 years. A significant amount of waste generation is still uncollected considering which the per capita waste generation will be found at a higher level than our observed level. However, the per capita waste generation in cities like Bhubaneswar, Cuttack and steel city Rourkela where per capita earning is more will be little more than the observed value.

Bio mining: During our visit to the bio- mining of legacy dump in Rourkela, it was reported that the waste which are excavated by porcelains and separated by conveyor and trammels, are ready to sale. The soil excavated is being taken for the filling of newly constructed Hockey stadium. However, the quality of the soil being used for filling need to be check the content of heavy metals and other hazardous substances. Appropriate actions should be taken depending on the test data. The Construction and Demolition waste (C&DW) received in the bio mining of legacy waste counts nearly 5-10% which may be explored for utilization in low graded construction activities through C&DW recycling process. It has been reported by the bio mining site operator; nearly 35% of the total excavated waste is non-recyclable Plastic wastes and mixed types are generated. This is the significant amount which has a potential to use in Co-processing in the cement plant. However, the quality of the non-recyclable Plastic waste needs to be adhered to the requirements of the cement plant for coprocessing. There must be a mutually beneficial trade off conditions between the municipal authority and the cement plant so that the NRPW can be utilized for the production of cement through coprocessing. As reported by the operator, the terms and condition for the co-processing are still in the discussion or negotiation stage. The effect of which will help in environment sustainable.

4.8: **Summary of chapter:**

To investigate the role of energy-intensive industries, like cement manufacturing plants in waste management and the potential of different cities to contribute to the circular economy concept of "waste to wealth" by making Refused derived fuel from the combustible fraction of MSW, in Odisha, the OPTOCE team in collaboration with the Odisha State Pollution Control Board, and the International Society of Waste Management, Air and Water (ISWMAW), conducted surveys in major cities in Odisha, like Bhubaneswar, Cuttack, Angul, Berhampur, Sambalpur, Kendujhar, Jharsuguda, Rourkela, Sundergarh and in major cities in West Bengal tells us that there is a huge potential of Indian states for co-processing of plastic waste in cement kiln.
The project "Ocean Plastic Turned into an Opportunity in Circular Economy – OPTOCE", conducted and managed by SINTEF, is a regional effort to address the main reason for micro plastics in the Ocean, namely inadequate treatment capacity for plastic wastes on land. OPTOCE aims to investigate and document how the involvement of energy-intensive industries, like cement manufacturing, can increase the treatment capacity for Non- Recyclable Plastic Wastes (NRPW) and thereby contribute to reducing the release of plastics into the Sea.

The major objectives of the survey are to study the solid waste management systems established and adopted in nine identified municipalities in Odisha. Studying and quantification of generation of non-recyclable plastics wastes (NRPW) and its supply chain. Analysation of the potential of utilization of the NRPW and other wastes through coprocessing in cement plants implementing Circular Economy concepts. Studying the bio mining processes adopted in those cities and the potential of the use of legacy wastes in cement plants. This survey gives us an idea of studying the socio-economic, health, and environmental issues of scavengers including female and child scavengers due to coprocessing of wastes in cement plants. Studying the coprocessing in Dalmia Cement plant at Rajgangpur to explore the potential of co-processing of wastes and the present situation, utilization process, and utilization limitation for waste as an alternative fuel in cement plant.

We also visited the Dalmia cement plant, Rajgangpur, Odisha. Questionnaire-based on the requirements of the OPTOCE project, regarding the status of pre-processing and co-processing in the cement plant, is discussed with the concerned officers of the plant. Different pre-processing sub processes are explained to the OPTOCE team and relevant data regarding the pre-processing process and quantification of waste/ RDF processed is gathered, and attached with the cement plant visit report. To analyses the status of Co-processing at the Dalmia cement plant, the team surveyedthe pyro-processes adopted at the plant. The whole pyro-process (the raw material and fuel to the end product clinker) is explained to the team and PI by the officers present at the plant. Different sections of the plant like the raw material storage section, pre-processing unit, calciner to the kiln operation are also visited and explained to the team.
So, this report will put light on the existing solid waste management policies adopted in different cities in Odisha, Processes followed at MRF & MCC facilities are explained in the report with the relevant data gathered during the visit. The condition of exiting dumpsite andits potential for bio mining of legacy waste to be used as RDF in cement plants are explained in the report. The report will help the policymakers to identify and quantify the existing problems in waste management for those cities and the report also provide recommendations for the improvement of the exiting PW management policies.

CHAPTER 5:

This chapter Based on potential use of waste tyres and recycling Li-ion batteries promoting circular economy

Potential Use of ELV Waste like Waste Tyres and Lithium-Ion Batteries Promoting Circular Economy

5. **Potential Use of ELV Waste like Waste Tyres and Lithium-Ion Batteries Promoting Circular Economy** :

5.1 **Waste generation** :

The global ELV generation is estimated to be 40 million ELV/ year; this accounts for 4% of total global automobile ownership. (Sakai et al. 2013). It is estimated that the number of vehicles to become ELV will be 21895439 by 2025. (CPCB report "Analysis of ELV sector in India", 2015) .End-of-life vehicle (ELV) recycling is a process that spends energy and could be an energy source as well like from waste tyres and li-ion batteries we can use it in cement manufacturing process .It is understood that scrapped, disposed and End-of-Life Vehicles (ELVs) can be mined for secondary raw materials, which largely comprises of recycled steel, aluminium, plastics, rubber, copper and, of course, tyres. An old car or an End-of-life vehicle (ELV), is responsible for polluting air 8 times more than a new one, and a 15-year-old truck is responsible for polluting the air 10 times more than a new one. In terms of a number of vehicles, as per the best estimates available, currently, there are close to 30 MN ELVs in India which have reached an age of 15 years. As per the latest data from the government, at least 10 MN of these vehicles do not have a valid fitness certificate. In the next 5 years, another 46 MN vehicles will cross the age of 15 years. Clearly, there is a need for a formal recycling sector and a water-tight scrap page policy impel mentation . The car producer will be the main actor for the overall chain of the ELV treatment. Its cooperation with downstream of the ELV chain (the collector, dismantler and shredder) and with supplier will face to changes in the traditional manufacture of vehicle as well as to the existing ELV recycling process. In 2013, the Deutsche Gesell schaft für Internationale Zusammenarbeit GmbH (or GIZ) and Chin tan initiated a study on the ELV sector in the Delhi region. The resultant report of the study that followed, Story of a Dying Car in India, suggested that vehicles have a thriving after-life which required more attention than it had received so far. The study threw light on the fact that a whole sector of entrepreneurs (working almost entirely in the informal sector) recycles ELVs to a surprising extent of material efficiency, and many parts are reused and sold in a dedicated market extending well beyond the city boundaries. Evidence from Delhi, Meerut, Mansard, Moradabad and Naziabad are just fragment of the enormous ELV landscape in India . For the purpose of this waste generation of end of life vehicle. In addition, the following definitions shall also apply for hoe the waste generated .

Authorization means the process of evaluating, assessing and approving the capabilities and capacities of the collection and dismantling centre involved in the dismantling of end-of-life vehicles.

Authorized Collection and dismantling centre means the establishment / undertaking authorized by the Government certifying agency to collect and treat the end-of-life vehicles as per the provisions laid under this standard.

Government Certifying Agency means the agency appointed by the Government for authorization of collection and dismantling centres in accordance with these rules.

Last owner is the person(s) who has (have) the legal possession of the End-of-Life Vehicle.

Certificate of Destruction means the certificate issued by the collection and dismantling centre to the last owner confirming that the treatment on the vehicle will be carried out as per the provisions mentioned in this standard.

In India, the used tires from the ELV are dispersed between recyclers who shred them for use in road-building or sports fields, firms that burn them as cheap fuel to make cement or bricks, and legal and illegal pyrolysis plants.(Factbox: Wheeler dealers: how to make money from scrap tires | Reuters)

The reference life span of vehicles by category, instead, was sourced from primary data collection, survey and structured in particular. Respondents who were prompted about on this point include: from these points we know the ELV generation in India.

- Disposers of vehicles;
- Traders of vehicles and their parts;

- Manufacturers, including OEMs and auto component manufacturers;
- Auto associations;
- Regional transport office
- State pollution control boards

Table 11: ELV count for different type of vehicle

Type of Vehicle	Total ELV count in 2025
Two Wheelers	1,77,23,951
Three Wheelers	7,57,932
Private cars/ SUVs	28,09,966
Commercial passenger vehicles	94,757
Commercial goods vehicles	11,88,833
Total vehicle count likely to be ELV in 2025	2,18,95,439

The burning of used tyres in kilns, as is beginning to happen in India, has also been of particular concern globally. Cement companies root for tyres for its high heat value (32.6 MJ/kg) compared with coal (18.6-27.9 MJ/kg). But tyres are believed to increase harmful dioxin emissions considerably. Metals are removed from the tyres and cut into small chips before feeding into kilns.

5.2 Supply Chain of tyre waste and li-ion batteries

5.2.1: Supply Chain and recycling of waste Tires

Every year, over one billion tyres are manufactured worldwide, and an equal number of tyres are permanently removed from vehicles, becoming waste. Tyres account for the largest amount of rubber utilized in a vehicle. However, End-of-Life Tyres (ELTs), or waste or scrap tyres, are tyres which are no longer safe for use because of the state of abrasion they've undergone due to wear and tear.

Tyres are made of high quality rubber and are considered a large potential source of raw material for the rubber industry. India has a big recycling industry which is pegged to be worth USD 914 million. In 2011, India produced 90,000 metric tonnes of reclaimed rubber from waste tyres (Mishra 2016).

