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Circular Economy of Plastics - A comprehensive Analysis

Irfan Mahmood Khan*, Yasir Qayyum Gill

Polymer and Process Engineering (PPE) Department, University of Engineering and Technology (UET) Lahore, Pakistan

Abstract:

The Circular Economy of plastics is a promising concept that has the potential to reduce pollution and close the loop on plastic waste. However, further research is needed to develop more efficient and environmentally friendly methods of recycling plastic. This review article discusses the Circular Economy of plastics, its potential benefits and drawbacks, and the challenges that need to be addressed to make it a reality. Some case studies are also examined to explore how the Circular Economy of plastics has been implemented across the globe.

Keywords: Circular economy; linear economic model; plastics; recycling

Corresponding Author: irfanm_khan@yahoo.com

1. Introduction

Extensive utilization of plastics causes global warming, environmental deterioration, and health risks, costing the economy nearly $139 billion yearly. On the other hand, the products of childcare to a coffin made with plastic have become an essential part of our daily life. Now, prohibiting the utilization of plastic products isn't sustainable. Thus, it has become essential to adopt CE (circular economy) in the area of plastic. It means, avoiding waste by making items that are competently recyclable and slowly substituting non-degradable plastic compounds with degradable ones. The chapter emphasizes the idea of circular economy in the plastic products industries, recovering and recycling techniques of plastics, the frameworks of government, and potential challenges encountered during the enactment of plastic circularity. Although there is an effective application of plastic circularity in some the arenas, it can be observed from several case studies that the practical use of circular economy is, currently, at the initial stages. This is due to the reason that a great number of commercial industries are not committed to cent percent circularity until the year 2025. This report also identifies that further developments in research and development, enhanced tax benefits and funds allocation, a necessity for joint business ventures, increased exigency for recuperated merchandise (by marketing), and augmented awareness of consumers and the producers (companies) are extremely important for accomplishing effective plastic circularity.

In current years, several are being made using plastics, primarily because of their low cost, ease of processing, and less weightiness. It is assessed that around 360 million metric tons of plastic products

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were made in the year 2018 to fulfill worldwide demands (Garside, 2019). The worth of the international plastic market was approximately $ 568.5 billion in 2019, with an estimated growth rate of around 3.50 percent until the year 2027 (GVMR Report, 2020). The usage of plastic per person for an entire year varies from 9-to 108 kg (Koh, 2019).

Figure 1. Usage of plastic products per capita (kilograms/person) (Barnes, 2019)

Fig 1 displays the usage of plastic products for each person across several states in 2015. PO (polyolefin) has the largest share, with LDPE (low-density polyethylene) having the major contribution trailed by HDPE (high-density polyethylene), PET (polyethylene terephthalate), and PP (polypropylene). Generally, a smaller contribution is made by PS (polystyrene), PVC (polyvinyl chloride), PA (polyamide), etc. Figures 2 & Figure 3 display the ingestion of common plastic products and utilization of the general plastics in various areas. The most common plastic products utilized in industries are non-biodegradable plastics. With the risky durability of plastic, the life period of plastic products and polymers is roughly around some centuries (Inoue, 2018; The Canberra Times, 2019).

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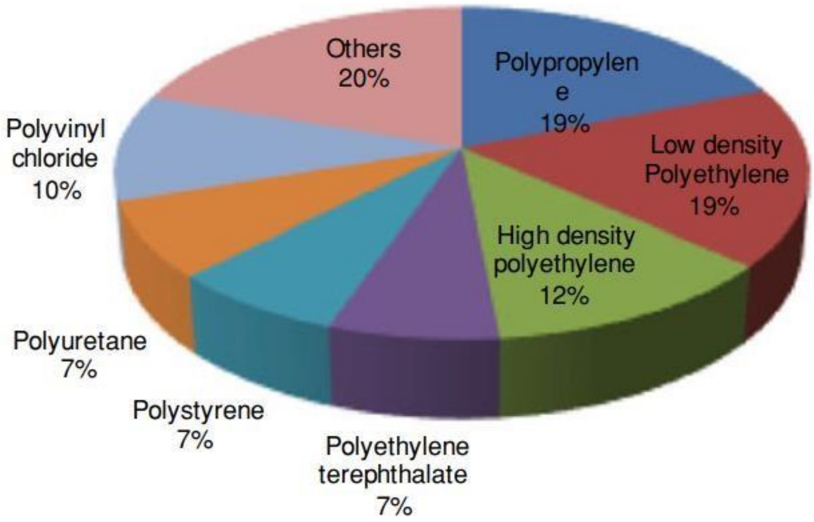

Figure 2. Global ingestion of general plastics (Yeo et al., 2018)

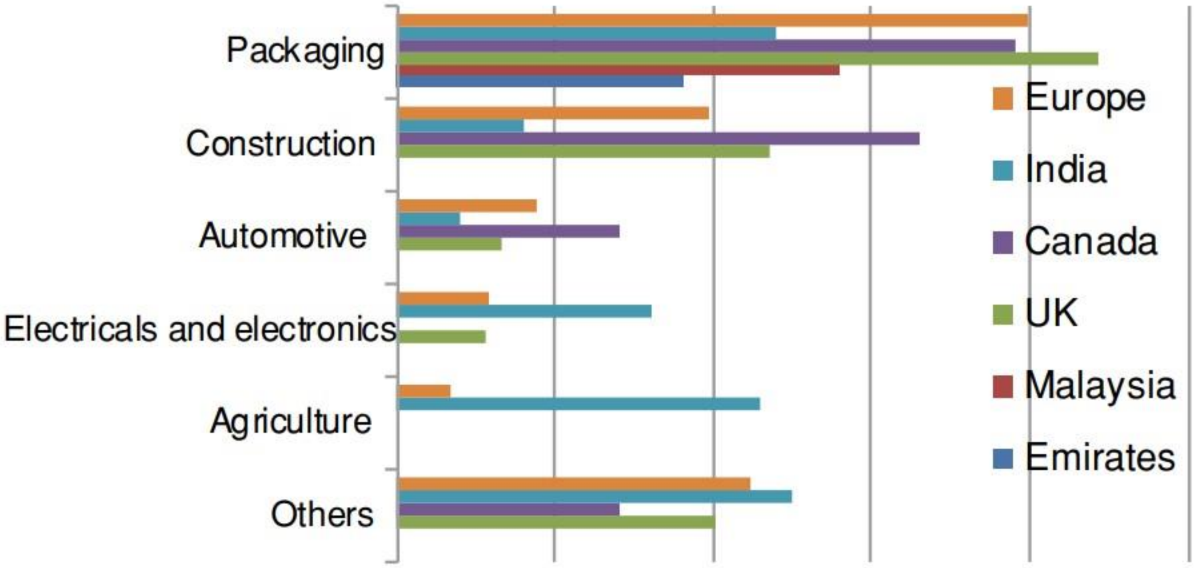

Figure 3. Usage of plastics by each sector (percent) (British Plastic Federation, 2020)

