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CIRCULAR PLASTIC ECONOMY: A ROAD-MAP TO ECONOMIC AND ENVIRONMENTAL SUSTAINABILITY

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By:

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Abstract

Circular plastic economy deals with reusing, repairing and recycling of plastic products. According to the worldwide plastic production the plastic waste increases by four folds worldwide and in Pakistan as well. This leads to many adverse effects including more global gas consumption, global carbon budget and ratio of plastic in oceans. Circular plastic economy provides solution to such problems by providing alternative feedstock for plastic, using plastic waste as a resource material, innovative design and redesigning of products and by developing sustainable business models. However, production of single use items, incineration of plastic waste and disposal of plastic waste in landfills are the major challenges to reduce plastic waste now days. Moreover, plastic waste upcycling technologies like conventional strategies including gasification, pyrolysis and emerging strategies i.e., microwave or plasma assisted conversion, compatibilization and polymer design modification are also underconsideration.

1. Circular Plastic Economy?

Linear Plastic Economy is a production and consumption model that focuses on the production of plastics and plastic products, their use via consumers, and finally their disposal through landfills or incineration. In this approach industries produce plastic products; consumers use those products and then dispose of the used products.

Recycling Plastic Economy is almost identical to linear plastic economy. The major difference between the two approaches is the addition of recycling of plastic products or waste after they have been consumed, to re-involve them in the production step.

Circular Plastic Economy refers to the industrial system that focuses on the reusing, repairing, recycling, and refurbishing of existing plastic products and waste, alongside production and consumption. This system leads to an extension to the life cycle of plastic products and reduces waste.

What differentiates Circular Plastic Economy from other two approaches is the addition of processes such as recycling of used products, reusing used products, returning reused products for manufacturing, repairing reused products and reusing them again, and selectively disposing, as displayed in *Figure-1*.

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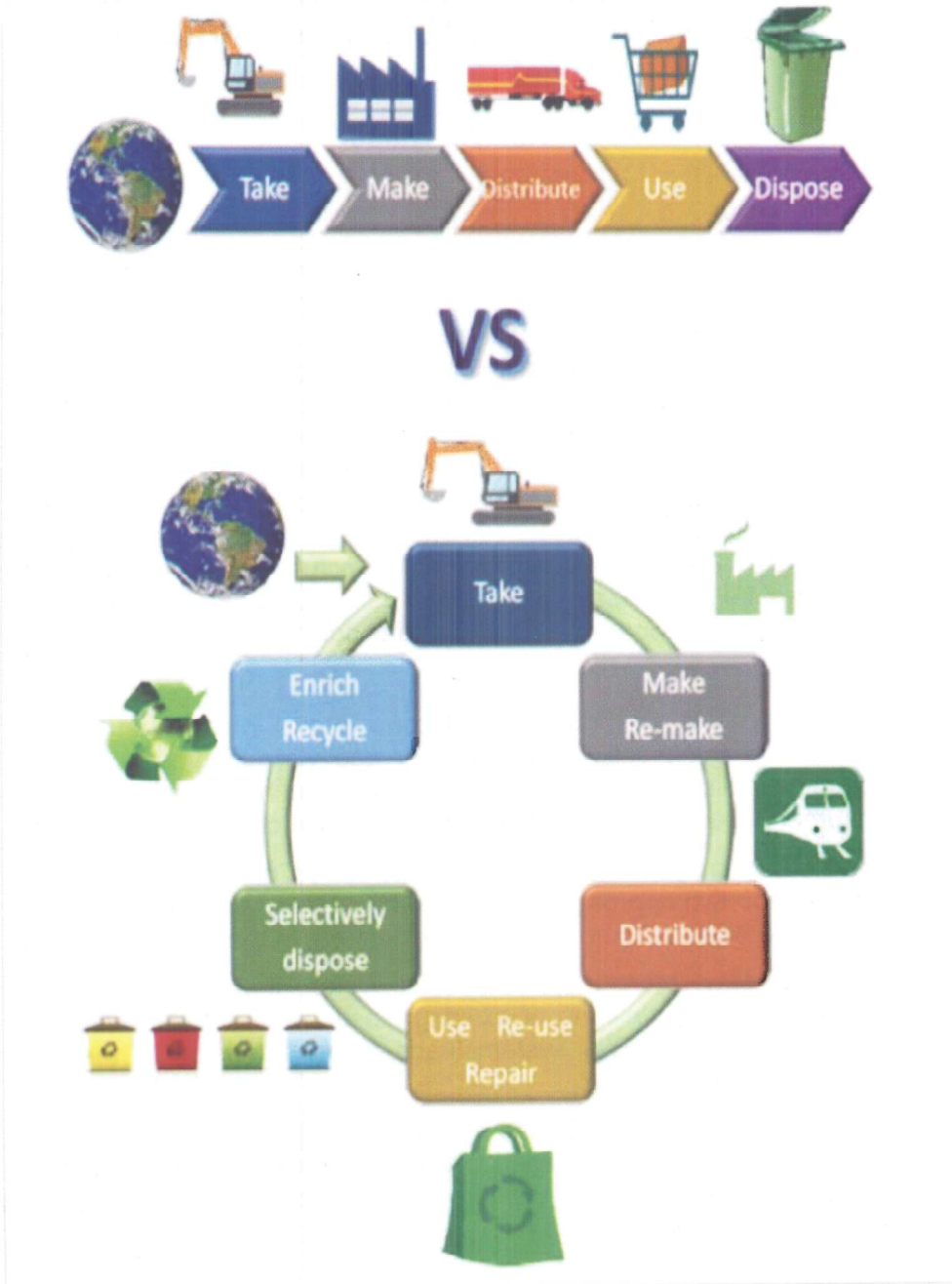


Figure-1: Linear, Recycling, and Circular Economies

2. Plastic Production and Waste Generation

As indicated in *Figure-2*, World Plastic Production (not including recycled plastics) increased by 33 Million Tons from 2016 to 2019 and decreased by 1 Million Tons from 2019 to 2020.