The U.S. is the largest producer of waste tyres, about 290 million a year, although increases in new vehicles sales in China and India are rapidly contributing to waste tyre volumes (https://www.iamrenew.com/green-transportation/world-has-another-plastic-pollution-problem-from-tyres/).

Although modern tyres are fundamentally rubber products, they are a complex mix of natural and synthetic rubbers, and various structural reinforcing elements including metals and chemical additives. This complexity has led to stockpiling, dumping and diversion to landfill. This has exposed communities to environmental and health risks and has squandered valuable resources locked up in tyre dumps.

Stockpiled tyres are at risk of fire and toxic smoke, the largest tyre fire in the world began in Wales in 1989 at Heyope, where 10 million tyres had been dumped, and took 15 years to extinguish. Other risks include the stagnant water in tyres that provides breeding grounds for mosquitoes and leaching of toxic substances into soils.

Globally, in 2011, only 7% of waste tyres were recycled on site, 11% were burned for fuel, 5% were exported for processing elsewhere. The remaining 77% were sent to landfills, stockpiled, or illegally dumped; the equivalent of some 765 million tyres a year wasted . India's waste tyres account for about 6-7% of the global total. With the local tyre industry growing at 12% per annum, waste volumes are rising. India has been recycling and reusing waste tyres for four decades, although it is estimated that 60% are disposed of through illegal dumping.

Despite this, India is the second largest producer of reclaimed rubber after China. In 2011, India produced 90,000 metric tonnes of reclaimed rubber from waste tyres.

By 2016, some100 000 kms of Indian roads had been laid with asphalt blended with recycled rubber, and over 500 000 tonnes of crumb rubber modified bitumen (CRMB) is used annually in road construction. New regulations introduced in 2016 allow for import of waste tyres for recycling. (Abhay Choudhary et. Al.)

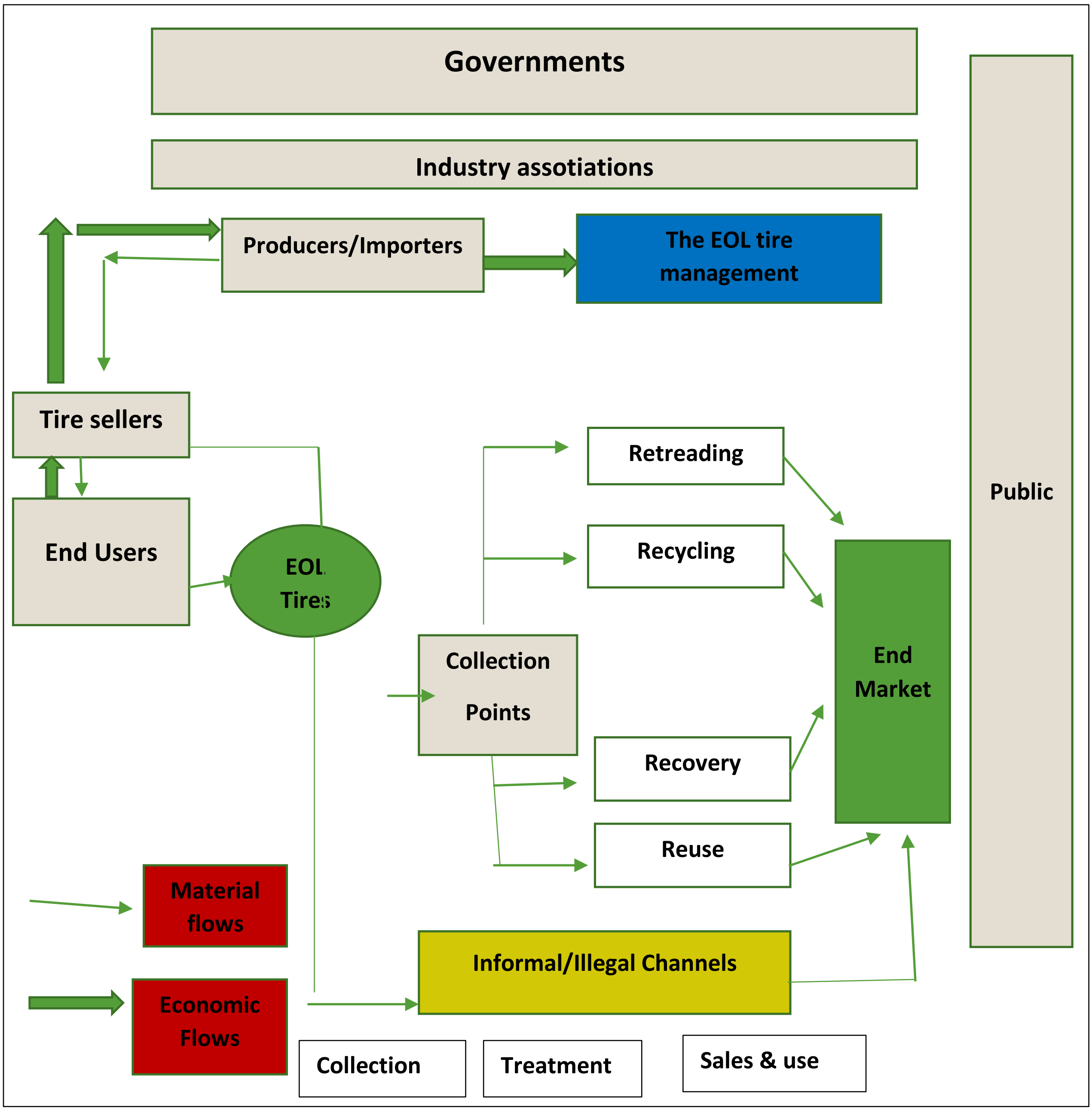


Figure 36: An integrated supply chain management system for EOL Tires

Global tyre manufacturing was calculated at 20 million tonnes in 2019 and it is increasing about 3.5% per year through 2024. Currently, only 15–20 percent of used tyres are considered for recycling or reuse. Furthermore, 75% to 80% of the used tyres are disposed of in landfills (Kinga Korniejenko et al.2021). Tyres include 46–50% rubber, 22–24% carbon black, 18–28% steel wires (belts and beads), and 5–6% textile overlays (polyester cord fabrics, rayon cord fabric nylon cord fabric, and aramid cord fabric) and also other admixtures (antioxidants, antiozonants, sulfur, zinc oxide, etc.) from this we can reuse it for various recycling treatment (Kinga Korniejenko et al.2021).

The tyres are usually made of rubber, CB, zinc oxide, organic additives and sulphur. After the thermal cracking, the main products structure of about 55% of pyro lytic oil, 15% of pyro lytic gas, 35% of CB and 15% of steel wire (Ruipeng Zhong et al.2019).

Tyres are processed according to all predicted forms in the waste management hierarchy.

Their utilisation includes:

- Reuse and/or export (the used tyre business is quite controversial, for safety reasons; However, according to the Rubber Manufacturers Association (RMA), between 30 and 35 million used tyres are sold annually)
- Re-treading (used tyre to a new tyre): Re-treading is another well established and acceptable safe practice for recycling tyres.
- Material recycling including civil engineering and construction applications, environmental rehabilitation projects, and consumer and industrial products. Particular implementations include, i.a., playground equipment, erosion control, and highway crash barriers or obtaining new constituents such as carbon silica ;
- Energy recovery for co-incineration and cement kilns as well as also pyrolysis. It is worth noting that this process usually requires technically demanding equipment and, furthermore, a large amount of CO2 and SO2 is released.
- Landfilling—many countries limited the possibility of storing used tires, due to the negative environmental impact and, in case of fire, the possibility of emission of different poisonous substances such as benzene, xylene, styrene, toluene, etc.

5.2.2: Supply Chain and recycling of Li-ion batteries :

The International Energy Agency predicts that the global electric vehicle stock will grow by 36% per year and by 2030 reaching 245 million EV stocks across the world (IEA, 2020). Electric vehicle batteries provide a good example of why thinking about the circular economy is so important. The production of a lithium-ion battery involves the use of various materials including lithium, cobalt, nickel and aluminium. A battery cell consists of four different components cathode, anode , electrolyte, and a separator from an electrochemical perspective but from a recycling perspective three additional components can be included those are collectors, one on the cathode and one on the anode, as well as the casing in here casing can be made of stainless steel , aluminium or plastics and collectors usually are made of copper or aluminium these are easily recycled and are in fact the only parts recycled widely today .

In battery industry Examples of use types of technologies are: lithium cobalt oxide (LCO), where cobalt is the main active material; lithium nickel cobalt aluminium oxide (NCA); lithium nickel manganese cobalt oxide (NMC); or Lithium-Iron-Phosphate and due to high specific energy, LCO batteries are most common in smartphones, laptops, and other hand-held electronics and for majority of electric vehicles the battery technology is NMC or NCA, but there are also vehicles with the Lithium-Iron-Phosphate technology and these types of batteries are considered the safest for the electric vehicles . The technology has none or very little interpretation when it comes to handling and transporting batteries, but from a recycling prospect the technology has a major impact on the value of the cells and the best-suited process for recycling. Their systematic reuse after being recycled is guaranteed by the automotive industry, but the process to do so is both complex and expensive, due largely to the series of chemical transformations required.

The principles of the circular economy would therefore suggest delaying that process as much as possible . Electric vehicle batteries like Lithium-ion batteries only reach the recycling stage after several years of extra use thanks to this second life. For battery life span laboratory tests have shown that lithium-ion batteries used in BPEVs can be used up to 20 years before they 31 reach their end-of-life (American-Chemical-Society, 2013) . At the end of their journey, the challenge is to then handle used batteries in such a way as to allow for the rapid reuse of the resources they contain, either within the automotive sector or an adjacent industry. That's the idea behind short-loop recycling, one of the driving forces of the circular economy.

