NJESR/ March-2023/Volume-5/Issue-3 E-ISSN-2582-5836

DOI-10.53571/NJESR.2023.5.3.10-24

Importance Of Plastics Recycling In Conservation Of The Environment In India-A Review

Ghanshyam Datt Sharma
Assistant Professor
Department Of Chemistry
Government PG College
Thanagazi
Alwar
Rajasthan

(Received:10Feburary2023/Revised:25Feburary2023/Accepted:5March2023/Published:11March2023)

Abstract

One of the most rapidly expanding waste streams in municipal solid waste worldwide is plastic waste (PW). In the value chain for plastic, India has emerged as a global player. Domestic production and imports impose a significant burden on the waste management system as a whole, despite the fact that consumption is low. This situation necessitates an in-depth comprehension of the circumstances and possible solutions to the crisis. Despite the fact that Indian researchers have extensively investigated technology-related issues in academic papers, there is a significant knowledge gap regarding the problem's depth and potential solutions. This review article focuses on India's current use, production, and waste of plastic. This review article mainly looks at data and information about how to manage PW in India and focuses on important topics like reverse supply chain, effective PW management, source-specific recovery, and Indian PW rules. In-depth, this review will assist in locating strategies that can be put into action by policymakers as well as research opportunities for upcoming researchers in holistic PW management and recycling in India, with a focus on the circular economy and sustainable development objectives.

Keywords: Circular Plastic Economy, Resource Efficiency, Extended Producer Responsibility, Literature Review, India

Introduction

Since the invention of various methods for the production of polymers from petrochemical sources, the plastics industry has grown significantly. In comparison to many other types of materials, plastics offer significant advantages in terms of their low weight, durability, and lower cost (Andrady & Neal, 2009; Thompson and co 2009a). In 2007, it was estimated that all polymers—thermoplastics, thermoset plastics, adhesives, and coatings, but not synthetic fibers—were produced worldwide at a rate of 260 million metric tons per year (PlasticsEurope 2008b). This indicates a yearly growth rate of approximately 9% in the past. Two-thirds of this production is made up of thermoplastic resins, and their use is growing at 5% per year. worldwide (Andrady, 2003).

Today, almost all plastics are made from petrochemicals made from fossil fuels like oil and gas. From petrochemical feedstock, approximately 4% of annual petroleum production is directly converted into plastics (British Plastics Federation, 2008). The production of plastics is responsible for the consumption of an equivalent additional quantity of fossil fuels due to the fact that its production also requires energy. However, it is also possible to argue that the use of lightweight plastics, such as in transportation applications where plastics replace heavier conventional materials like steel, can reduce fossil fuel consumption (Andrady & Neal, 2009; Thompson and co 2009b).

Between 20 and 25% of plastics are used for long-term infrastructure like pipes, cable coatings, and structural materials. The remaining plastics are used for durable consumer applications with intermediate lifespans like electronic goods, furniture, vehicles, and so on. Single-use disposable applications include packaging, agricultural films, and disposable consumer items. In 2007, the European Union (EU) produced 24.6 million tonnes of post-consumer plastic waste (PlasticsEurope 2008b). According to Waste Watch 2003, Table 1 provides a breakdown of the consumption of plastics in the UK in 2000 as well as their contributions to waste production. This demonstrates that the primary source of waste plastics is packaging; however, it is evident that other sources, such as waste electronic and electrical equipment (WEEE) and used cars (ELV), are gaining prominence.

Table 1: Consumption Of Plastics And Waste Generation By Sector In The UK In 2000 (Waste Watch 2003).