With an upsurge in worldwide utilization of plastic products, they frequently finish up in landfills after usage. The utilization of plastic products has become an insistent problem for the world, as plastic is the primary source of health hazards, global warming, and a decrease in the groundwater because of the clogging of canal streams/river. Management of the waste of plastic has become so pervasive that it generally has activated the struggle to frame the global settlement under the testimony of the UN. To handle the problems, the shareholders are starting to accept the circularity of plastics. The circular economy is implemented by evolving and following the concept of the CE. European parliament devised a definition of the circular economy that is *''the model centered on leasing, sharing, reutilizing, repairing, renewing and also recycling, where the items and the comprised materials are valued highly, and where the waste is decreased to the minimum''* (Briefing of the European Parliament, 2017).

Worldwide momentum for fundamental plastics reconsideration is greater nowadays. Plastics have taken the place of the universal mainstay materials of the contemporary economy, i.e., merging low cost with unequaled functional features. The use of plastic products has augmented twentyfold in the last 50 years. Whereas plastics and plastic-based packaging are recognized as an integral part of the world economy and offer many advantages, the archetypically linear, take-make-dispose chains of plastics entail substantial environmental and economic disadvantages. It is just in the last few years that the factual extent of the disadvantages has become clear. It is now known, around more than forty years after the inauguration of the 1st worldwide recycling symbol, that 14 percent of the plastic packaging is gathered for recycling internationally (FICCI, 2014; IEA, 2020). Every year, around 80-120 billion USD value of plastic packaging material is lost to the economy. Given the anticipated growth in manufacturing, in the business-as-usual situation, by 2050 oceans might comprise more plastics than fish. Across the complete range of plastic products, not only packaging, worries are raised regarding the potential negative influence of particular substances on the economy and society. Governments and businesses are now recognizing the necessity to fundamentally reconsider the worldwide plastics system. The increasing recognition is initiating action across the globe. Policy-makers carry on widening and refining guidelines for plastics, presenting landmark legislation globally throughout 2016, like bans and restrictions on single-use plastic bags (Cleetus et al., 2013; Yeo et al., 2018). The European Commission is scheduled to publish the approach to plastics as part of the Circular Economy Action Plan by 2017. NGOs and the public are progressively calling for modification, with movements like the #breakfreefromplastic campaign catching attraction. The industry groups and front-running businesses are taking action. The main question is, will the societies gradually discard the material because of its negative impacts and forgo its numerous advantages, or will the societies carve out the future for it categorized by novelty, remake, and harmonization, centered on the circular economy principles?

2. Circular Economy of Plastics

In current drifts, all of the shareholders are normally moving towards the more ecological strategy of CE from a linear economy (LE), in which the items are utilized and disposed of. CE objects to retaining resources in utilization till feasible, utilizing the utmost value of these products, and recuperating and redeveloping materials and products when their service life ends. It provides a chance to reduce the adverse effects of plastic whereas providing most of the advantages of plastics and their corresponding merchandise and offering ecological, social, and economic benefits. The evolution of plastics from LE to CE is demonstrated in Figure. 4 (Government of Canada, 2017); British Plastic Federation, 2020).

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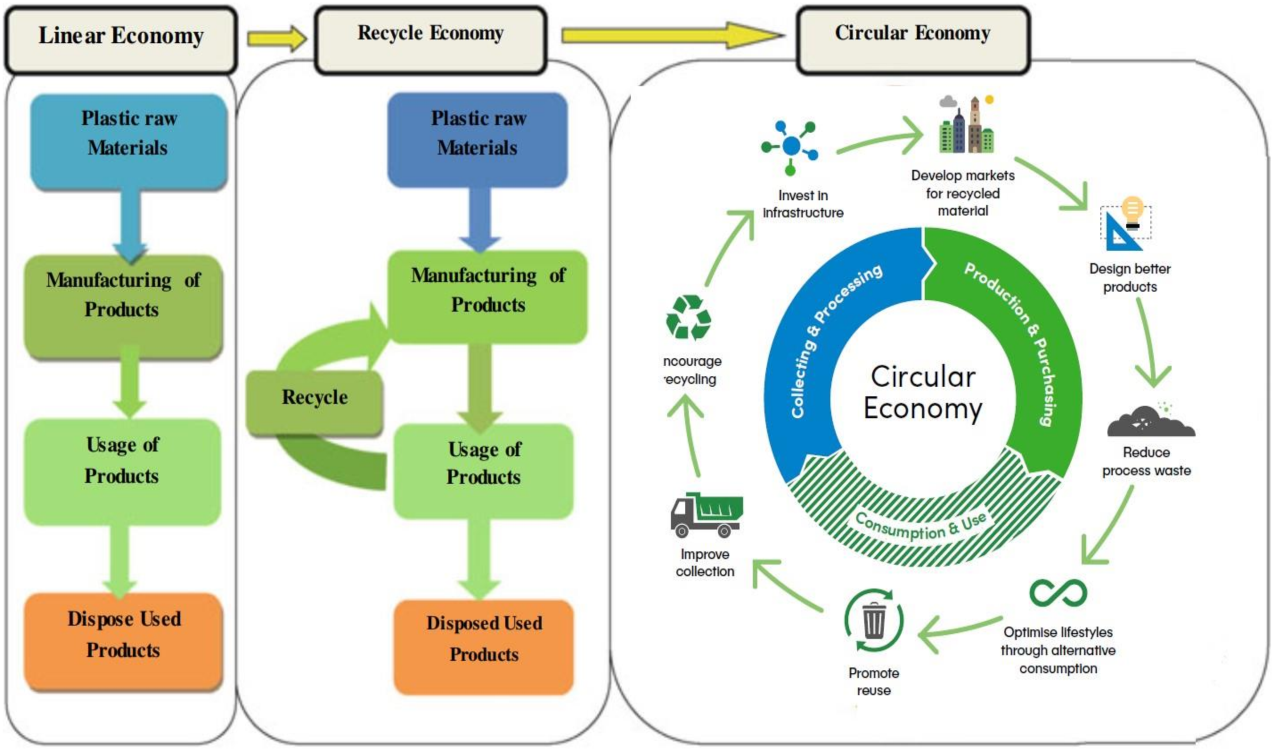

Figure 4. Developments in the use of polymeric packaging materials from a linear economic model to the circular economic model

In short, 3 vital rules to control the circular economy or circularity of the plastics, generally, are as follows (European Union, 2017; NPCS, 2017):

a) Retain and improve the original capacity by governing limited stocks and harmonizing the renewable resources flow.

b) Utilize high-value raw materials and improve the materials and production via merchandise circularity.

c) Eliminate the undesirable externalities by making the method efficient.