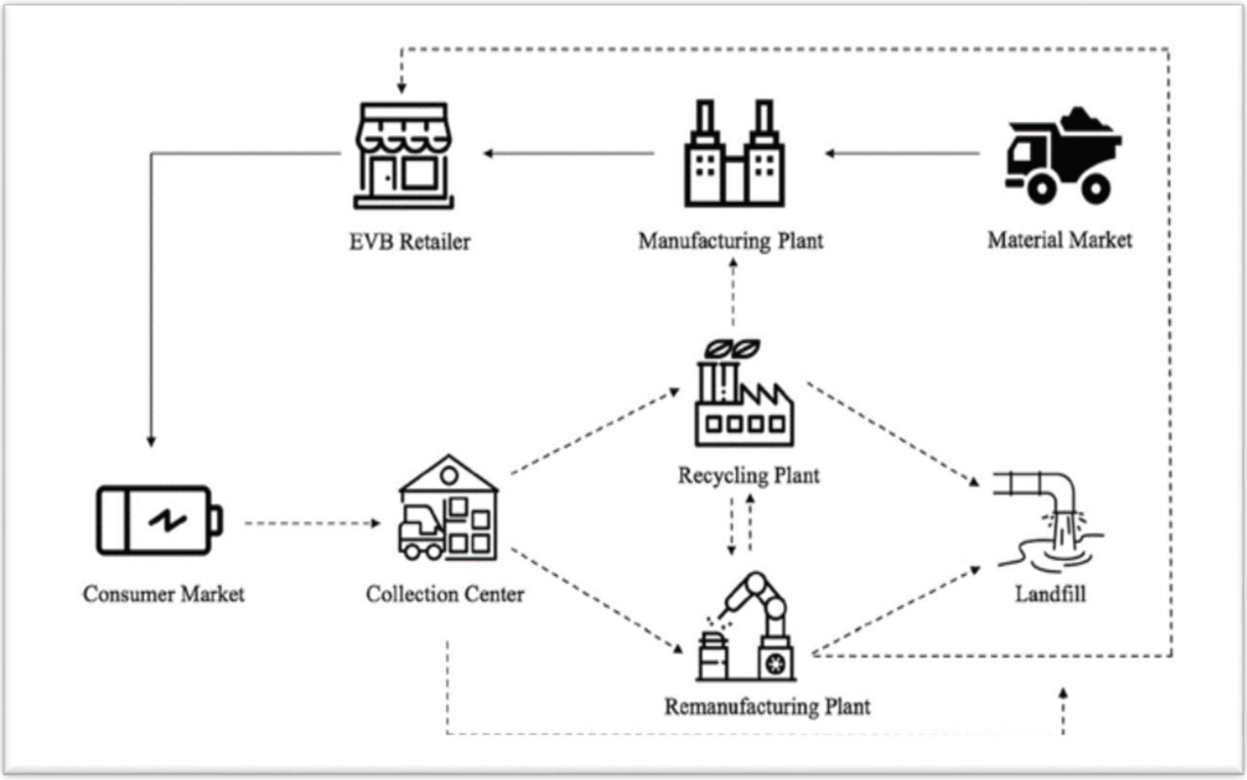


Figure 37: Closed loop supply chain management (Li L. et. al, 2018)

Dismantling of li-ion cells for recycling

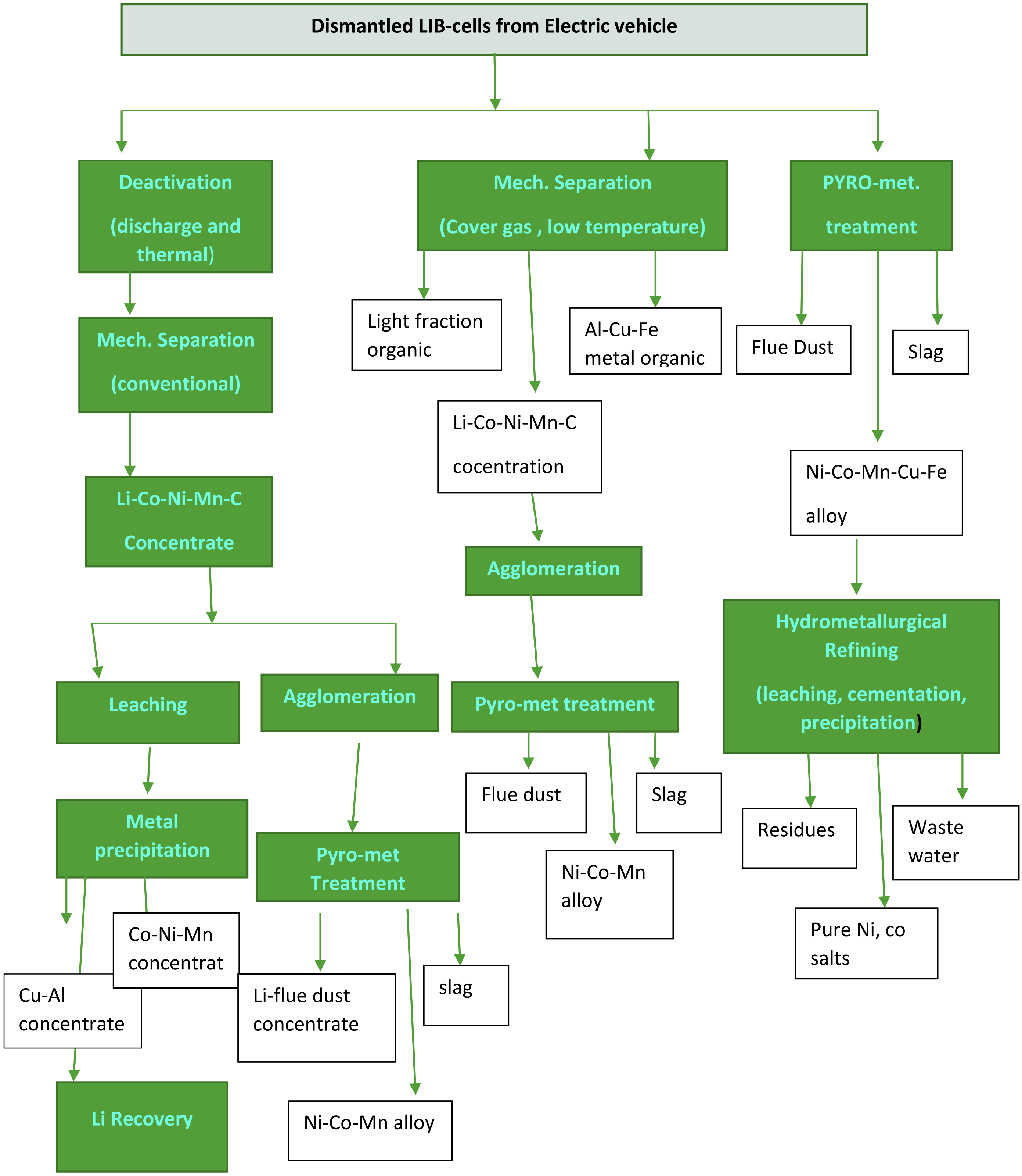


Figure 38: Different Dismantling procedure of li-ion cells for recycling

Recycling method	Pros	Cons
Hydrometallurgy : It Does mechanical pre-treatment and metal recovery from the black mass by means of leaching, precipitation, solvent extraction, ion-exchange resins, and bioleaching .	❖ Applicable to any battery chemistry and configuration ❖ Flexibility in separation and recovery processes to target specific metals ❖ High recovery ❖ High purity of products ❖ Energy efficient in comparison to pyro metallurgy ❖ No air emissions	❖ Battery cells must be crushed ❖ High volume of process effluents to be treated and recycled or disposed.
Pyro metallurgy : It Requires the processing of spent lithium-ion cells at high temperature without any mechanical pre-treatment and loading batteries directly into the furnace.	❖ Applicable to any battery chemistry and configuration ❖ No mechanical pre-treatment needed (for consumer electronics batteries , whole packs can be treated) ❖ Battery types do not have to be separated ❖ High recovery of metals	❖ Gas clean-up is required to avoid toxic air emissions ❖ Energy intensive ❖ Further refining is needed to produce elemental metals from the metal alloys produced in the smelting process.
Direct recycling (supercritical CO2, Mechanical process) : It Includes crushing and physical separation of components and recovery of the black mass .	❖ Almost all battery materials can be recovered	❖ Mechanical pre-treatment and separation required. ❖ Recovered material may not perform as well as virgin material ❖ Mixing cathode materials could reduce value of recycled product .

Black mass – a new resource found from recycling of Li-ion batteries

- Recycling of LIBs starts with mechanical operation this yields " black mass ",
- It mainly contains valuable Co, Ni, Mn , Li , but also carbon and many contaminants.

Chemical treatments are needed to extract the valuable metals from "black mass"

5.3 Present disposal method and Technologies:

For jointly add value to ELV the main components in the reverse supply chain for ELV management consist of networks of stakeholders. Material, information, and financial flows are formed these connections within networks .Each ELV is dismantled into thousands, even tens of thousands, of different individual parts, each with its own distinctive market and environmental burden. For the purposes of clarity and effectiveness, this study focuses on a selected number of ELV components based on considerations of their toxicity and waste. These components are broken down into simple categories, fluids on one side and solids on the other. Further to these toxic parts, the economics of non-toxic, more valuable parts was studied in order to understand the major source of revenue generation for dismantlers.