From these 367 Million Tons, China accounted for 32% of the production, which was the highest share, followed by North American Free Trade Agreement (NAFTA), the rest of Asia, Europe, Middle East and Africa, Latin America, Japan, and the lowest contributor Commonwealth of Independent States (CIS).

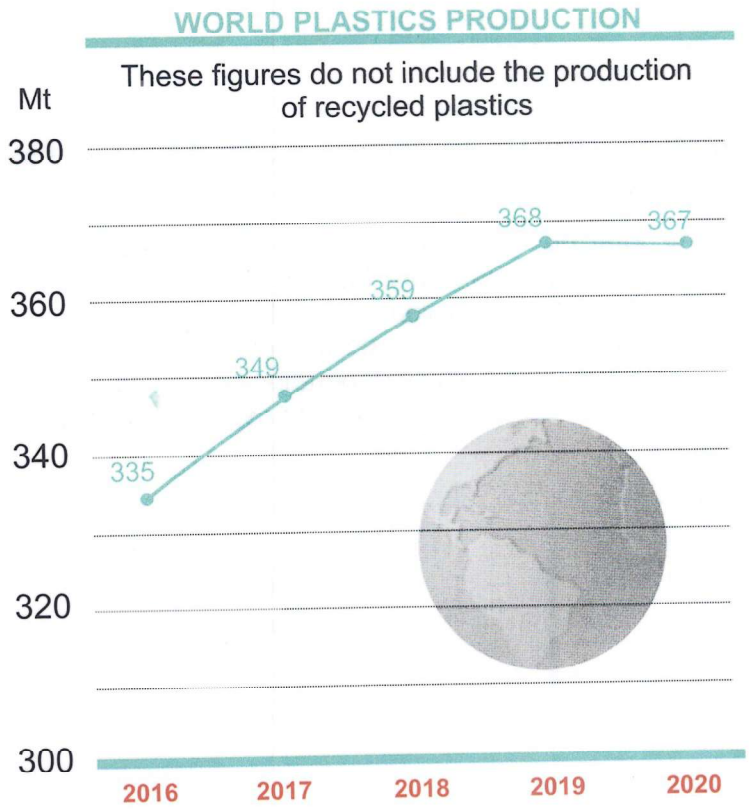


Figure-2: World Plastic Production 2016-2020

Pakistan produces four resins including polyvinyl chloride (PVC), polystyrene (PS), polyethylene terephthalate (PET) and alkyd resins etc. and all four plastic raw material producers are located in Karachi.As represented in *Figure-3*, a closer look at the Pakistani Plastic Processing Industry indicates that there are around 11000 processing units and these can be grouped into basic processing types such as extrusion, injection molding, blown film packaging and blow molding with dominating packaging production.

The contribution of these processing units to the GDP and National Tax Collection is about 15%. Directly 500,000 and indirectly 2 million individuals are reportedly involved in the plastic industry workforce.

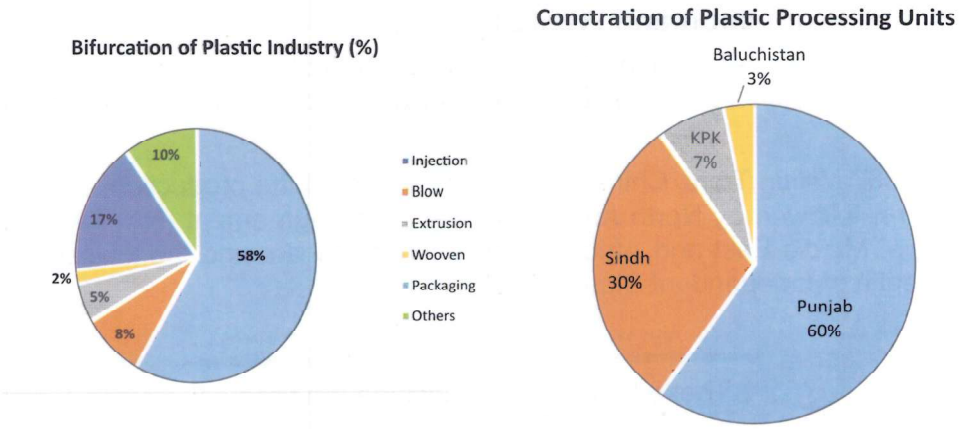


Figure-3: Division of Plastic Processing Units throughout Pakistan

3. Plastic Waste Generation

When discussing the total plastic waste generated, as shown in *Figure-4*, countries including US, India, Indonesia, Russia, UK, Mexico, South Korea and Italy all witnessed an increase in plastic production from years 2010 to 2016 whereas countries including China, Brazil, Japan, and Germany witnessed a decrease in plastic production in these years.*Figure-5*represents the plastic waste generation per capita, and *Figure-6* highlights mismanaged plastic wastes for different countries, the most mismanaged waste belonging to China.