	Usage		Waste Arising	
	ktonne	(%)	ktonne	(%)
Packaging	1640	37	1640	58
Commercial And Industrial	*490*			
Household	*1150*			
Building And Construction	1050	24	284	10
Structural	*800*		*49*	
Non-Structural	*250*		*235*	
Electrical And Electronics	355	8	200	7
Furniture And Housewares	335	8	200a	7
Automotive And Transport	335	8	150	5
Agriculture And Horticulture	310	7	93	3

Other	425	10	255a	9
Total	4450		2820	

Since plastics have just been efficiently manufactured for something like 60 years, their life span in the climate isn't known with sureness. According to Andrady (1994), the majority of plastics are extremely long-lasting and are not biodegradable. As a result, the majority of polymers made today will last for decades, if not millennia, at the very least. As rates of degradation depend on physical factors like levels of ultraviolet light exposure, oxygen, and temperature (Swift & Wiles, 2004), biodegradable plastics require the presence of suitable microorganisms, whereas degradable plastics may persist for a considerable amount of time depending on local environmental factors. As a result, landfills, terrestrial environments, and marine environments all have distinct degradation rates (Kyrikou & Briassoulis, 2007). Even when a piece of plastic is weathered, it first breaks down into smaller pieces of plastic debris, but the polymer itself may not completely degrade in a significant amount of time. End-of-life plastics are accumulating in large quantities in landfills and as natural debris, posing problems for waste management and harming the environment (see Barnes et al.). 2009; 2009 Gregory; Oehlmann and others 2009; Ryan and co. 2009; Teuten and co. 2009; Thompson and co 2009b).

While in a natural ecosystem there are only products, recycling is clearly a waste management strategy (Frosch & Gallopoulos, 1989;). However, it can also be seen as a current example of putting the idea of industrial ecology into practice. Braungart and McDonough, 2002). One strategy for reducing environmental impact and resource depletion is plastic recycling. Fundamentally, high recycling rates, in conjunction with reuse, reduction in use, and repair or re-manufacturing, can enable a particular level of product service with lower material inputs than would otherwise be required. As a result, recycling has the potential to improve eco-efficiency and reduce energy and material consumption per unit of output (WBCSD 2000). However, it should be noted that the system's ultimate sustainability will be determined by its capacity to maintain any residual level of material input, energy inputs, and the effects of external impacts on ecosystems.

We will briefly discuss related economic and public interest issues, as well as life-cycle evidence for the eco-efficiency of plastics recycling and the current systems and technology for plastics recycling, in this paper. Since packaging is Europe's largest single source of waste plastics and has seen significant recent expansion in recycling initiatives, we will concentrate on packaging production and disposal.

The Importance Of Plastic Recycling

Plastic materials can take centuries to decompose once discarded. They overburden facilities that process waste and clog landfills. Recycling helps the environment and creates new economic opportunities by recycling bottles, packaging, and other plastic waste into new products. Recycling plastics encourages businesses to create novel, cutting-edge products out of materials that are still useful and keeps them out of landfills.

Recycling And Plastics

Some plastics can only be recycled once or twice, but others are difficult to recycle due to technical and financial constraints. Styrofoam, for instance, is rarely accepted by recyclers because the lightweight foam structure makes it difficult to handle. However, polystyrene products like compact disc cases and forks are recyclable. Vinyl packaging, polypropylene medicine bottles, disposable drink cups made of low-density polyethylene, and high-density polyethylene milk bottles are among the other common recyclable plastic products. Regular instances of products made with reused plastics incorporate cleanser bottles, traffic cones, floor tiles and oil channels.

Burden On The Environment

Products made of plastic are useful because they last for a long time, but when they are thrown away, this makes them less useful. Plastic materials are less affected by the natural processes that degrade many products made of paper, cardboard, and wood in a few months. Plastics build up in landfills, resulting in a volume of trash that never seems to go away. Plastic fragments become unsightly annoyances and hazard to animals in nature. Plastics are kept out of landfills and the natural environment by being diverted from the waste stream and turned into new products.

Innovative Uses

Designers, technicians, and manufacturers must use innovative thinking in order to incorporate recycled plastics into products. Construction decking made of recycled plastic that never rots is one innovation; styles of sportswear; and the interior of a car. Recycled plastics have been used by artists to create projects that make people think. Even though they only use a small amount of plastic when compared to commercial uses, they help people become more aware of the environment and encourage creative thinking.