Fluid Parts of an ELV and their Disposal Method

Fluid	Disposal method
Engine Oil	Drained or sold to the vendors. Oils are sold at Rs. 25/L. The collected oils are either sold to furnaces or small informal refineries. The vendors sell them on to informal refinery units. The refined oil is either packed and resold into the market, or sold loose and adulterated. The unrefined oil is sold for application on cog wheels in machines, such as crushers or bucket wheels, for lubricating crane wires, and also burned in furnaces or boiler for generation of heat.
Transmission Coolant Fluid Power Steering Fluid Brake Fluid Hydraulic Fluid Gear Oil	All of these oils are mixed together and "refined" by heating. They are then mixed with a viscosity amending chemical which allows the solidified mix to be used for the lubrication of cogs. There are some traders who do not have the necessary scale to produce this lubricant themselves so sell it on, or alternatively, in rare cases, drain it to the ground.
Battery Acid	Drained
A.C. -Gas	Released into the air

Solid parts of an ELV containing hazardous compounds and their disposal and recycling methods :

Solid Part	Disposal and Recycling method
Air Filter	If the air filter cannot be reused directly, the ferrous parts are sold to kabaris for Rs. 15 - 18 per Kg and the foams are burned or dumped. **Key Toxicity**: Foams are made up of polyurethane which release potentially hazardous dioxins when burned.
Oil Filter	Non-working oil filters are sold to scrap dealers. First, paper from the filter is removed - dumped or burned. Metallic parts are sold to kabaris for Rs. 15-22 per Kg, which is then sent to the recyclers for Rs. 25 per Kg. **Key Toxicity**: Residue oil and toxic particles released to ground and air from dumping and burning the filter paper
Brake Shoes	Brake shoes often contain a asbestos traces, sometimes equivalent to 20 percent of the weight of the shoe. The asbestos is removed and dumped, while the metallic part is sold to kabaris, which is then sent for recycling. Scrap dealers sell these metal brake parts to recyclers. The ferrous brakes are sold for Rs. 23-30 per Kg, while aluminium brakes are sold for Rs. 70-90 per Kg.

	Key Toxicity: Asbestos fibres cause asbestosis, various other lung disorders, and even lung cancer
Battery Terminal	Metal parts of battery terminals are sent for recycling and sold to scrap dealers for Rs. 20-25 per Kg. The ferrous metals are sold at Rs. 23-28 per Kg and brass or copper is sold for approximately Rs. 100-200 per Kg. **Key Toxicity**: Copper is extracted using acid, which causes pollution and affects the respiratory and dermal system of workers and others living nearby
Switch	Non-functional switches are dumped by automobile parts dealers. They are picked up by street waste pickers who usually break them to recover the metal parts. Brass or Copper is sold for Rs. 100-200 per Kg. whereas ferrous parts are sold at Rs. 23-25 per Kg. **Key Toxicity**: Switches contain toxic mercury which is released into the environment
Rubber	Most of the rubber parts are dumped and some of them are picked up by street waste-pickers and sent for recycling. They are then sold to big recyclers at Rs. 2-5 per Kg. **Key Toxicity**: Rubber is used in furnaces, emitting several pollutants.
Clutch Discs	Clutch-discs can often be repaired and reused. Non-functioning clutch discs are broken to remove the asbestos layer which is dumped. Ferrous parts are sold at 23-28 per Kg to kabaris, which are then sold to recyclers through big scrap traders. **Key Toxicity**: Asbestos is dumped on the ground, or at best, in municipal dumps, exposing the public at large to this highly toxic material which causes asbestosis, various lung disorders, and even lung cancer
Electronic Parts	Electronic parts, such as circuits, are sold to e-waste collectors, where they are tested for reuse. Parts, including PCB, are sold for Rs. 40 per Kg. Working parts are taken out and sold to refurbishers, and price variation depends on the working components that can be as expensive as Rs. 200 per Kg. Waste components are sold to e-waste dismantlers and recyclers. **Key Toxicity**: Extraction of precious metals is typically not done in an environmentally-safe manner