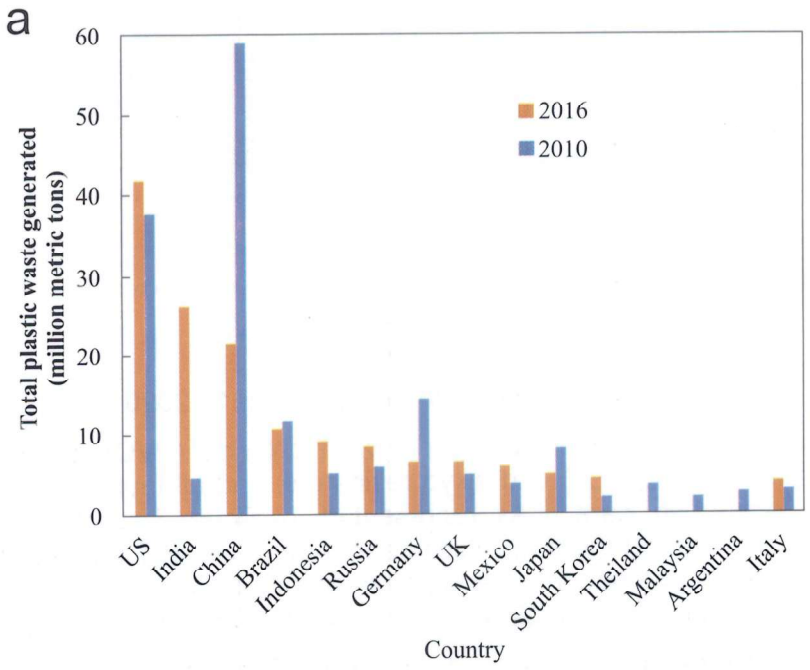


Figure-4: Plastic Waste Generation of Countries

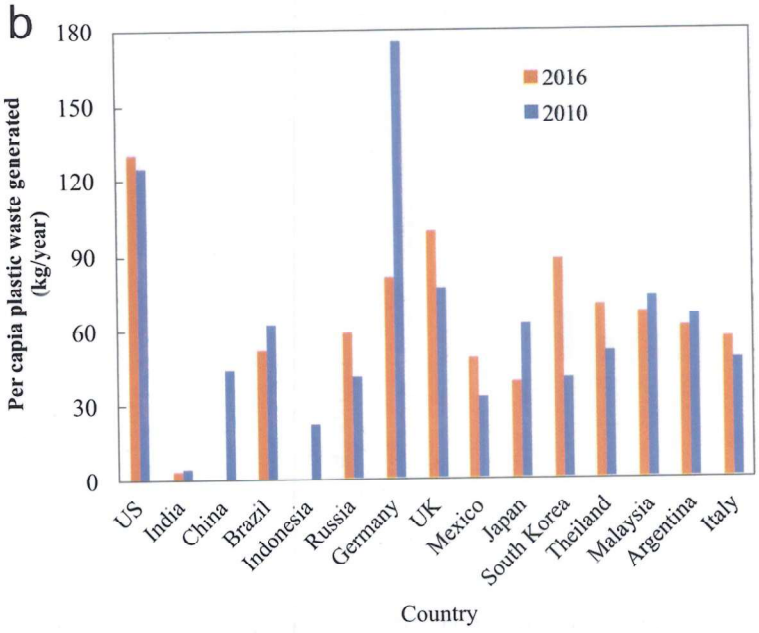


Figure-5: Per capita plastic waste generated

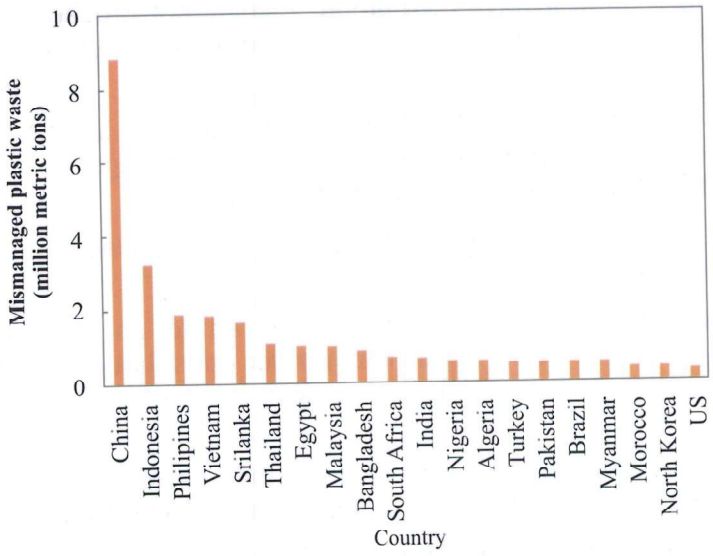


Figure-6: Mismanaged plastic waste

With regard to quantity, shown in *Figure*-7, from years 1960 to 2017, plastic production and waste generation increased by 400 million metric tons.