Fuel Drain

Recycling plastics helps cut down on the use of fossil fuels. The Energy Information Administration reports that in 2010, 191 million barrels of crude oil, or about 2.7% of all consumption in the United States, were used to make plastics. In addition, the production of materials and resins by plastics manufacturers required 412 billion cubic feet of natural gas; 13 billion cubic feet of this were converted into plastic, and 399 billion cubic feet were used as fuel during the manufacturing process. Recycling plastic not only saves energy needed to make new materials, but it also saves oil. A ton of recycled plastic saves 7,200 kilowatt-hours, or enough energy to power a household for seven months, according to Stanford University.

The Advantages Of Plastic Bottles

Since the last part of the 1970s, plastic containers have been broadly taken on as bundling materials for refreshments, cleanser and other shopper products. Plastic bottles now have a number of advantages, including toughness, energy savings, and ease of production, thanks to compounds like polyethylene terephthalate. Bottles made of plastic are recyclable, safe, and cost less to produce.

Rugged And Safe

Plastic bottles, in contrast to glass containers, are durable and enduring. They are safe to handle for products and packaging because they do not shatter into sharp pieces when dropped. Plastics have useful physical properties like toughness and resistance to chemicals because they are polymers—long molecules made by linking many short ones together. Because of their similar resilience, plastic bottles are not likely to burst or leak, safeguarding both the contents and the exterior of shipping cartons.

Energy Savings

Because plastic bottles weigh less than glass bottles, shipping products requires less energy and costs less money. Plastic bottles require less energy to manufacture than glass bottles due to their softness and relatively low melting points.

A Recyclable Material

PET and other kinds of plastic bottles can be easily recycled into a wide variety of secondary products after they have been used once, such as carpet fibers, pillow stuffing, tote bags, and strapping materials. Recycled plastic is also used in some non-food containers and beverage bottles. The low cost of transporting materials to recycling centers is reduced by the light weight of plastic bottles.

The Disadvantages Of Recycled Plastics

Due to its inability to break down through biodegradation, plastic is frequently regarded as a threat to the environment. However, plastic is increasingly being used in the manufacturing and packaging of consumer goods. Recycling can help reduce the continuous use of plastic in production, but it has some drawbacks.

Limited Use

Plastic that has been recycled typically has a lower initial strength after going through recycling processes. As a result, many products made from recycled plastic cannot be recycled again. Additionally, certain plastic containers cannot be recycled due to their potential for toxicity. Due to the possibility of bacteria, recycled plastic cannot be used to make food packaging or containers. Because of the dangers they pose, plastic containers used to store harmful substances like pesticides cannot be recycled.

Diminished Value

The value of recycled plastic is lower than that of virgin or original plastic. The industrial economy's demand for recycled plastics is impacted by this factor. A manufacturer's desire to use recycled materials is mitigated by the potential decrease in customer perception of value if it intends to produce a plastic-based product or component. Research into ways to enhance the quality of recycled plastic is ongoing. However, for some products, industrial companies still frequently prefer virgin plastic.

Plastic Production And PW

Due to their remarkable properties (durability, light weight, and good thermal and electrical insulation) and numerous application opportunities at low prices, plastics have become a global commodity[1]. The production of personal protective equipment (PPE) out of plastics is a remarkable application during the global COVID-19 outbreak[2]. Production of resin and fiber was estimated to be 2 million Mt in 1950, rising to 380 Mt in 2015[3] and 367 Mt in 2020 due to the impact of COVID-19 on the sector[4]. In 2018, Polypropylene (PP), one of the most important plastic polymers used in consumer goods, produced 23% of all plastic[5]. According to a report from the United Nations Environment Programme (UNEP), over 400 Mt of plastic waste are produced annually worldwide[6]. As depicted in Figure 1, PW management has a direct connection to a number of Sustainable Development Goals (SDGs). Between 1950 and 2015, it was estimated that 6.3 billion tonnes of PW were produced. Only 9% of this waste was recycled, and 80% of it ended up in landfills or in natural ecosystems[7]. The most recent data from the Organization for Economic Co-operation and Development (OECD) show that the amount of plastic waste produced worldwide doubled between 2000 and 2019, reaching 353 Mt[8]. According to the most recent study, which was carried out in 2021 by Benson et al., plastic waste production skyrocketed as a result of the COVID-19 pandemic[9]. The estimated amount of plastic waste produced worldwide reached 584 Mt. Lebreton and Andrady[1] anticipated that by 2060, in a the same old thing situation, botched plastic waste (MPW) age will be 155-265 Mt each year. PW the board is an arising issue which requires the advancement of fitting arrangement and the executives apparatuses[11], and the status is basic for both created and emerging nations[2]. Figure depicts the lifespan distribution of plastic products in various application fields and global plastic production in Mt.