3. Cataloging of plastics in an economy

Plastics are available in various sizes and shapes and can generally be rigid or flexible. Plastics can be manufactured from a single polymer or numerous layers of dissimilar polymers. Usually, plastics or their products can be categorized into bio- or petrochemical-based, dependent on the raw material from which these plastics are made (The Energy and Resources Institute, 2018; Heijmans, 2019). The plastics based on petrochemicals are produced from a broad range of polymers originating from petrochemicals also known as conventional plastics. These plastics can be parted into thermosets and thermoplastics. The thermoset plastics are perpetually cross-linked with each other and thus hard to be re-melted and restructured. Thermoplastics can usually be re-melted and restructured and these are the

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most regularly utilized plastics in an economy (Morgan, 2019). Due to the huge majority of the plastics trending in an economy being the thermoplastics (McDowall et al., 2017), this chapter emphases explicitly the circularity of the petrochemical-based plastics.

Bio-based plastics are the plastics that originated from biomass and this biomass is the material of the biological origin eliminating materials from the geological fossilized or formation, as described by European Standard EN 16575 (EN 16575, 2014) (Ellen MacArthur Foundation, 2019). Bio-based plastics in an economy can usually be categorized into polymers made completely from biomass and those made partially from biomass (Kalmykova et al., 2018).

All of the plastics and their products, irrespective of whether the plastics are bio-based or petrochemical-based, can be made to act in 2 different ways: i) non-biodegradable and ii) biodegradable. Biodegradable plastics can usually be decayed into an environment by the action of microorganisms (fungi or bacteria) into the water, methane (CH_4), carbon dioxide, and biomass. Conversely, the biodegradability of these plastics can differ widely centered on the intrinsic and aimed properties of plastic (Avantium, 2016; Kalmykova et al., 2017), climatic (rain, wind, UltraViolet radiation), and the particular conditions of the process, and the speed of degradation. The subcategory of biodegradable plastics might be compostable (Al-Sabagh et al., 2016).

Compostable plastics should be exhibited to be proficient in enduring biological disintegration in the stimulant site as a component of an accessible program and the subsequent breakdown fragments are entirely utilized by microorganisms under some specific conditions qualified by international standards ISO 17088, ASTM D400, EN 13432 of Europe, and D6868 of United States. Therefore, all the biodegradable plastics aren't compostable but all the compostable plastics are generally biodegradable (Beyene, 2014; Ragaert et al., 2017). The kinds of plastics, i.e., bio- and petrochemical-based plastics, presently accessible in the market and their applications (transportation, construction packaging, agriculture,) are given in Table 1. They are categorized concerning the origin of materials and their biodegradable capacity (Chavan, 2013).

Bioplastics, which comprise both biodegradable and bio-based plastics, signify nearly 1 percent of the 336 metric tons of the total worldwide plastic produced yearly (Plastics Europe, 2017). Europe is an important contributor to the worldwide manufacturing of bioplastics, making around 19 percent in the year 2018, whereas Asia covers around more than 50 percent of the worldwide production of bioplastics (Bioplastics, 2017). The market for them is expected to increase quickly in the coming future with more modern biopolymers, uses, and emerging products. For instance, bio-PE (bio-based polyethylene) and bio-PET (bio-based polyethylene terephthalate), which are indistinguishable from the petrochemical-based equivalents and can usually be utilized in precisely similar applications- hence known as the drop in materials - are mainly popular (Pandi et al., 2017).

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Table 1. Main kinds of bio- and petrochemical-based plastics accessible in a market, their key applications, and circularity prospective (Hahladakis et al., 2020)

Type	Prevalent polymers	Circularity prospective	Main applications
Petrochemical-based and non-biodegradable	Polyethylene	Non-renewable; recyclable	Packaging; electronics; agriculture; leisure and sport; and construction and building
	Polystyrene	Non-renewable; recyclable	Packaging; construction and building; electronics; leisure and sport; energy and healthcare
	Polypropylene	Non-renewable; recyclable	Packaging; construction and building; electronics; healthcare; and leisure and sport
	Polyvinylidene chloride	Non-renewable; recyclable	Packaging
	Polyvinyl chloride	Non-renewable; recyclable	Packaging; leisure and sport; construction and building healthcare; energy; and mobility and transport
	Polyethylene naphthalate	Non-renewable; recyclable	Healthcare; packaging; and blending material for enhancing PET performance
	Polyethylene terephthalate	Non-renewable; recyclable	Packaging; transport and mobility; electronics;
	Polycarbonate	Non-renewable; recyclable	Packaging; transport and mobility; electronics;
Petrochemical-based and biodegradable	Ethylene-vinyl alcohol	Non-renewable; recyclable	Packaging; electronics; agriculture; healthcare; and transport and mobility
	Polyamide	Non-renewable; recyclable	Packaging; transport and mobility; electronics
	Poly(vinyl alcohol)	Non-renewable; recyclable	Textiles, papermaking, and coatings
	Polycaprolactone	Non-renewable	Production of polyurethanes and PVC (utilized as plasticizers)

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	Poly(butylene succinate)	Non-renewable	Agriculture; packaging; construction and building
	Poly(butylene adipate-*co*terephthalate)	Non-renewable	Packaging
	Polyglycolic acid	Non-renewable; non-recyclable	Construction and building; healthcare
	Poly(propylene carbonate)	Non-renewable; non-recyclable	Packaging; an agent of toughening for the epoxy thermosets; and microelectronics
Bio-based and non-biodegradable	Bio-based polyethylene terephthalate	Renewable; recyclable	Packaging
	Bio-based polyethylene	Renewable; recyclable	Packaging
	Polyethylene furanoate	Renewable; recyclable	Packaging
Bio-based and biodegradable	Polylactic acid	Renewable; recyclable	Healthcare and packaging
	Thermoplastic starch	Renewable; recyclable	Agriculture and packaging
	Polyhydroxyalkanoates, polyhydroxybutyrate	Renewable	Agriculture; Packaging; healthcare; leisure and sport; and transport and mobility