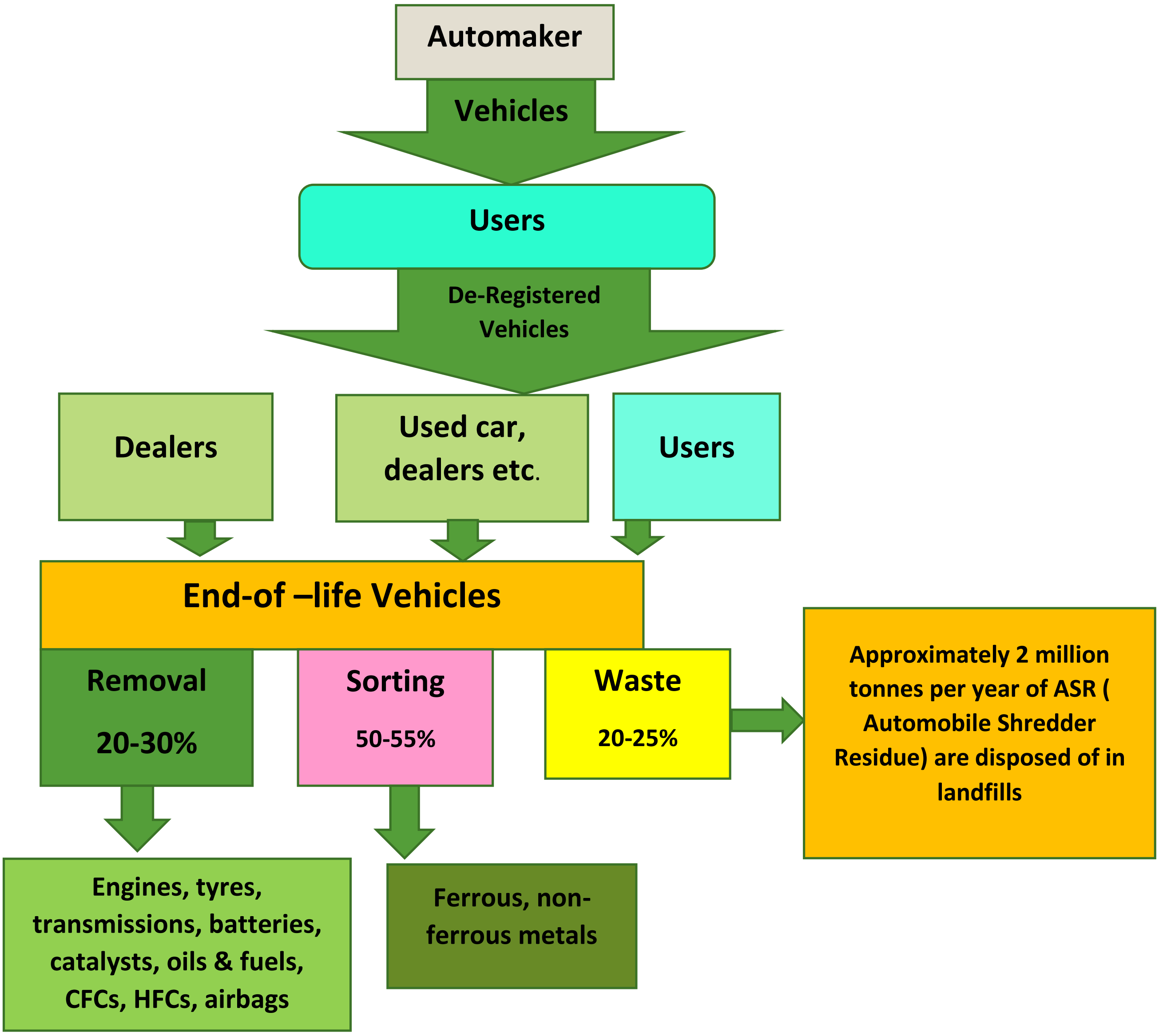


Figure 39: Present disposal method and Technologies of end of life vehicle

5.4 Improved disposal method and Technologies:

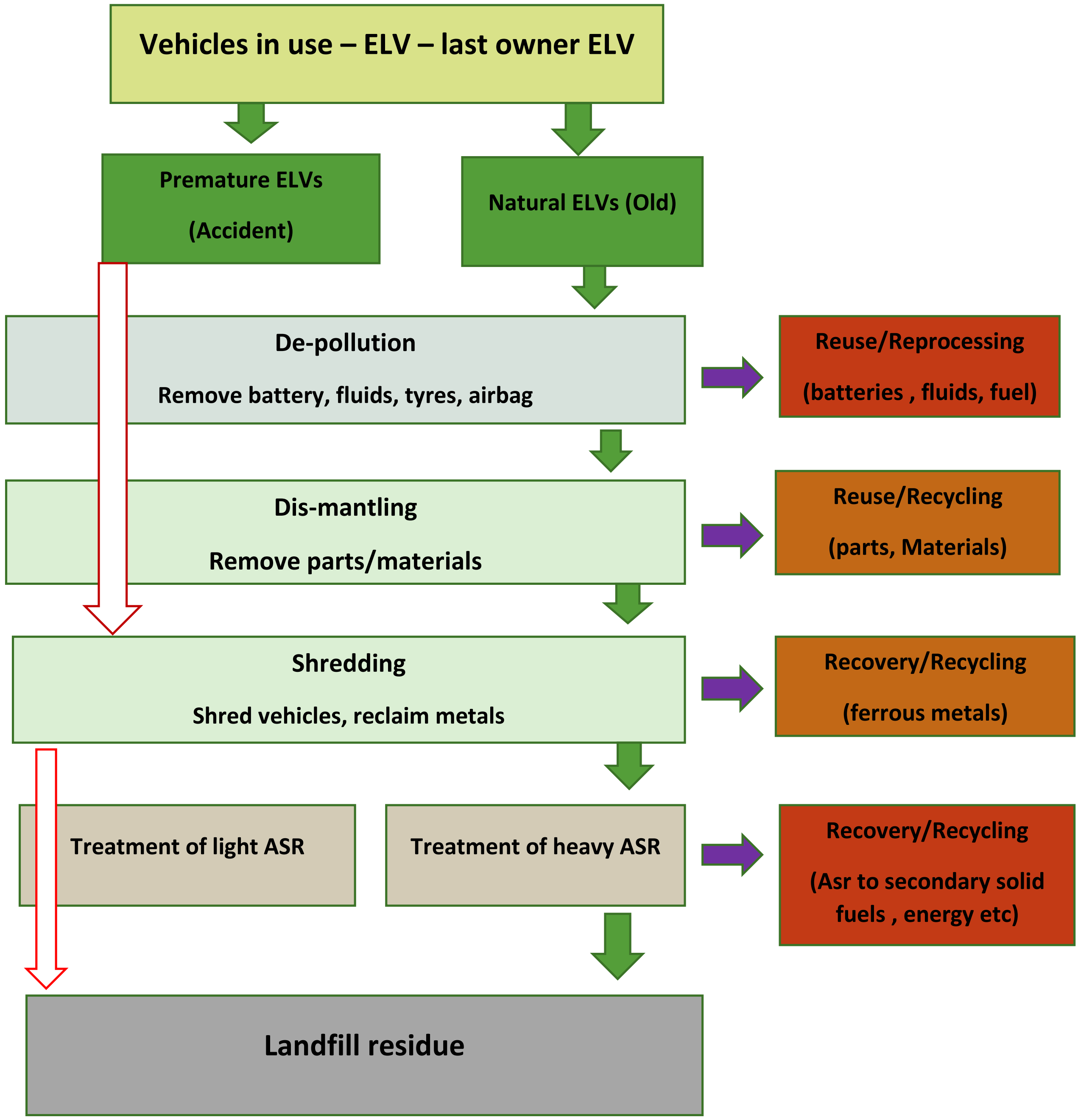


Figure 40: Improved disposal method and Technologies of end of life vehicle

5.5 **Improved supply chain for co-processing of ELV** :

Insight into internationally renowned procedures and technologies for the Environmentally Sound Management of ELVs - Comprehensive framework for the ESM of ELVs in India, including detailed descriptions of the following procedures:

1. Declaration of ELVs, deregistration of vehicles and ownership transfer
2. Collection and channelization of ELVs
3. Repair and refurbishment, dismantling and recycling
4. Identification of residues and processing for safe disposal
5. Setup of ELV recycling facilities
6. Design and implementation of a Shared Responsibility scheme

5.6 **Zero discharge** : For zero discharge I have study the main parts of automobile vehicle those are containing recycled plastics . The primary objective of the study was to implement generic specifications for 75% virgin automotive plastics and 25% recycled plastics that can be used as a basis for standards across the industry . In below I have mentioned the summarized of the result .

Polypropylene : To remove most of the associated dirt we have to work on polypropylene involved using pieces that were handpicked from shredder residue and washed. In the PP it had properties that were mixture of 25% recycled and & 75% virgin with in the specifications , expect for the elongation at yield , melt flow index and fog number . For a fog number minor improvement are possible. Air filter housing units by molding process that did not required any changes in tooling or processing conditions. The small pieces of metals from the recycled material are the main problem for discharge . The authors T. Weatherhead concluded that PP and EPDM and EMPP that can be used as making a new cars beacause these materials are 100% recycled rubber modified by using extruded and pelletized (T. Weatherhead, 2005) .

ABS : No changes in tooling or processing situation were needed for the ABS containing recycled material from ELVs and electronic was used to make auto radiator grilles. The recycled automotive ABS was inferior in comparison with the electronics ABS that are use in the elengation at break and thre notched izod. In the electronics ABS there is present of the fire retardants though that did nor affect the properties of the recycled material . In the ABS the recycled material was stiffer beacause the tensile strength at yield was found to be greater for the recycled material and it was observed thatr even with the reduced flexibility the 25%/75% material molded well .

High-Density Polyethylene (HDPE) : In discharge process before shredding of the End-Of-Life vehicles those automobile washer bottles made of HDPE were manually dismantled and these test pices made from recycled material are not cause any problem when it use in injection molded without he the use of additives .

Ploymide PA66 (Nylon 66) : Radiator end caps , that are made of PA66 that collected from ELV were contaminated with rust, water (2.4%) and ethylyne glycol(0.7-0.8%) and also by the observation this process is labor-intensive. Foaming are happened for this processing of the material beacause of the absorbed fluids and it did not extrude well even after excessive drying .

PVC : Flexible linings and body slide moldings are the two types of PVC collected from ELVs . Here I found in a example of 10 sample of the flexible lining material analyzed, two exceeded the limit for chromium, two esceeded the limit for arsenic ,one exceeded the limit for mercury and six exceeded the limit for antimony thus for PVC the major problem found were heavy metals . Antimony was used for fire retardent and lead was used as a stabilizer for PVC .

Overall the key findings of the study included that are :

- To meet well qualification and specifications I have found that PP and ABS collected from ELVs were sufficient quality for recycled .
- 25%/75% recycled ABS/virgin ABS worked well as well as The 25%/75% recycled PP/virgin PP .
- It was observed that for the PP and ABS it could not be used at the 100% level so it required compounding with virgin material .
- Here we found from 20 vehicles sampled the amount of plastic recovered was about 3kg per vehicle .

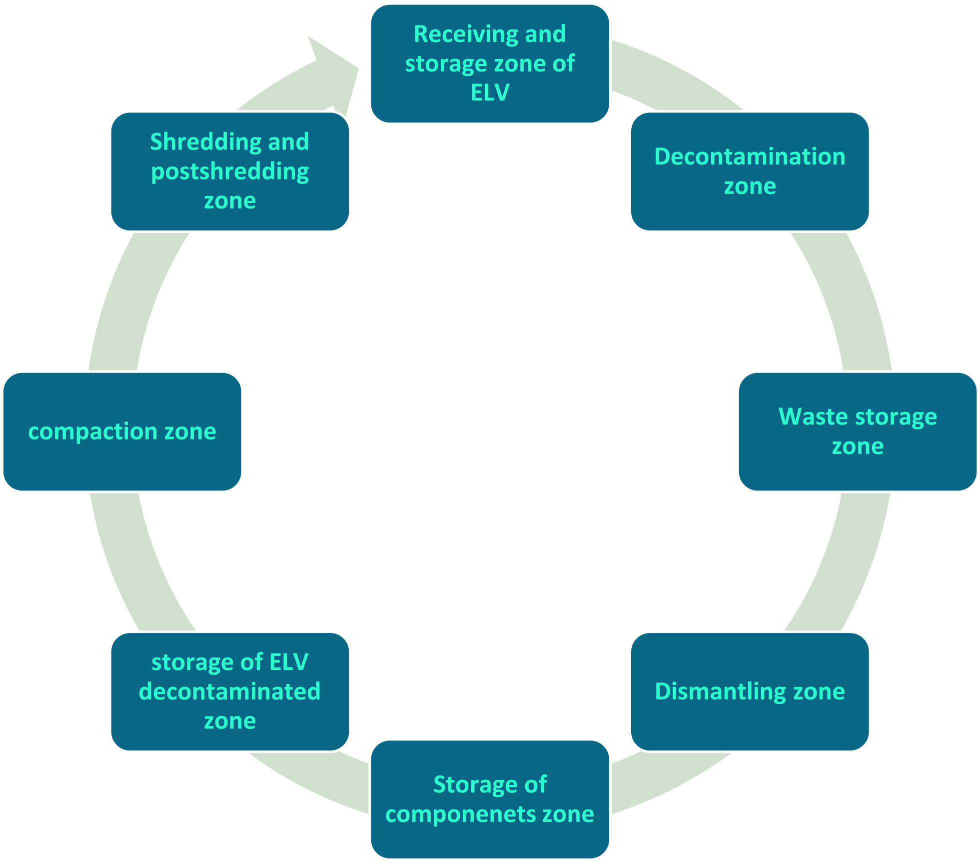


Figure 41: Procedure of zero discharge of end of life vehicle

5.7 Zero inert :

Transport to the vehicle dismantlers (when not delivered by driving or towing with a private vehicle) (https://www.gov.uk/guidance/non-hazardous-and-inert-waste-appropriate-measures-for-permitted-facilities)

- ELV dismantling incorporating preparation of secondary material and products;
- Transport of the dislodged ELV to a shredder (in both a crushed (via a scrapyard) and uncrushed) form.
- Shredding of the ELV into a ferrous fraction, NFM fraction, and fluff fraction, including the provision of secondary material, transport, and energy use.
- Transport of the NFM fraction to a Heavy Media Separation Plant (HMSP) and separation into secondary material and NFM waste.
- Transport of fluff and NFM waste to landfill, and/or combustion facilities are appropriate.
- Waste in a landfill.
- Combustion of waste in a blast furnace, cement kiln (including further processing of waste), and MSW incinerator.

• Transport of combustion waste to landfill and behaviour in the landfill.

5.8 Output in co-processing of cement plants :

Waste Tires contain zinc and ferrous materials in their composition both of which increase the chemical properties and quality of cement.