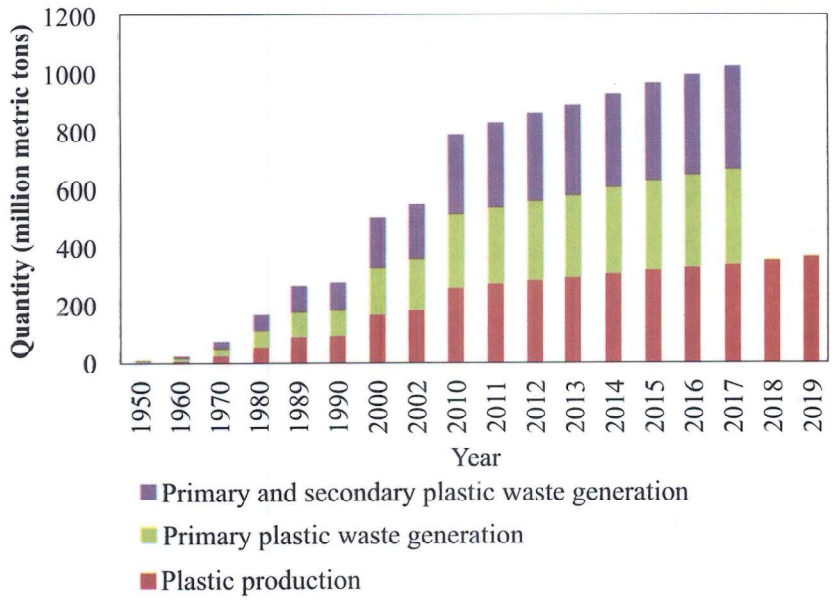


Figure-7: Quantity of plastic, primary, and secondary plastic waste generation

4. Plastic Waste Management

Plastic Waste Management involves a number of different procedures that are often carried out together rather than relying on one. The most common are discussed below and outlined in *Figure-8*.

Disposal: Plastic Waste may either be disposed of in allotted landfills or they may be disposed of improperly. Improper waste disposal often has negative consequences for the environment as it often leads to soil, water, and air pollution.

Recycling: If not disposed, plastic waste is recycled instead. Recycling includes further types as described below.

Physical Recycling: Physical Recycling, also referred to as traditional physical or mechanical recycling, breaks down plastic into smaller parts that are mixed and moulded together to create plastic products. Different methods to alter physical properties may be employed.

Biological Recycling: Biological Recycling involves the use of organisms that consume and break down waste materials, resulting in the formation of new materials.

Thermo-Chemical Recycling: Thermo-Chemical Recycling involves industrial processes that convert plastic waste into raw material for polymers, so that the building of polymers may begin again. Thermo-Chemical Recycling includes a variety of processes, the most common listed below.

Gasification: Gasification is the heating of waste plastic with air or steam, in order to produce a valuable industrial gas mixture called synthesis gas that is then used to produce fuels like petrol or diesel for electricity generation.

Incineration: Plastic waste may be mixed with other materials and then processed in an incinerator to produce heat, electricity or hot water. This technique converts waste into energy.

Pyrolysis: Pyrolysis is the thermal decomposition of plastics at high temperatures. In this process, the chemical composition of the material is altered. Pyrolysis can further be broken down into different types including:

1. Thermal Pyrolysis
2. Catalytic Pyrolysis
3. Microwave Pyrolysis
4. Plasma Pyrolysis

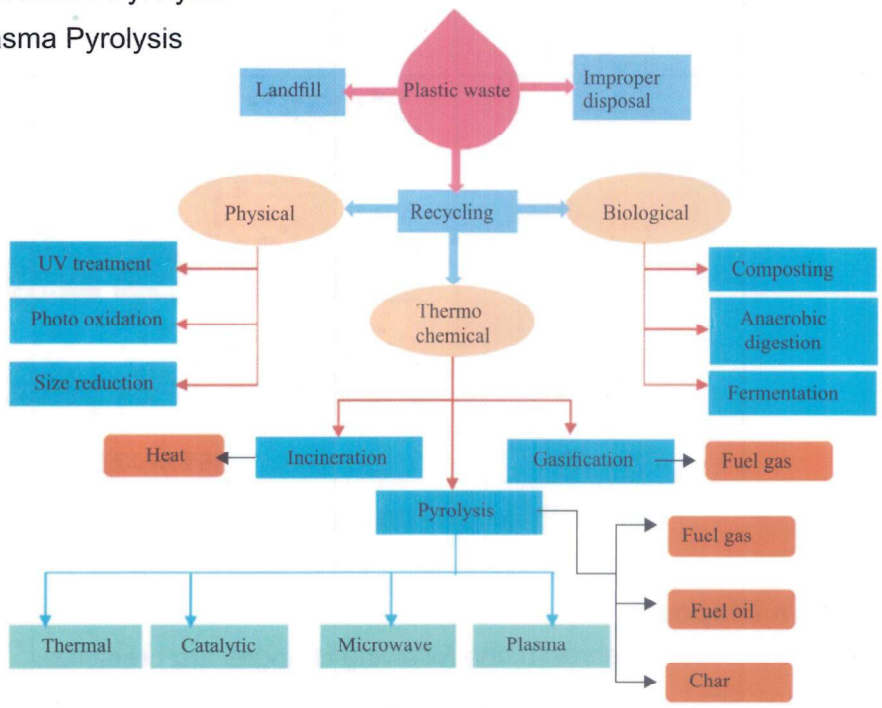


Figure-8: Outline of plastic waste management

1. Impacts of Continuing Linear Production

1.1 Impact on Production

The continued plastic production implies that (Figure 9):

- The quantity of plastic produced will increase by four times between 2015 to 2050.
- Plastic production will require 20% of global oil and gas by 2020 as opposed to 6% in 2015.
- The global carbon budget of plastic will increase by 14% from 2015 to 2050.