PW has a complicated structure that includes a variety of valuable composite materials, harmful emissions, and residual ash[4]. As a result, managing waste is difficult because, frequently, plastic's recyclability is limited by the presence of other types of waste[5]. Collection and segregation operations are carried out by multi-tier actors (the informal sector) in many developing nations, including India. This makes it more difficult to identify the flow of waste and its traceability in the various waste streams[6] and also because of the widespread applications as an integral part of product manufacturing and processing[7]. A common coding system has been developed by the American Society of Plastics Industry to define and distinguish the most important kinds of plastic. There are approximately fifty distinct types of plastic, each with hundreds of variations. Seven groups consist of these plastic products: polyethylene terephthalate (PET), high-density polyethylene (HDPE), low-density polyethylene (LDPE), vinyl/polyvinyl chloride (PVC), polypropylene (PP), polystyrene (PS), and a number of additional kinds of products made of plastic[1]. Table 1 details the chemical structure, resin identification code, general virgin material applications, toxic element presence in polymers, advantages, challenges, and recycled use of various polymers.

In the customary straight economy, item utilization winds up creating an enormous measure of waste. Utilizing economic resources while minimizing pollution and negative effects on the environment necessitates careful consideration[19]. A circular economy, on the other hand, is defined by the Ellen MacArthur Foundation[2] as "a systemic approach to economic development designed to benefit businesses, society, and the environment." A circular economy, in contrast to the linear model of "take, make, throw away," is designed to be regenerative and aims to gradually separate growth from resource consumption. Over 1,000 organizations around the world are working together through the "New Plastics Economy" initiative to create a circular economy[1]. Figure 2 depicts the central activities of the systematic approach as well as the vision for the new circular plastic economy.

Products made of plastic and polymer materials are used in the linear economy according to the traditional "take–make–waste" model for a single use. This requires special care and proper collection and disposal because 10 million tonnes of PW leak into the natural ecosystem each year[2]. 14%, 40%, and 32% of PW are disposed of through incineration and/or energy recovery, landfilling, and leaking into the surrounding ecosystem[3].

Research Motivation And Scope Of The Article

Various aspects of PW have been the subject of research, and in recent years, the number of studies has increased exponentially, particularly in the recycling field. Utilizing the watchword "plastic waste" in the Snare of Science (WoS) center assortment data set, it was observed that sums of 15,243 articles were distributed from 1981 to Walk 2021 (counting reports, for example, unique examination articles, survey articles, and others). Between the year 1990 and March 2021, approximately 1220 articles were published in India. The distribution of the articles over this time is depicted in Figure 3. Review articles are crucial because they help policymakers understand the potential for growth in their respective research areas and develop effective management strategies. According to the findings of a study that was carried out by Liang, Tan, Song, and Li[1], post-consumer plastic packaging products and microplastics that are found in the marine environment are the two primary emerging issues that pertain to PW. Recycling technologies and plastic pollution, on the other hand, are the emerging research hotspots that pertain to the subject. The review articles on PW that were published in India and cover a wide range of topics that are relevant to this article are listed in Table S1 of the Supplementary Materials.