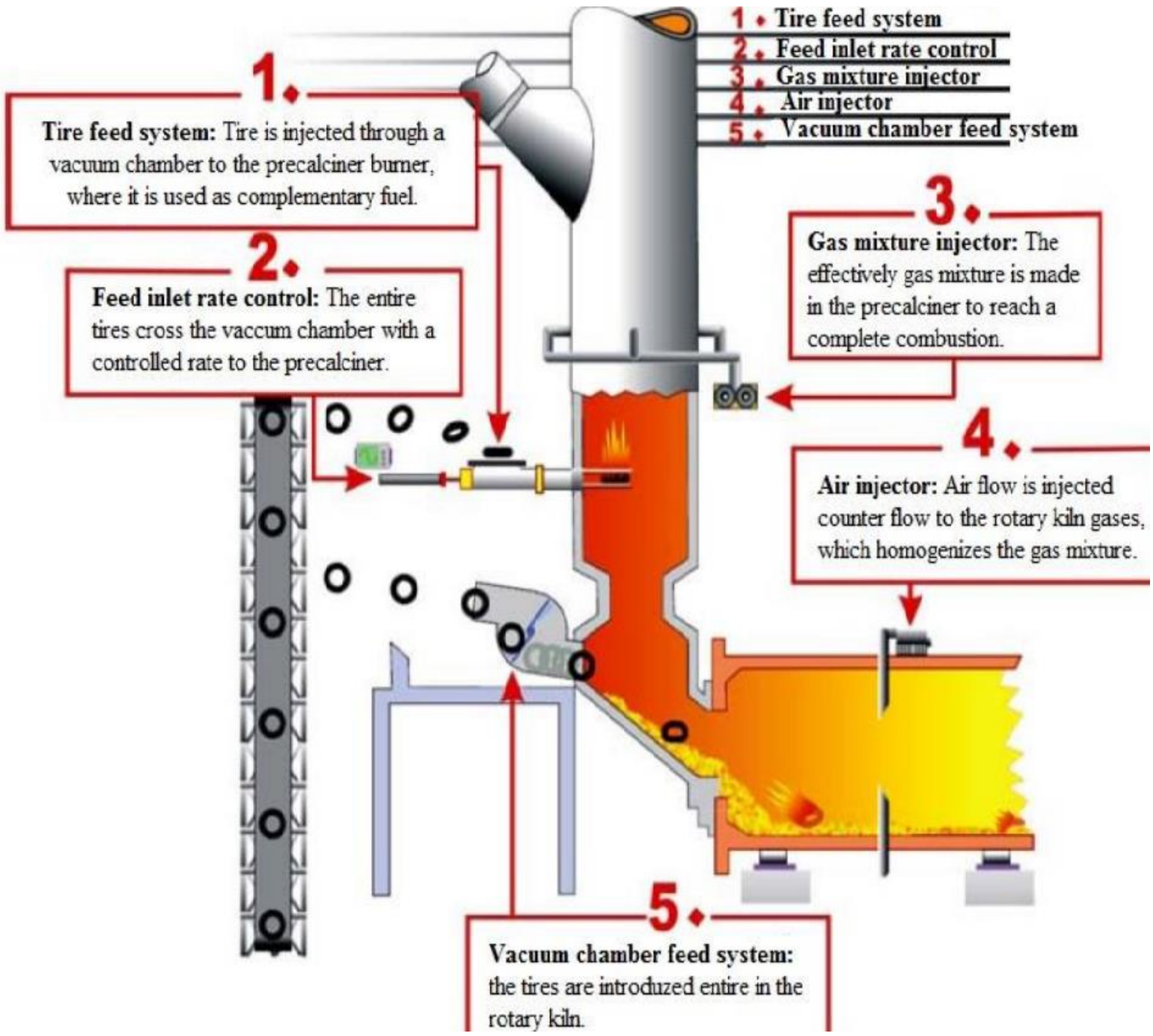


Figure 42: **Tire feed system in preheater and pre calciner in cement industry**

Various tires have identical in chemical composition and rubber is the main part of the tire so in cement production industries this characteristics facility using of tires as an alternative fuel.

The thermal value of waste tires are 32 MJ/Kg with low humidity that consists of 90% of hydrogen, carbon and oxygen. Waste tires, just as another alternative fuels, have a greatest percentage that can be consumed in the kiln, due to pollutant emission.

Table 12: Chemical composition and thermal value

Composition	Natural gas %	Fuel Oil %	Tire %
Humidity	0.2	1	0
Carbon	80.1	83.8	78.2
Hydrogen	14.3	11.2	7.1
Nitrogen	5.3	0.1	0.2
Sulphur	4.5 ppm	3.9	1.6
Zinc oxide	0	0	0.9
Steel	0	0	12
Thermal value	36.6	41.7	37.6

5.9 **Research Gap**:

1. Automatic & intelligent recovery system

2. Efficiency & Safety disassemble

3. Recycling Market Chaos

4. Application in Industrial Scale

5. Most organizations do not have a central governance body for sustainability and only half of the automotive industry have sustainability targets for key executives.

6. To know automotive original equipment manufacturers (OEMs) and their suppliers doing to ensure that the entire automotive value chain is sustainable – from responsible mining of metals to sustainable waste disposal?

7. We have to know how automotive organizations will in implementing their sustainability initiatives.

8. How can the automotive industry ensure that major sustainability drivers such as electric vehicles and supporting a circular economy deliver on their promise?

9. What can automotive organizations learn from leading players who are at the forefront of sustainability?

5.10 **Research question:**

1. How to design a recycling network model to reduce costs and carbon dioxide emissions for waste tyre and li-ion batteries?
2. How do different factors affect the optimal location of facilities in the recycling network?
3. How to further reduce costs to promote recycling of used batteries based on the designed recycling network model for waste tyre and li-ion batteries?
4. How to integrate black mass into a circular economy of lithium-ion batteries?
5. What is the importance of Automotive Quality standards for circular economy (reverse logistics) in the Automotive Industry?
6. What are the existing problems of Automotive Quality standards for circular economy (reverse logistics) in the Automotive Industry?
7. How to improve the efficiency of Automotive Quality standards for circular economy (reverse logistics) management based on an environmental view?
8. To what extent is the circular economy achieved and implemented in the automotive and HDOR sectors? And what industrial practices and regulations are prevalent and commendable for the circular economy? How do existing policy frameworks foster the move towards CE?
9. What are the key areas in legislative EU-context hindering transitions from linear to circular economy for service-based business models in white goods industry and remanufacturing in automotive industry?
10. What are feasible EU-policy adjustments that would facilitate circular economy implementation for service-based business models in white goods industry and remanufacturing in automotive Industry?
11. How to effectively collect, dismantle, and recycling ELVs grows into a global topic?
12. How to solve Gaps in public infrastructure for waste collection systems and treatment facilities will need to be addressed as this will enable private sector circular economy activity?
13. How to move toward more sustainable vehicles to design different power train vehicles and adopting lightweight materials in car manufacturing?

14. How to used alternative materials thus weight reduction but retaining the safety performance and robustness?
15. What are the multi material design to reduce mass of the vehicle for fuel efficiency, safety comfort and better environment performance?

5.11 **Research objective**:

1. To save of energy, and to generate energy from renewable sources to power industries plants and buildings.
2. To reduce electricity consumption, CO_2 emissions and solvent use for environmental production.
3. For environmental management systems we need to installation , operation , acquisition of waste processing, treatment, reduction, elimination and recycling; and environmental improvement measures, such as ecosystem protection, clean-ups, green space development and natural landscape conservation .
4. Circular economy practices need to be infused more broadly across the automotive value chain to benefit from their cost and resource utilization benefits.
5. Potential Use of ELV Waste like Waste Tyres and Lithium-Ion Batteries Promoting Circular Economy.

5.12 **Discussion & Conclusion from Test results:**

Scrap tires from End of life vehicles can be an environmentally-compatible alternative energy resource when used in relevant applications and the net result has been substantial conservation of non-renewable fossil fuels.

5.12.1: How Much available of waste tyre and li-ion batteries for recycling:

Every year I found that 1.6 billion new tyres are produced and around 1 billion of waste tyres are raise but the recycling industry processed near about 100 million tyres every year (goldsteinresearch.com). In India every day produce 670000 tyres and refuse 280000 tyres (india.mongabay.com).

5.12.2: What is treated from waste tyre?

A: What are the value-added products from waste tyre?

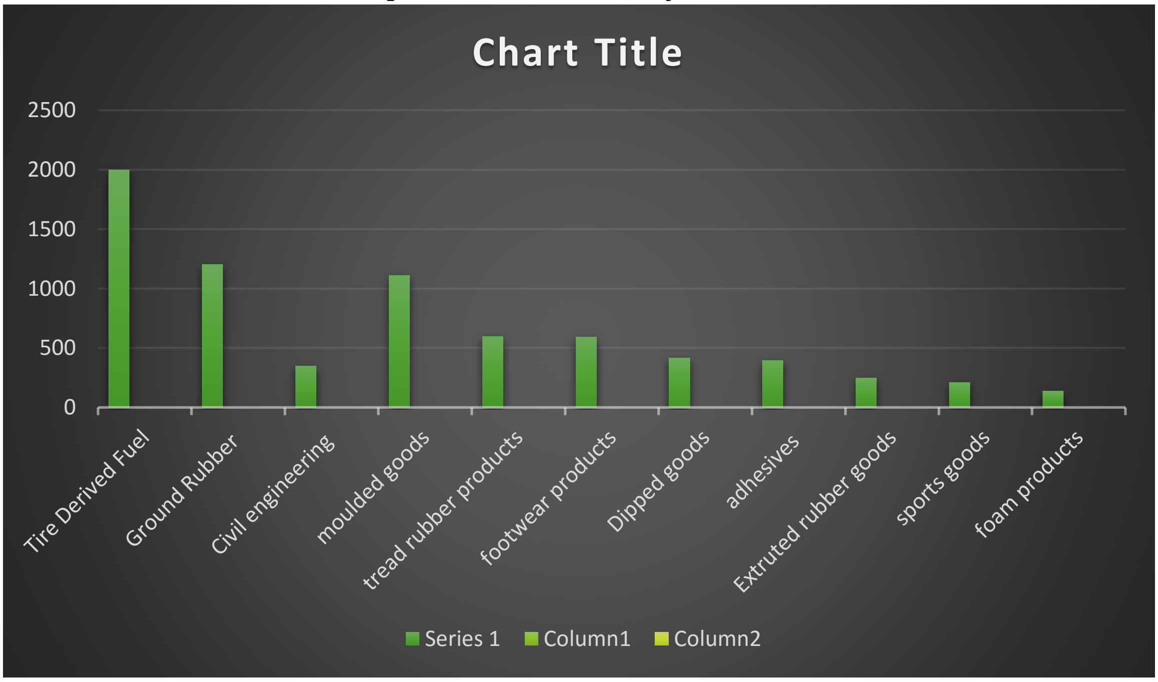


Figure 43: Value added product from waste tyre (RSDC, 2016)