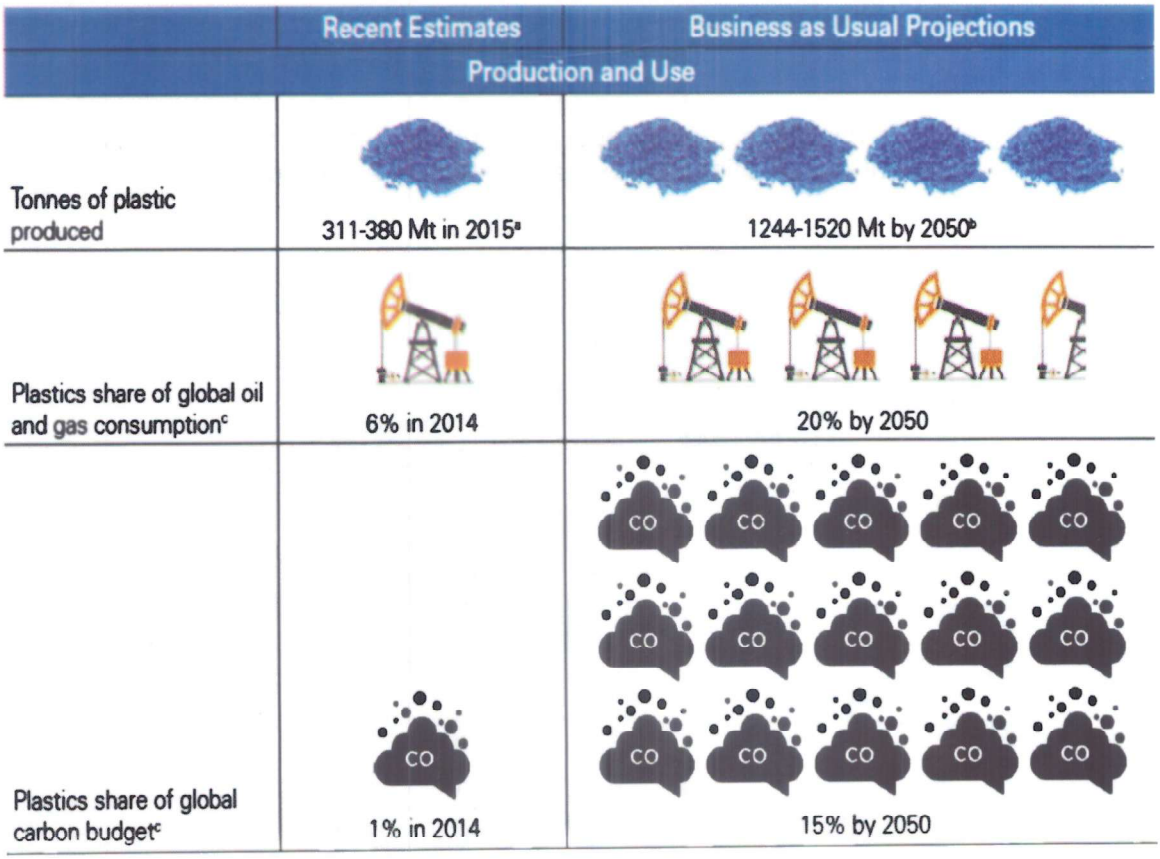


Figure-9: Projected plastic production

1.2 Impact on Disposal

As for disposal, as shown in *Figure-10*, the following changes are predicted:

- The quantity of plastic waste generated will increase fivefold between 2015 to 2050.
- Landfills and oceans will contain three times as much plastic between 2015 to 2050.
- The ratio of plastics to fish will increase from 1:5 in 2015 to 1:1 by 2050.