Table 2. Properties and kinds of some additives utilized for the making of plastic raw materials (Hahladakis et al., 2020)

Kind of additives	Compounds	Properties
Plasticizers	epoxidized oils; Phthalic esters	Offer flexibility and softness in the brittle polymers. Eighty percent of the plasticizers are utilized in PVC
Fillers	Inert (talc, and calcium carbonate,); reinforcing (carbon and glass)	Lower the cost and improve hardness
Heat stabilizers	Phenolic antioxidants and organophosphites	Avert disintegration of the plastic polymers during the processing
Flame retardants	aluminum and magnesium hydroxides; Organohalogen compounds; antimony trioxide; phosphate ester compounds; and others	Avert flame spread or ignition to meet the fire safety standards
Modifiers of surface property	Antistatic agents (polyhydric alcohols, ethoxylated fatty amines, and quaternary and non-ionic ammonium) Anti-fogging agents (glycerol, and nonionic ethoxylates)	Avert gathering of electrical charges in plastic films
Antiaging additives	Free radical scavengers; antioxidants; heperoxide decomposers; antimicrobials/ biostabilizers; UV stabilizers;	Avert aging processes because of oxidation, temperature, and microorganism attack
Optical property modifiers	Anti-blocking agents (alkylamines, teramide, alkyl quaternary ammonium, clays, starches, and colloidal silica) Pigments (white titanium dioxide, carbon black, molybdate orange, yellow cadmium sulfide, and ultramarine)	Avert the creation of droplets of water on the inside surface providing a purer view of the contents of the package; utilized in the range of 0.5% to 4% Avert sticking of plastic sheets and films because of the non-electrical conductivity; utilized in the range of 0.1% to 0.5% Make plastic materials more colorful

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Additives of Lubricant	External (paraffins, polyethylene waxes, fatty acids, amides,); internal (esters and fatty alcohol)	Avert harm during the processing of plastic; increase processability by growing the ability of flow; and provide glossy finish
Agents of foaming or blowing	Butane; carbon dioxide	Form gases in the plastic via chemical or physical procedures to yield the foam raw material

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Biobased-PET is the utmost conspicuous bioplastic accounting for forty percent of the worldwide manufacturing of bioplastics (Robertson, 2014), trailed by the cellulose acetate (utilized in the production of cellophane), PLA (polylactic acid), PBAT, and numerous famous companies like Vittel, Coca Cola, Volvic, and Heinz utilize bio-PET in the packaging. The trends of the international market exhibited that bio-PE, bio-PET, PHA, PBS, PBAT, PLA, PCL, and the starch-based making of plastic is anticipated to an upsurge shortly, particularly in Europe (Van den Oever et al., 2017). Commercialization of bioplastics is increased in 2020 with PHA and bio-PE the most predominant among all. Added forecasts envisage that the worldwide production of bioplastics will reach 8.6 metric tons in the year 2021 (European Environment Agency, 2018).

Apart from the selection of raw materials utilized to manufacture plastics, some additives are also utilized during manufacturing. Additives are the supplementary constituents added to a base polymer to enhance the production process and improve the plastic polymer's properties without varying the chemical structure. By utilizing additives, plastics can be clean, safe, enduring, colorful, and tough. The comprehensive, but not extensive, list of some additives utilized in the production of plastics is given in Table 2.

Even though comparable additives to the ones utilized in the traditional plastics are also utilized in bio-based plastic, struggles are largely engrossed in making replacements, like biodegradable fertilizers or renewable polyamide additives (Chemical Institute of Canada, 2013). For instance, glycerol is utilized as a plasticizer to enhance the thermoplastic starch's ductility in the range from 29 percent to 40 percent (Mohammadi Nafchi et al., 2013).

4. Rates of Recycling, Initiatives, and Policies for the Circularity of Plastic Products Adopted in Numerous Countries

Reprocessing and recyclability are some fragments of ingenuities adopted for the promotion of the circularity of plastic products. In the initial phases of plastic use, various international states were trading the plastic litter with various other countries for getting the litter recycled. Currently, among the states, China was the only main state to import the waste of plastic from numerous states. For example, Australia exported nearly 1.24 Mt of the wastes of plastic from 2016 to 2017.

In the year 2018, China started imposing the National Sword policy, in which strict regulations and rules were enforced on the plastic waste's quality of plastic litter to be imported. Furthermore, in recent times, only China has been able to significantly reduce the import of plastic waste from major industrial states. As the restriction was imposed by the state of China, several states began recycling the plastics inside their territory. Though, the rates of recycling are yet lower. Fig 5 exhibits the rates of recycling of waste plastic across several states in the year 2018. South Korea, India, China, and Japan are the main stages in the recycling of waste plastics.

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It can be observed from Figure 5 that the rates of recycling in states like the USA, Singapore, and Brazil are low (i.e., 4-20 %). To Figure out the strategies for the management of waste, several organizations and governments are embracing modern practices regarding the circularity of materials.

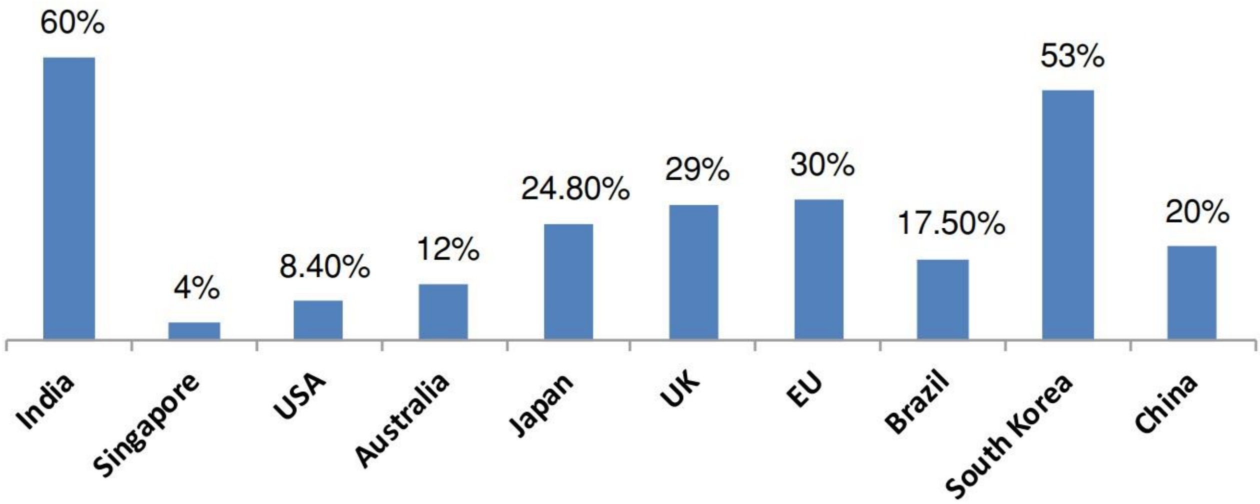

Figure 5. Rates of recycling of the wastes plastic of dissimilar countries (European Union, 2017)