5.12.3: Various properties of Tire derived fuel relative to coal

PROPERTY	TDF	COAL
Particle size (qm)	180-220	65-80
Fixed carbon (%)	22	52
Volatiles (%)	53	35
Ash (%)	26	14
Carbon (%)	62.3	72.5
Hydrogen (%)	5.5	4.9
Sulfur (%)	2.5	1.4
Nitrogen (%)	0.3	1.4
Oxygen (%)	7.2	7
Heating value (%)	30	30.2

5.12.4: Proximate Analysis

Characteristic	Coal	Tires with Wire	Tires without wire
Moisture	7.76	0.75	1.02
Ash	11.05	23.19	8.74
Volatile	34.05	54.23	67.31
Fixed Carbon	47.14	21.85	22.93
Total	100	100	100

5.12.5: Ultimate Analysis

Characteristic	Coal	Tires with Wire	Tires without wire
Carbon	67.69	67	72.25
Hydrogen	4.59	5.81	6.74
Nitrogen	1.13	0.25	0.36
Sulphur	2.30	1.33	1.23
Ash	11.05	23.19	8.74
Chlorine	0.01	0.03	0.09
Moisture	7.76	0.75	1.02
Oxygen	5.47	1.64	9.67
Total	100	100	100

5.12.6: Elemental Ash Analysis

Characteristic	Coal	Tires with Wire	Tires without wire
Aluminum	20.70	1.93	13.11
Calcium	3.30	0.56	3.80
Iron	18.89	0.35	2.37
Magnesium	0.79	0.10	0.68
Phosphorus	0.62	0.10	0.68
Potassium	2.06	0.14	0.95
Titanium	0.82	0.14	0.95
Silicon	47.98	5.16	35.05
Sodium	0.48	0.13	0.88
Sulphur	4.33	0.99	6.72
Zinc	0.02	5.14	34.81
Metal	0	85.26	
Total	100	100	100

5.12.7: Comparison of the calorific value of waste tires with other combustible materials

Combustible material	Calorific values MJ/Kg
Biomass	15.1
Paper / Cardboard	17.4
Fabrics	18.4
Coal	26.4
Worn tires	31.4
Petroleum	39.5

These tables bring out why it is safe to use tires as secondary fuel in the clinker burning. In clinker burning the most commonly used fuels and TDF supports the view that TDF is an effective fuel for clinker burning for the values of the most important parameters such as Quantities of sulphur, nitrogen, carbon, hydrogen, and of course its heating value in fuel but the main problem that revolt from the use of different fuels in the clinker burning for the formation of rings in the kiln caused by salts – such as KCl, K2SO4, Na2SO4, Ca2SO4 that are formed by Volatiles that is called cyclic phenomena and for this blockage in the kiln seems to be most harmful (P. Pipilikaki et al.).

5.13 **Conclusion**

Cement plant allows the use of alternative fuel and raw materials adoption of efficient control methods of pollutant emissions in clinker manufacturing and this process presents a solution for adequate disposal of industrial waste and non-recyclable plastic waste for this energetic recycling technique takes advantage of the waste LHV to generate energy and simultaneously to promote thermal destruction and the thermal treatment of waste (Alexandre Oliveira Lopes et al.).

Use of waste tires from the end-of-life vehicle such as Tyre-Derived-Fuel use in cement plant , ground up or crumb rubber for asphalt & insulation landfilled, in civil engineering like roadbeds, barriers, retaining walls and for recycled like use in playground surfaces , railroad crossing for promote the circular economy.(David E. Ross,2019).

The adoption of efficient control methods of pollutant emissions by cement plants allows the use of alternative fuel and raw materials in clinker manufacturing. This process presents a solution for adequate disposal of industrial waste. This energetic recycling technique takes advantage of the waste LHV to generate energy and, simultaneously, to promote a thermal destruction and thermal treatment of waste.

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Annexures

Prepare a table with the list of cement plants co-processing NRPW and RDF in year 2019 (or before) and in year 2021-22

Sl. No.	Name of cement plant	Address	Type of waste co-process
1.	M/s ACC Ltd., Bargarh Cement Ltd.,	Cement Nagar, PO Bardol, Distt. Bargarh (Orissa), 768 038	Chemical ETP Sludge (Automobile industry), Grinding dust (Rolling bearing & seal industry), WTP; Sludge (Soft drink industry)
2.	ACC Ltd., Chaibasa Cement Works,	P.O. Jhinkpani Distt. West Singhbhum (Jharkhand) 833 215	Phosphate sludge (Automobiles Industry), WTP Sludge (Soft drink Industry), Spent Carbon (Soft drink Industry), Grinding muck (Textile Machine Manufacturing Industry); Spent catalyst (IOCL, Barauni Refinery); Oily rags (Automobile industry), ETP Bio Solid (Soft drink industry), Chemical ETP Sludge (Automobile industry), Chemical Sludge (Automobile industry), Grinding dust (Automobile industry) Incineration Ash (Tata Motors, Jamshedpur)
3.	ACC Ltd., Chanda Cement Works P	.O. Cement Nagar Distt. Chandrapur (Maharashtra) 442 502	Chemical ETP sludge (Automobiles Industry), ETP Bio solid (Soft drink Industry), Grinding Muck (Textile Machine manufacturing Industry), Expired consumer products (Shampoo), Phosphate Sludge (Automobile Industry), Spent carbon (Soft drink Industry), WTP Sludge (Soft drink Industry) Oily rags (Automobile industry), Grinding dust (Automobile industry)
4.	M/s ACC Ltd., Gagal Cement Works,	P.O. Barmana, Distt. Bilaspur (HP), 174 013	
5.	ACC Ltd., Jamul Cement Works,	Distt. Durg (Chhattisgarh),490 024	ETP Bio solid (Soft drink Industry) and Spent Carbon (Soft drink Industry) Chemical Sludge (Automobile industry), Phosphate Sludge (Automobile industry), Grinding muck (Textile machine manufacturing), Oily Rags (Automobile industry), Chemical

			ETP Sludge (Automobile industry), Grinding dust (M/s SKF India Ltd, Bangalore), WTP Sludge (Soft drink industry)
6.	M/s ACC Ltd., Kymore Cement Works,	P.O. Kymore, Distt. Katni (MP), 483 880	ETP Sludge (KEC International Ltd.), ETP Sludge (M/s Godrej Consumer Product, Malanpur)paint sludge & petroleum refining sludge , Dismantled Lube/Fuel oil filter
7.	M/s ACC Ltd., Lakheri Cement Works,	P.O. Lakheri, Distt. Bundi (Rajasthan), 323 603	
8.	ACC Ltd., Madukkarai Cement Works,	P.O. Madukkarai Distt. Coimbatore (Tamil Nadu); 641 105	Chemical ETP sludge (Automobiles Industry),ETP Bio-solids (Soft drink Industry),Grinding Muck (Textile Machine Manufacturing Industry) , Oily rags (Automobiles Industry), Phosphate Sludge (Automobiles Industry), Plastic & Laminates (Consumer goods), Spent Carbon (Soft drink Industry), WTP Sludge (Soft drink Industry) Green mesh with resin (M/s Suzlon Energy Ltd.), Poly residue (M/s SRF India Ltd.); Grinding dust (Rolling bearing & seal industry) Waste/residues (sludge from process)and filters & filter material & Process residue.
9.	M/s ACC Ltd., Wadi Cement Works,	P.O. Wadi, Distt. Gulbarga Karnataka 585 225	Grinding Muck (Textile Machine Manufacturing Industry), ETP Bio Solids (Soft drink Industry) Chemical ETP sludge (Automobiles Industry), Phosphate Sludge (Automobiles Industry), Spent Carbon (Soft drink Industry) and WTP Sludge (Soft drink Industry); Solar Evaporation Pond Sludge (M/s Jubilant Organosys Ltd.), N Butanol salt (M/s Jubilant Organosys Ltd.), Green mesh with Resin (M/s Suzlon Energy Ltd.) and Grinding dust (M/s SKF India Ltd.); Oily rags (Automobile industry) & Grinding dust (Automobile industry); Benzofuran (Kumar Organic Product