Figure 1. SDGs Related To PW management

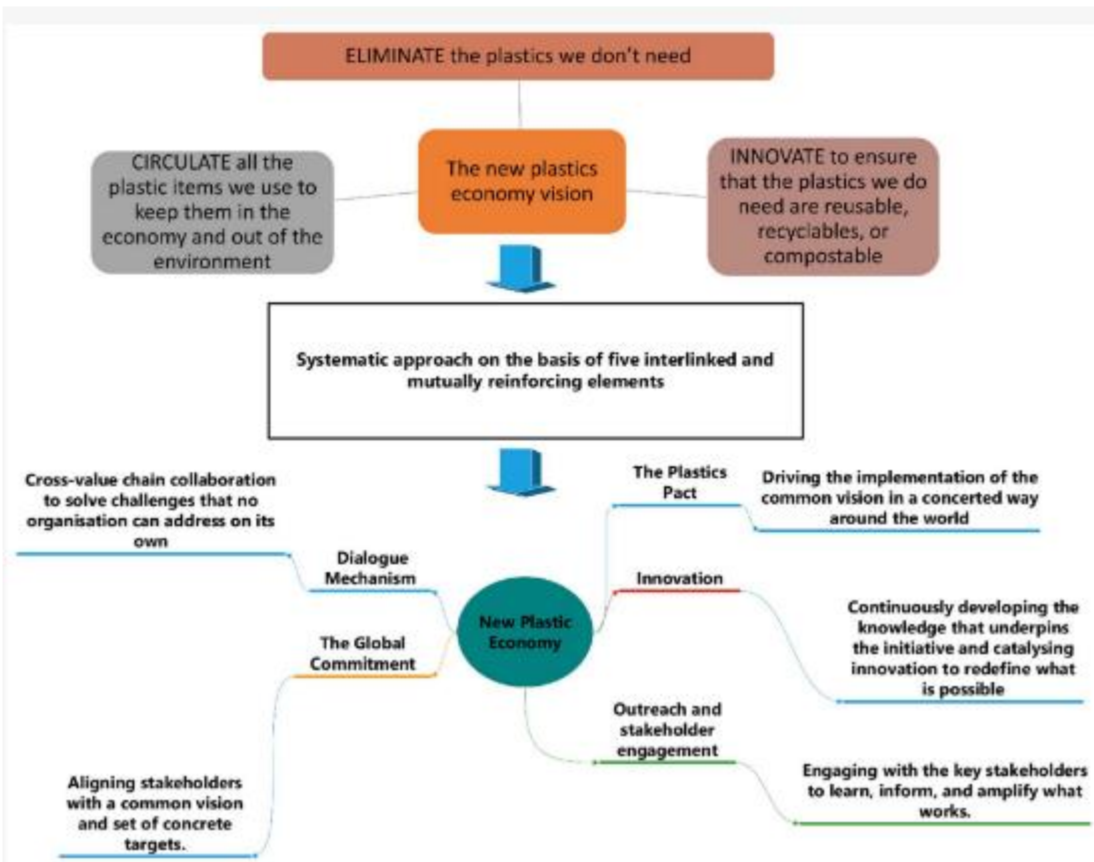

Figure 2. Objects And Key Elements Of The Circular Plastic Economy (Information Adapted From Ellen MacArthur Foundation [2].