In the year 2012, Circular Economy Act was imposed by Germany (i.e., the German Circular Economy Law). Furthermore, European Union (EU) took a practical step in the implementation of the CE in 2015. The European Union's Circular Economy Package emphasized the novel pathway of the closed-loop cycle for the production, utilization, reuse, and recycling of plastic products. The EU framework acts as the point of reference for conscripting the circularity principles for states, which concentrated on circular economy in the later years. Concerning the approaches for plastic products in emphasis, the agenda was enforced in the year 2018. Later, in the year 2016, the Netherlands enforced novel legislation known as *''A Circular Economy in the Netherlands by 2050''*. Various other initiatives and programs like *Green Growth*, the *Bio-centered Economy*, *and VANG* are motivated to accept plastic circularity.

5. Challenges Confronted in Accepting Circularity of the Plastic Products

In the complete evolution from linear/open-loop utilization of the plastics to execution of circularity/close-loop of plastic products, all of the members from consumers to industrialists must face the significant challenge. Various approaches are appraised and accessible for the execution of CE, particularly in the industries of packaging. Analysts and researchers have made a database of main factors and obstacles that must keep in mind in effective operation for an undertaking of circular economy (Kalmykova et al., 2018), which is summarized in Figure. 6. Several significant challenges confronted are described in the following sections:

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5.1. Finding Value

The reprocessed plastic products are occasionally costly as compared to the original plastic raw materials. Although the plastics that are recycled are usually costly, the quality is often uncertain. Thus, there is a necessity to discover the significant value addition to these recycled plastic-based materials.

5.2. Remodeling and Redesigning

Numerous items are manufactured in such a way that the reprocessing of the plastic content becomes complicated. To satisfy the market demands, several merchandise like packaging covers and bottles are frequently manufactured with additives materials like bonds and glues. Though, these compounds are known to cause trouble during the segregation of these products into waste products. Thus, an ecological strategy must be approved to design these products with an emphasis on simple recycling. Furthermore, novel and green raw materials must be made which offer good recyclability and are also eco-friendly. For example, a novel bio-centered plastic product, polyethylene furanoate, is being synthesized which acts as a substitute for prevailing PET bottles. The AVANTIUM with the corporation of some other prominent companies like ALPLA, Coca-Cola, and Danone stepped forward to begin the joint venture known as Sylvia in the year 2016. They established the production unit in Belgium (an EU country) for the manufacturing of bio-based raw ingredients which provide chances to be reprocessed (Al-Sabagh et al., 2016; Avantium, 2016).

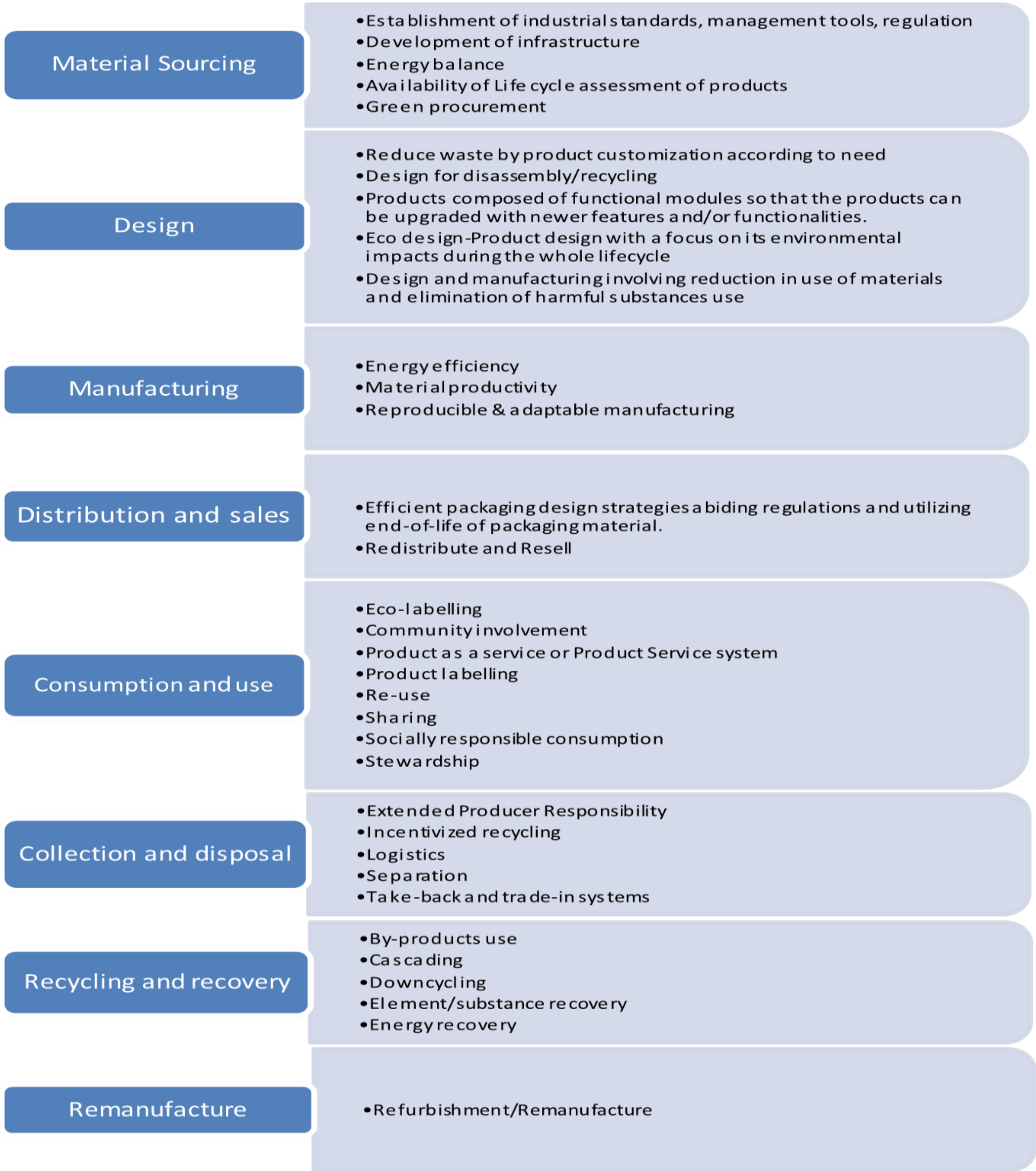

Figure 6. Encounters and main signs in the execution of CE (circular economy) (Kalmykova et al., 2017)

5.3. To upsurge Availability

Finding a substitute sustainable raw material is the main aspect of the execution of a circular economy. Furthermore, it is significant to confirm that novel materials must possess a stable supply, for a continuous process of manufacturing.