			Ltd) Chemical ETP sludge (M/s Syngenta India Limited, Goa);
10.	M/s Anjani Portland Cement Ltd.,	Nalgonda, Andhra Pradesh.	spent carbon (pharmaceutical industries); solid & liquid spent solvent (pharmaceutical industries)
11.	M/s Ambuja Cement Ltd.,	P.O.Ambujanagar, Tal.-KodinarDistt. Junagadh, Gujarat- 362715	TDI Tar; Waste mix liquid (M/s Lupin Ltd., Ankleshwar); Waste mix liquid (M/s Bharuch Enviro Infrastructure Ltd., Ankleshwar, Gujarat); spent carbon
12.	GajAmbuja Cement Plant	P.O. - Ambujanagar TalukKodinar; Distt. Junagarh Gujarat-362 715	Waste mix liquid (M/s Gujarat Enviro Protection and Infrastructure Ltd., Surat waste mixed liquid (distillation residue & process residue waste) (M/s Unimark Remedies Ltd.)
13.	M/s Ambuja Cements Ltd., Bhatapara,	PO – Rawan, Tehsil Baloda Bazar, Distt. Raipur, Chhattisgarh	Mixed waste (distillation residue, residue & waste, spent catalyst & spent carbon & date expired medicine & off specification drugs
14.	Ambuja Cements Ltd.,	P.O. Rabriyawas, Teh. Jaitaran Distt. Pali (Rajasthan)	Paint sludge; ETP sludge (M/s Sona Processors (India) Ltd., Bhilwara -Textile Industry)
15.	Ambuja Cements Ltd., Suli,	P.O. Darlaghat Distt. Solan (HP)	Paint sludge (automobile industry); solid waste mix (ShivalikSolid Waste Management Ltd., Nalagarh)
16.	Bharathi Cement Corporation Pvt. Ltd.	Nallalingayapalli village, KamalapuramMandal, KadapaDistt. – 516 289, Andhra Pradesh	liquid & Solid Organic Spent Solvent
17.	Chettinad Cement Corporation Ltd., Kallur Works, Sangem K,	GaragappalliPost,Chandapur (SO), Chincholi (TK), Gulbarga (DT), Karnataka-585 305	Solar Evaporation pond sludge, n-Butanol salt, solid and liquid organic spent solvent & spent carbon of pharmaceutical industries, paint sludge, phosphate sludge, ETP Sludge & oily rags of automobile industry
18.	Chettinad Cement Corporation Ltd.,	Ariyalur Trichy Road, Keelapur post, Ariyalur dist-621707,	Fiber Reinforced Plastic (Green Mesh with Resin of M/s SuzlonEnergy Ltd.)

		Tamilnadu	
19.	M/s Chettinad Cement Corporation Ltd.,	Rani Meyyammai Nagar, Karikklai PO, Guziliamparai (via), DindigulDistt., Tamilnadu 624 703	
20.	M/s Chettinad Cement Corporation Ltd., Puliyur Cement Works,	KarurDistt., Tamilnadu	
21.	M/s Dalla Cement Factory,	Village – Dalla, Distt. – Sonebhadra, UP 231207	
22.	M/s Dalmia Cement (Bharat) Ltd.,	SF, No. 630, Thamaraikulam Village, Ariyalur - TamilNadu	Solid waste mix (M/s Gujarat Enviro Protection & Infrastructure Ltd., Tamilnadu); Bio-mass, Resin Waste, Rubber Foam waste, Tire Chips, RDF, Carbon Black, Cotton Waste, Waste mix liquid, Plastic waste
23.	M/s Dalmia Cement (Bharat) Ltd., Dalmiapuram,	Dist. Tiruchirapalli- 621651 Tamil Nadu	
24.	M/s Dalmia Cement (Bharat) Ltd.,	V&P- Chinnakomerla, Mandal-Mylavaram, Jammalandhu, Distt. Kadapa, AP	
25.	M/s J. K. Cement Works,	P.O.- Muddapur-587122, Distt.-Bagalkot, Karnataka.	ETP sludge of M/s BASF India Ltd., Karnataka
26.	M/s J. K. Cement Works, Mangrol, C/o J.K. Cement Works, ,	Kailash Nagar, Nimbahera Distt. Chittorgarh 312617	
27.	M/s J. K. Cement Works,	Kailash Nagar, Nimbahera,	

		Distt. Chittorgarh 312617	
28.	M/s J. K. Lakshmi Cement Ltd., Jaykaypuram,	Distt. Sirohi, Rajasthan 307 01	
29.	M/s Kesoram Cement Ltd., Post-Basantnagar, .	Karimnagar Dist.- 505 187,Andhra Pradesh	spent carbon, liquid organic solvents & solid organic solvents
30.	M/s Kalburgi Cement (formerly VicatSagar Cement), Chhatrasala,	Gulbarga Karnataka	
31.	M/s Keerthi Industries Ltd., Mellacheruvu	(V &M), NalgondaDistt., Telangana 508	
32.	Lafarge India Ltd., Sonadih Cement Plant(Line -I)	PO Reseda, Via Baloda Bazar Distt. Raipur , Chhattisgarh	Waste mix solid & waste mix liquid (GEPIL, Surat); Plastic & Resin Waste (M/s GEPIL, Faridabad); Process sludge & ETP sludge, SCRAP PTA (Purified Terephthalic Acid), Empty PTA contaminated plastic liner & oil contaminated jute & rags (M/s MCC PTA India Corporation Pvt. Ltd., West Bengal)
33.	Lafarge India Ltd., Sonadih Cement Plant (LineII) ,	PO Reseda, Via Baloda Bazar Distt. Raipur , Chhattisgarh	Waste mix solid & waste mix liquid (GEPIL, Surat
34.	Lafarge India (P). Ltd., Arasmata Cement plant,	PO Gopal Nagar, Janjgir, Champa, Chhattisgarh	Waste mix solid, waste mix liquid (GEPIL Surat)
35.	M/s Lafarge India Pvt. Ltd., Chittor Cement	Plant, Chittorgarh, Rajasthan	waste mix liquid & waste mix solid from M/s Recycling Solutions Pvt. Ltd., Panoli, Gujarat

36.	M/s My Home Industries Limited Mellacheruvu (Post &Mandal),	Dist – Nalgonda , Telangana- 508246	Liquid Organic Spent Solvent (Pharmaceutical Industries)
37.	M/s Trinetra Cement Ltd., Mahi Cement Works,	P.O. Walwana, Banswara – 327025, Rajasthan	Waste mix liquid & solid (GEPIL, Surat).
38.	M/s Sagar Cement Ltd., Nalgonda,	Telangana	spent carbon, Solid organic spent solvent & Liquid organic spent solvent of pharma industry
39.	M/s Sanghi Cement Ltd.,	Kutch, Gujarat	spent carbon, Solid organic spent solven& Liquid organic spent solvent of pharma industry
40.	M/s Shree Cement Ltd., AndheriDeori,	Post Box No. 33, Bangur Nagar, Beawar, District - Ajmer, Rajasthan – 305901	
41.	M/s Shree Cement Ltd.,.	Village-RAS, Tehsil-Jaitaran, Distt.-Pali, Rajasthan	Paint sludge (automobile industry); ETP sludge (Textile industry); CETP sludge (Pali); ETP sludge & Phosphate sludge.
42.	Ultra Tech Cement Ltd., ,)	Andhra Pradesh Cement Works, Bhogasamudram PO: ChukkalurMandal:Tadipatri Distt. Anantapur (AP	Solid and liquid organic spent solvent
43.	Ultra Tech Cement Ltd., Aditya Cement,	Adityapuram, PO Sawa Distt. Chittorgarh (Rajasthan) -312 612	
44.	M/s UltraTech Cement Ltd., Rajashree Cement works,	Adityanagar, Malkhed Road, Dist. Gulbarga, Karnataka 585292	Paint sludge, Phosphate sludge, ETP sludge & oily rags of automobile industries, solid & liquid organic spent solvent and spent carbon o-pharmaceutical industries, n-Butanol salt of M/s Jubilant Organosys Ltd.,

			Mysore, ETP sludge of M/s BASF India Ltd
45.	M/s Ultratech Cement Ltd., Narmada cement-Jafrabad Works,	Babarkot, Taluka- Jafrabad, Distt. Amreli, Gujarat.	Waste liquid blend and waste solid blend (Colortex Industries Ltd.)
46.	M/s Ultra tech Cement Ltd.	P.O. Mohanpura, Tehsil Kotputli, Distt. Jaipur, Rajasthan- 303108	
47.	Ultra Tech Cement Ltd., Gujarat Cement Works,	P.O. Kovaya, Taluka Rajula, Distt. Amreli (Gujarat)-365 541	Waste mix solid & waste mix liquid (GEPIL, Surat); Waste liquid blend and waste solid blend from M/s Colourtex Industries Ltd. (Unit 2);
48.	Ultratech Cement Ltd., Vikram Cement Works,	Vikram Nagar, P.O. Khor, Distt. - Neemuch, M.P. -458 470	ETP Sludge (Textile industry); Paint Sludge (automobile industry).
49.	Ultra Tech Cement Ltd.	P.O. Reddipalayam, Ariyalur, Distt. Perambalur (Tamil Nadu)-621 704	ETP Sludge (BASF I. Ltd.), Tyre Chips, Paint sludge, Refinery sludge and plastic waste CETP/IETP sludge (textile industry) oily rags; chemical sludge; phosphate sludge (M/s Ford India Ltd., TamilNadu - automobile industry); Green mesh with resin (M/s Suzlon Energy Ltd, Pondicherry); spent carbon, liquid and solid organic spent solvent of pharmaceutical industries; ETP Bio solid waste, WTP sludge and spent carbon of soft drink industries.
50.	M/s Ultra Tech Cement Ltd., Rawan Cement Works	P.O. Grasim Vihar, Distt. Baloda Bazar – Bhatapara, Chhattisgarh – 493196	
51.	M/s Ultra Tech Cement Ltd., Hirmi Cement Works, Hirmi, Bhatapara,	Distt. Baloda Bazar Chhattisgarh – 493195	
52.	M/s Zuari Cement Ltd.,	Dondapadu, Distt.- Nalgonda,	

	Sitapuram,	Telangana	
53.	M/s Zuari Cement Ltd., Krishna Nagar, Yerraguntla,	KadapaDistt., AP 516 311	
54.	M/s Vasavadatta Cement,	Post &Tq- Sedam, Distt. Gulbarga Karnataka- 585 222	