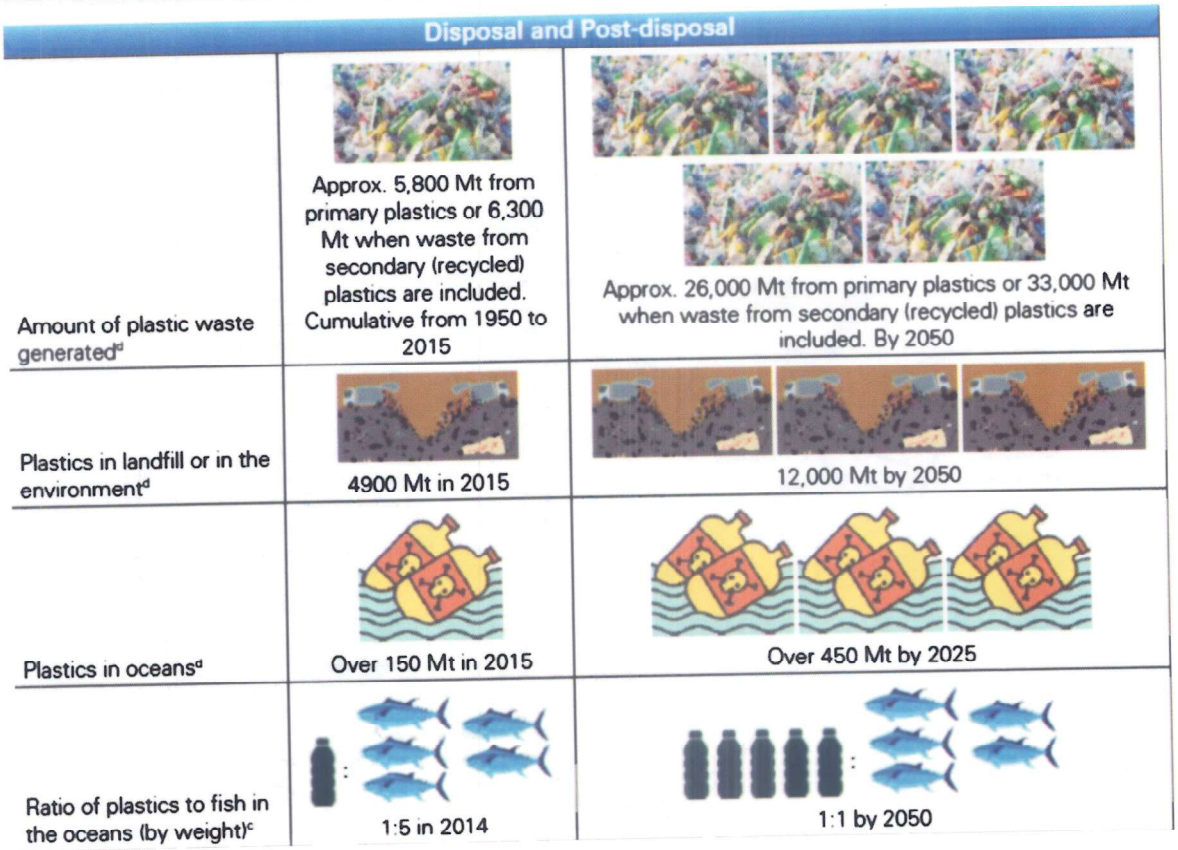


Figure-10: Projected plastic disposal

2. Circular Plastic Economy Solutions

Some of the solutions to the plastic challenge, summarized in *Figure-11*, involving the circular plastic economy include:

1. Alternative Feedstock for Plastic: Alternative feedstock for plastics include sugarcane, oils, cellulose, greenhouse gasses, sewage sludge, food waste and naturally occurring biopolymers.
2. Plastic Waste as a Resource: Plastic waste can be used to manufacture new plastics or other products.
3. Redesign and Innovation: Changes can be made to existing plastic products to ensure longevity, reusability, recycling and waste prevention.
4. Business and Consumer Cooperation: Businesses and consumers can cooperate in a way so that waste from one industry (consumers) becomes the raw material for producing new products.
5. Sustainable Business Models: Changes in business models and their implementation should be made to promote products as services that in turn lead to a decrease in the production of manufactured products. Consumers may rent and return products rather than buy them.

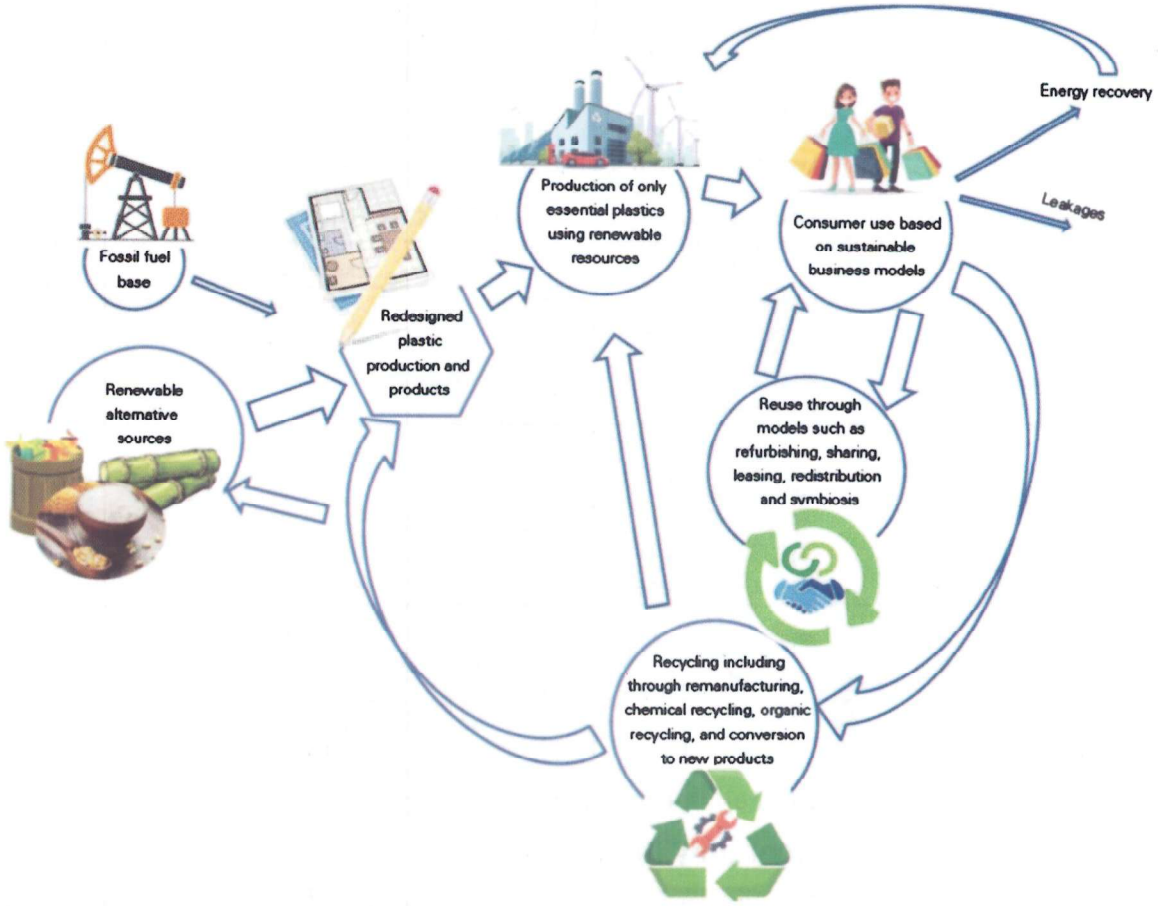


Figure-11: Circular Plastic Economy solutions

2.1 Challenges

The main challenges encountered when shifting from a linear to a circular plastic system, shown include (Figure-12):

1. Plastics are most often produced using fossil fuels as opposed to biological materials.
2. New products are often not made from recycled plastics.
3. Most plastic products are designed to be used once.
4. The production of plastic involves additional materials that results in hazardous plastic material.
5. Once consumed, plastic products are often not recycled. Instead they are disposed in landfills or incinerated which both have drastic effects on the environment.