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5.4. Respecting Procedures of Manufacturing

Redesigning and utilization of novel substitute raw materials might affect the current manufacturing procedure. Thus, it is essential to find effective approaches that don't hinder the prevailing production cost and processes.

5.5. Sorting

As dissimilar goods of plastic have adjustable attributes like design, shape, diverse chemical properties, structure, and color, it becomes tough for the units of recycling to sort out and classify them to recover the good produce of reprocessed plastics. Induction sorting, manual sorting, triboelectric separation, eddy current sorting, sink float separation, and speed accelerators are a few technologies utilized in existing facilities of recycling. X-ray, laser-induced and infrared breakdown spectroscopies are a few technologies utilized to control the quality of the sorting procedure.

5.6. Recycling

It is amongst the significant features of the circular economy to control the plastics leakage from a loop. Generally, plastics are reprocessed either by chemical or mechanical recycling. A comprehensive description of the kinds of plastic reprocessing is described in the sections below.

5.6.1. Mechanical Recycling

Utilizing this technique of recycling, the litters of plastic are processed into recycled/secondary materials without changing the chemical configurations of the polymer. This recycling is appropriate and restricted to thermoplastic polymers. This technique is frequently not appropriate for thermoset polymer primarily because of the cross-linked structure. The stages included in mechanical recycling comprise gathering, sorting, chipping, cleaning, and then pelletizing. The key task encountered in this reprocessing is that the waste plastic must be sorted, as plastic wastes are vulnerable to pollution. Another disadvantage is that the heat that happened during the procedure inclines to unstiffen the polymers or triggers degradation occasioning the poor properties of reprocessed produce.

5.6.2. Chemical Recycling

This technique is utilized for transforming the larger chains of polymers into very smaller units that can generally be further utilized into a range of beneficial resources. For example, the wastes of plastic are transformed into fuels, gases, and some chemicals through several procedures like gasification, hydrogenation, and pyrolysis. On the other hand, hemolysis or chemical depolymerization technology is utilized to transform the wastes of plastic into oligomers, higher hydrocarbons, and the monomers that can normally be utilized to produce again the plastic products that have been reprocessed or can generally be utilized for producing novel plastic raw materials. The conditions of processing, benefits, and trials of a procedure and instances of plastics treated and the yield are given in Table 1.

5.6.3. Collaboration

The acceptance of the circularity of plastic products is very a dull evolution, which is frequently not feasible by a single shareholder. All of the stakeholders indulged in product and the chain of supply must corporate and act as a team for the smooth advancement from linear to circular economy.

6. The Novel Plastics Economy

The Novel Plastics Economy is the vision of CE for plastic, where plastic isn't wasted. It provides the root cause answer to plastic contamination with profound economic, societal, and environmental benefits. The 'Novel Plastics Economy' provides the new objective, associated with the principles of CE, to capture the opportunities. With a systemic and collaborative strategy, the Novel Plastics Economy objects to overcoming the restrictions of today's incremental enhancements and disjointed initiatives, creating a shared sense of orientation, sparking the wave of novelty, and also to move the value chain of plastics into a positive spiral of the value capture, better environmental, and stronger economics outcomes. This chapter highlights the basic rethink for packaging of plastic and plastics in general; it provides a new strategy with the prospective to convert worldwide flows of plastic packaging materials and thus escort the Novel Plastics Economy.

For the packaging of plastic, explicitly, a circular economy recognized is defined by 6 characteristics:

1) **Elimination of unnecessary or problematic packaging of plastic through redesign, novelty, and novel delivery models are the priority**

a) Plastic brings numerous benefits. Simultaneously, some challenging products in the market must be eliminated to accomplish the circular economy, and at times, the packaging of plastic can be averted altogether while maintaining utility.

2) **Reutilization models are made practical where relevant, decreasing the necessity for single-use packaging**

b) Whereas improving recycling is critical, out of the plastic problems faced currently the way cannot be recycled.

c) Wherever appropriate, reuse business models must be explored as the preferred inner loop, decreasing the necessity for single-use packaging of plastic.

3) **All packaging of plastic is 100 percent recyclable, reusable, or compostable**

d) This needs the amalgamation of redesign and novelty in business models, packaging design, materials, and reprocessing technologies.

e) Compostable packaging of plastic isn't the blanket solution, but instead one for particular, targeted applications.

4) **All packaging of plastic is recycled, reused, or composted in practice**

f) None of the plastic must end up in an environment. Incineration, landfill, and waste-to-energy aren't part of the CE target state.

g) Businesses selling or producing packaging have the responsibility afar the design and utilization of the packaging, which involves working towards it being gathered and recycled, reused, or composted in practice.

h) C Governments are necessary for setting up efficient collection infrastructure, aiding the establishment of associated self-sustaining mechanisms of funding, and offering an enabling regulatory and policy landscape.

5) **The utilization of plastic is completely decoupled from the ingestion of finite resources**

i) This decoupling must take place first and at the top by decreasing the utilization of virgin plastic.

j) Utilizing recycled content is necessary to decouple from the finite feedstocks and also to stimulate demand for gathering and recycling.

k) C Over time, residual virgin inputs must switch to the renewable feedstocks that were verified to be beneficial environmentally and also to come from reliably managed sources.

l) Over time, the manufacturing and recycling of plastic must be powered completely by renewable energy.

6) **All packaging of plastic is free of dangerous chemicals, and the safety, health, and rights of the people involved are cherished**

m) The utilization of dangerous chemicals in packaging and the manufacturing and recycling procedures of plastics should be excluded.

n) It is necessary to respect the safety, health, and rights of the people involved in the parts of the plastics system, and mainly to enhance the conditions of workers in informal sectors.

o) This objective is the target state strived for overtime, recognizing that comprehending it will need substantial struggle and investment; identifying the significance of taking the complete life-cycle and the systems perspective, targeting for improved economic and environmental consequences overall, and knowing the time to take action is now.

7. Key transition approaches for Plastic Economy

The three main transition approaches and associated priority areas of action are:

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7.1. Without Essential Redesign And Novelty, About 30 Percent Of Packaging Of Plastic Will Never Be Recycled or Reused.

Today, these applications of packaging – signifying as a minimum half of all the items of plastic packaging, or about 30 percent of the demand by weight – are, by the design, destined for incineration, landfill, or recovery of energy, and are frequently possible to leak into an environment after the short single utilization. This segment comprises *small-format* packaging, like sachets, lids, sweet wrappers, and tear-offs; *multi-material* packaging composed of various materials fixed together to improve the functionality of packaging; *uncommon* materials for plastic packaging of which only comparatively low volumes are generally put on the market of packaging, like PVC, PS and EPS, and highly *nutrient-polluted* packaging, like fast-food packaging.

Urgent actions for the worldwide value chain of plastic packaging include:

a) Fundamentally redesign the delivery models and packaging formats for the *small-format* packaging of plastic, averting small arrangements where possible and relevant

b) Increase material novelty in compostable or recyclable replacements to the presently *multi-material* that is unrecyclable uses as described above

c) Actively explore substituting PVC, EPS, and PS as *uncommon materials of* packaging with replacements.

d) Scaled up compostable wrapping and associated infrastructure for the directed *nutrient polluted* applications

e) Discover the perspective along with the restrictions of chemical reprocessing and the other technologies to reuse presently unrecyclable wrapping of plastic into novel plastic feedstocks.

7.2. For at Least 20 Percent of Plastic Packaging, Reutilization Offers an Economically Striking Opportunity

New, advanced delivery models and developing patterns of utilization are unlocking the opportunity of reuse for at least 20 percent of plastic packaging, worth at least 9 billion dollars. Novel models that efficiently substitute single-use packaging with reusable replacements are already being validated in the personal care and cleaning market by just shipping active constituents in amalgamation with reusable dispensers (McCarthy, 2018).

Actions of priority in the field of reuse comprise:

a) Innovate towards innovative, novel models of delivery centered on reusable wrapping

b) Substitute single-use bags of plastic with recyclable substitutions

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c) Scale-up recyclable packing in the business setting for pallet wrap and large in flexible packaging.

7.3. With Concentrated Struggles in The Design and After-Utilization Systems, Reprocessing Would be Attractive Economically for the Residual 50 Percent of Plastic Packing

Implementation of good standards and practices in the design of packaging and after-use procedures as a share of the International Plastics Protocol, permitting for regional dissimilarities and continued novelty, would support recycling as an economically attractive substitute for incineration, landfill, and energy recovery (Dykes Paving, 2020). As a portion of redesigned and recycled packaging defined above will also trigger recycling, the 50 percent mentioned here shouldn't be understood as the upper limit for the recycling target. In regions having high leakage levels into the environment, another crucial short-term act is to arrange basic gathering and management infrastructure – needing dedicated and different struggles. Priority actions for enhancing recycling economics, quality, and uptake include:

a) Implement design variations in the packaging of plastic to improve economics and recycling quality (additives, selections of materials, and arrangements) as the first stage toward the International

Plastics Protocol

b) Complement and accept the finest practices for sorting and collection systems, as a share of the International

Plastics Protocol

c) Scale-up recycling processes of high worth

d) Discover the perspective of material makers to upsurge sorting quality and yields

e) Develop and use advanced sorting mechanisms for the post-consumer stretchy films

f) Increase demand for reprocessed plastic products through policy instruments and deliberate commitments, and discover other policy measures to support recycling

g) Deploy sufficient sorting and collection infrastructure where it isn't yet in place.

8. Case Studies Related to Circularity of Plastics

With the challenges mentioned above, there exist, several designers, activists, economists, manufacturers, and industrialists bringing new ideas to plan the circularity of the consumer utilized plastics. Numerous cooler explanations for redesigning, recycling, and negligible disposal of waste

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plastic are being executed in daily life. The ingestion of some of the developed consumer brand, retail and hospitality companies, and packaging companies are summarized in figure 7. Furthermore, the organization's obligation to reuse and utilize post-consumer reused plastics by the year 2025 is presented in figure.7. Some instances of the wastes of plastic circularity concerning downcycling and upcycling are briefed.