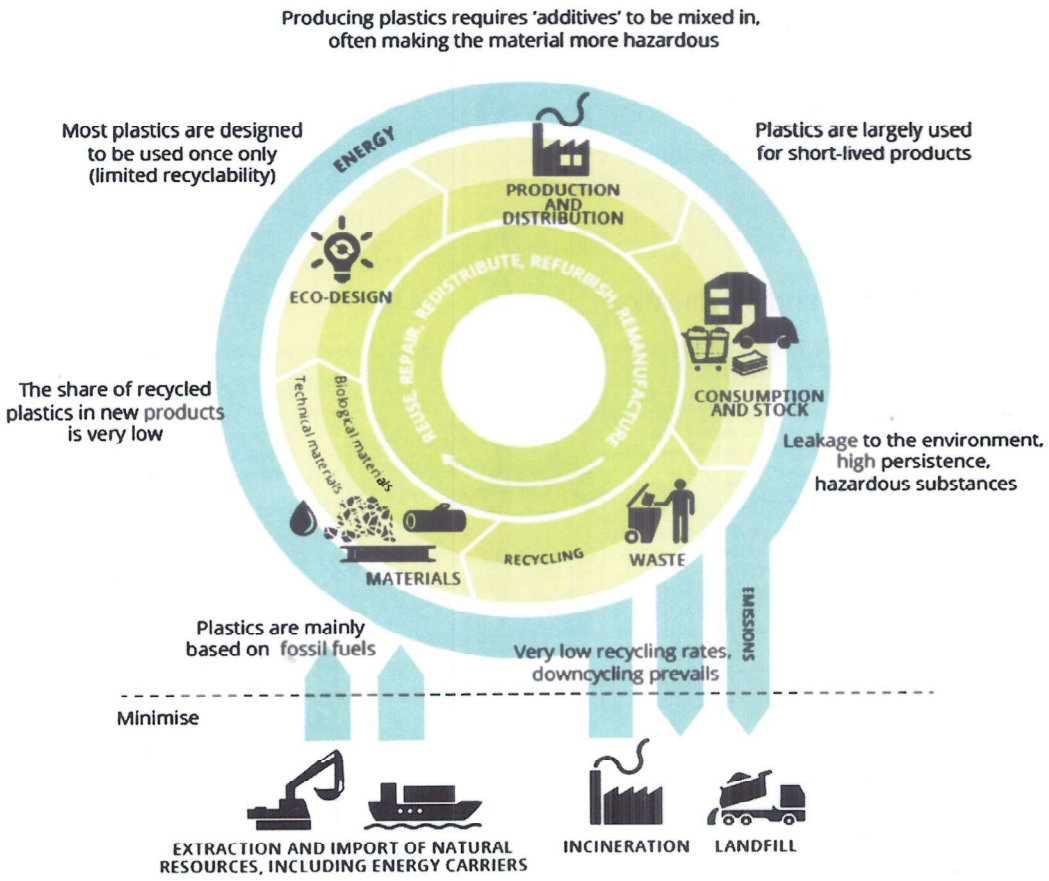


Figure-12: Challenges in shifting from a linear to a circular plastic system

1. Plastic Waste Upcycling

Plastic upcycling is the process of recreating new items and products from waste plastic materials.

Some of the recycling and upcycling technologies are listed below and briefly discussed in *Figure-13*.

Conventional Strategies

1. Pyrolysis
2. Gasification
3. Incineration
4. Landfilling
5. Mechanical Reprocessing

6. Biochemical Conversion

Emerging Strategies

1. Microwave- assisted Conversion
2. Plasma-assisted Conversion
3. Supercritical water conversion
4. Photoreforming
5. Compatibilization
6. Polymer design and modification