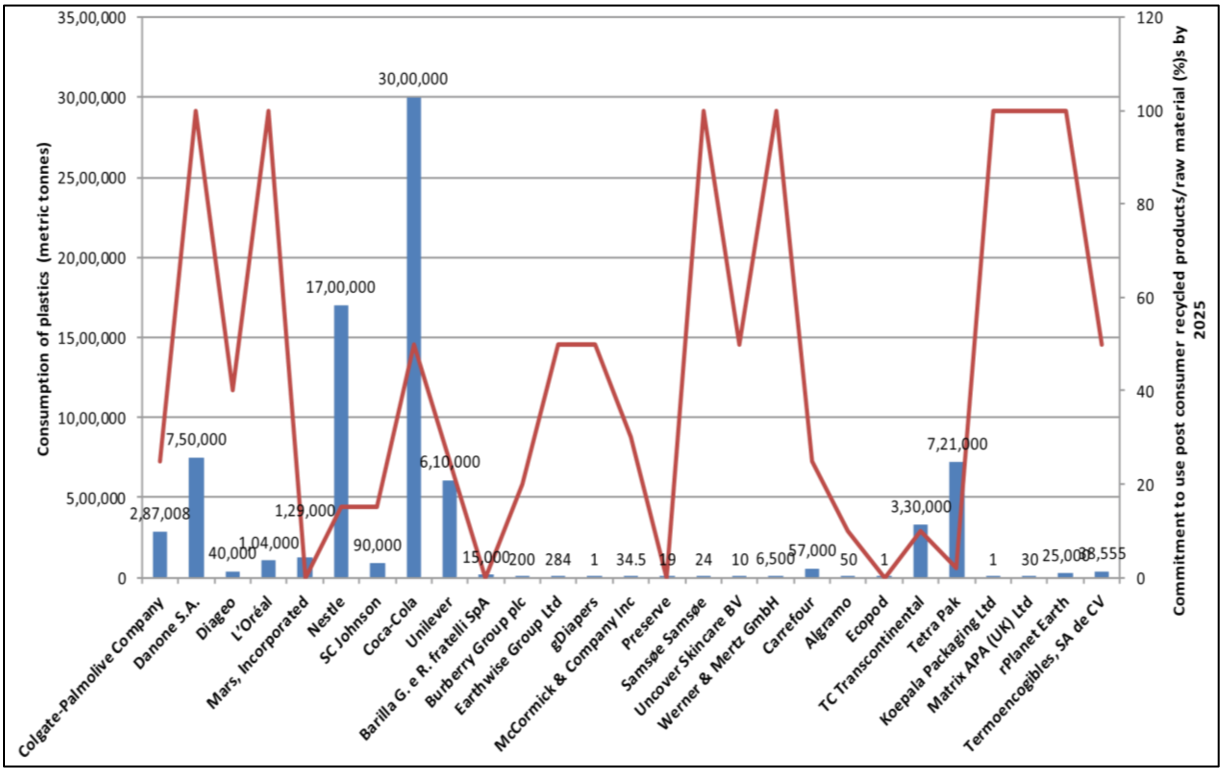

Figure 7. Ingestion of plastic products by some companies and the obligation to the circularity of plastic products (Data Source New Plastics Economy Global Commitment Report—2019)

8.1. Wastes of Plastics in Maintenance and Construction of Roads

To accept the circular economy, a novel trend toward utilizing recycled plastic products in making pavements and roads has been validated and carried out across several states. Generally, the gathered wastes of plastic are first separated into thermosetting plastics and thermoplastic. Thermoplastics are favored mostly because for the idea, the unstiffening point of the thermoplastics is generally in the level of acceptance with the temperatures of processing of the tar and bitumen (155–165 degrees C). Moreover, waste of plastics is melted and then mixed with bitumen in the ratio prescribed (from 5-20 percent) based on the tar or asphalt quality. Usually, blending occurs when the temperature reaches 45.6 degrees C (Chavan, 2013). The mixture is then heated to a higher temperature of nearly 156 degrees C, for improving better bonding between the plastics and bitumen. This heated mixture is utilized for setting roads. Other advantages of the roads of plastic comprise the following (Patel et al., 2014; Trimbakwala, 2017):

a) Nearly, the expense of setting roads decreases up to Rs. 44 thousand per kilometer.

b) The road strength is nearly doubled concerning the traditional roads.

c) As seepage during the rainwater sluggishness is decreased, the issues of recurrent potholes existence are likely to decrease.

d) The issue of draining that happens in the hot weather is decreased.

e) The utilization of roads made with plastics doesn't require any specialized or additional machinery and technologies. Therefore, no substantial change in the expense of operation.

f) Decreases the utilization of initial materials like bituminous, asphalt, or tar causing the lessening of procurement price.

8.2. The circularity of Liners and Bottles made of Plastic

Procter & Gamble cooperates with Purecycle™ to reutilize PET bottles. The recycling plant has been made in Ohio, United States of America to possess the commercial capacity to reprocess 104 million pounds of PP and PET bottles with operations recommencing in the year 2020. They utilize the patented technology of depolymerization, which consumes less energy to produce the recycled raw materials economically feasible (Clean Technica, 2019). Procter & Gamble has also worked in partnership with some other recycling specialists like SUEZ and TerraCycle to utilize the beach/ocean reused plastics in making bottles of shampoo. These companies have dedicated themselves to utilizing up to 26 percent of beach plastics in the production of bottles of shampoo (P&G, 2017).

CCEP (Coca-Cola European Partners) accompanied by Viridor, Avery Dennison, and the PET United Kingdom have cooperated with the mission to reprocess the liners of PET bottles instead of incinerating them. In the year 2016, they recycled around 72 tonnes of PET bottle liners. The sheets of thermo-foam are also made from these wastes of plastic which will be utilized in the manufacturing of trays (SB, 2017).

8.3. The circularity of Plastic Products Utilized in Absorbent Hygiene Products

Single usage disposable porous sanitation products like nappies, sanitary napkins, and diapers are often produced utilizing porous pads covered with the plastics like polyethylene and polypropylene. Polyester fleeces are utilized in the production of diapers or cloth. It is assessed that nearly 302 thousand tonnes of utilized diapers accumulate in the Netherlands and around 902 thousand tonnes in Italy. Nearly 5.5 percent of landfills in the United States of America comprise absorbent hygiene products (Chemistry of Advanced Materials Circularity, 2019). Most frequently, the wastes are treated and incinerated for the recovery of energy. However, currently, many new concepts have generally been developed to reprocess and reutilized the plastics obtained from these wastes. Procter & Gamble in Russia has begun an effort to utilize reprocessed plastics from products in the applications of cement. Moreover, the company has collaborated with Fater Spa and Angelini Group to mature options of circularity. The plastics obtained from the wastes are planned to be reprocessed into several applications like bottle caps, automotive, and plastic park benches (McIntyre, 2017).

Conclusion

Concerning the growing pressure on the management of plastics wastes, there is a dire necessity for the execution of plastic products CE. To help all of the shareholders to move towards the implementation of CE, various non-government and governmental organizations have approved novel legislation and framework. However, it should be observed that not all of the major companies, industrialists, and some of the smaller countries have committed to authorization of the entire circularity of plastic products. These might be primarily due to the challenges like

a) Absence of more proof of the demerits and merits of the reprocessed plastics,

b) Absence of more particular waste gathering and handling infrastructure, less advancement in setting the requirements of eco-design,

c) Absence of modern technologies, and the high price of reprocessed plastics as compared to original plastics.

Despite these challenges, some studies have exhibited that the circularity of plastics is feasible.

Though, the execution hasn't touched its maturity. It can be observed from the market study that the entities are concentrating on handling the mentioned challenges. Focusing and highlighting the priorities below can make the substantial advancement from linear to the circular economy of the plastic products easier:

a) Accessing methods to offer better collection/transportation/categorization of plastics

b) Increasing the rules of eco-design

c) Assisting and enhancing the demand for the circular products

d) Offering resources for the research advancements

e) Utilization of novel raw materials and offering more tax advantages.

It can be observed from the case studies that inspiring and emerging more efficient models of business for cooperation among the companies, the commodity manufacturers, and experts will assist the development to be faster and better. Furthermore, the idea of circularity of plastic products shouldn't be loaded on the government and established companies' shoulders but must be cultivated as a social duty from the initial levels.

Conflict of Interest

The authors report no conflict of interest.

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