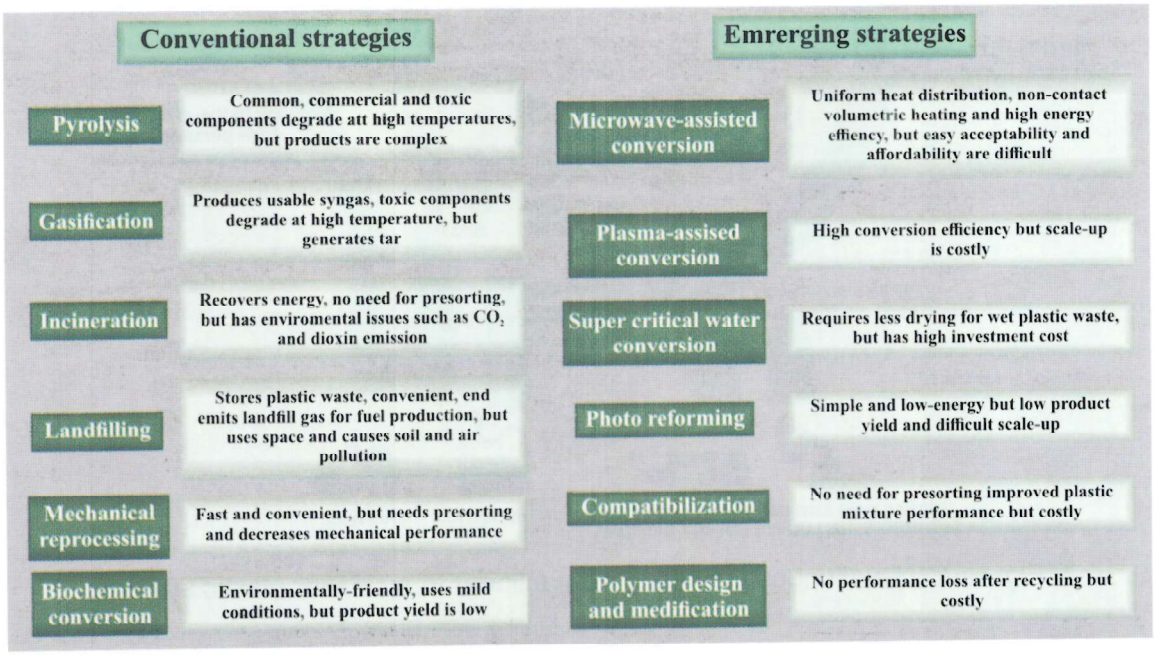


Figure-13: Plastic Waste Recycling and Upcycling Technologies

7.1. Upcycling and Catalytic Degradation of Plastic Wastes

Degradation of plastic waste involves the conversion of plastics into carbon dioxide and water. *Figure-14* shows a comprehensive overview of the plastic waste generation and their disposal from commodity plastics such as polyolefin (A & B) and compares various recycling and upcycling strategies (C-E).

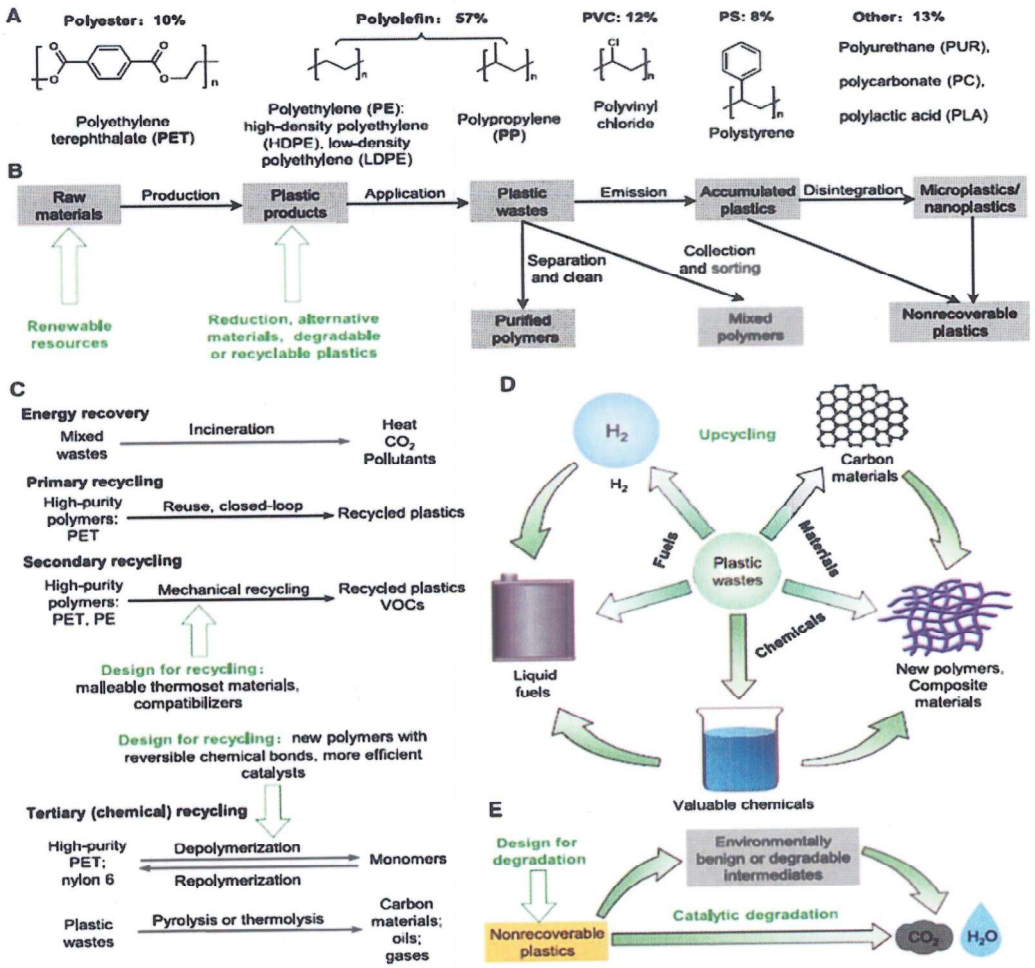


Figure-14: Degradation of Plastic Waste

Conclusion

Due to linear plastic economy, many environmental problems arise including more global carbon budget and more consumption of fossil fuels. Moreover, the increment in plastic waste causes many problems like water pollution etc. Circular plastic economy reduces such problems via different solutions discussed above in this report. Challenges like production of single use items etc. are encountered in circular plastic economy. However, redesigning and sustainable designing of polymer products and upcycling of plastic waste is the solution to problems that arise due to linear plastic economy.

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