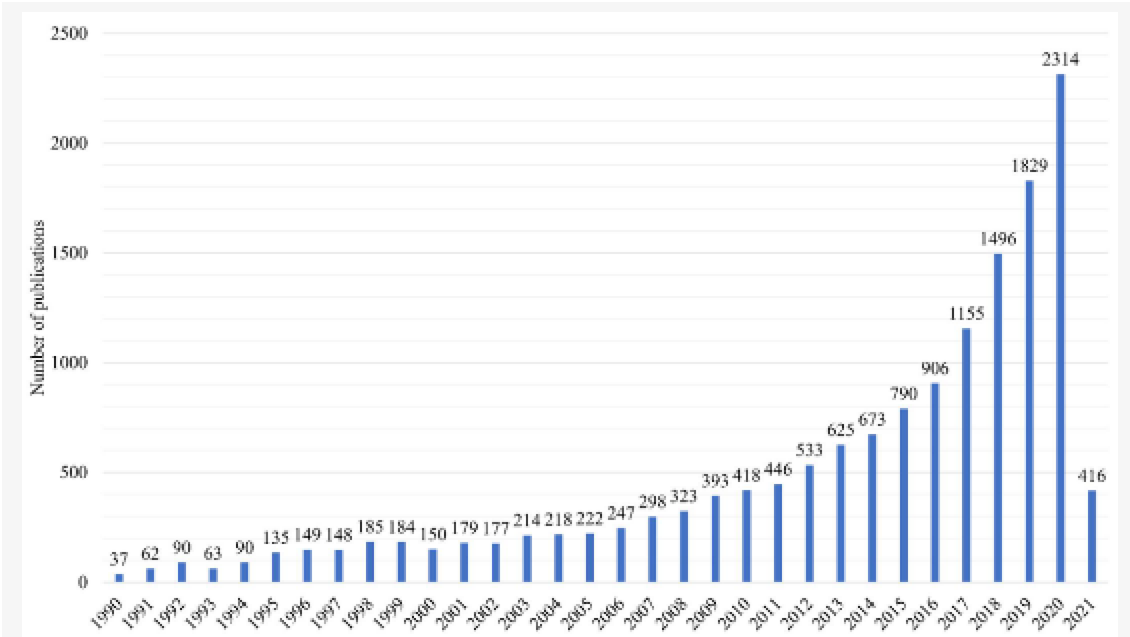

Figure 3. Yearly Distribution Of Publications On PW (1990–2021, Up To March).

Research Contribution Of The Article

An overview of the production and consumption of plastic, the primary consumption sectors, an evaluation of PW management and generation, rules and regulations, marine and microplastic pollution, and extended producer responsibility (EPR) are detailed and discussed in the context of India in this review. From a desk research perspective, this is one of the earliest reviews to examine potential improvement areas. Frequently, information are dispersed and not promptly accessible, making group of people yet to come assessment troublesome utilizing strategies like unique material stream examination. Restructuring reverse supply chains, source-specific recovery, and the repercussions of EPR and PW are the primary topics of this article. Squander the board and microplastic-contamination moderating measures are examined in view of proof from India. An overview of this review article can be found in Section 5.

A thorough survey is expected to comprehend the maximum capacity of PW created in India and its ensuing application in different areas (as reused materials) to accomplish a round plastic economy, which is right now missing in scholarly papers. With the growth of the plastic industry, the consumption of plastic products, and the disposal patterns of PW, there are significant knowledge gaps in academic papers on how PW could be an essential waste stream in achieving a circular economy from the Indian context.

Plastic Production Industry And Consumption In India

There are 28 states and 8 union territories in India, which is a federal union. India is one of the G20 economies that is growing at the fastest rate, at 7.5 percent annually. It also has some of the world's fastest urbanization and strong incentives for infrastructure development[4]. With a GDP of $8.7 trillion, it ranks third in terms of purchasing power parity (PPP)[5]. Among the BRICS nations (Brazil, Russia, India, China, and South Africa), India has the highest GDP and growth rate. The business area addresses the biggest part of Gross domestic product development[5]. All the more explicitly, quick monetary, geographic, and segment development are the principal drivers of emotional development in the petrochemical area in India[6]. There are upstream and downstream sectors in the Indian plastic industry's value chain. The upstream polymer fabricating area embraced cutting edge advances from worldwide pioneers, which brought about creating cutthroat measured assembling plants and worldwide seriousness. However, 75% of registered plastic processing units are in the downstream plastic processing industry. In India, the industrial sector consumes 25% of the total amount of plastic. The downstream sector uses about 30% of recycled plastics[7]. Figure depicts the structure of the Indian plastic value chain.

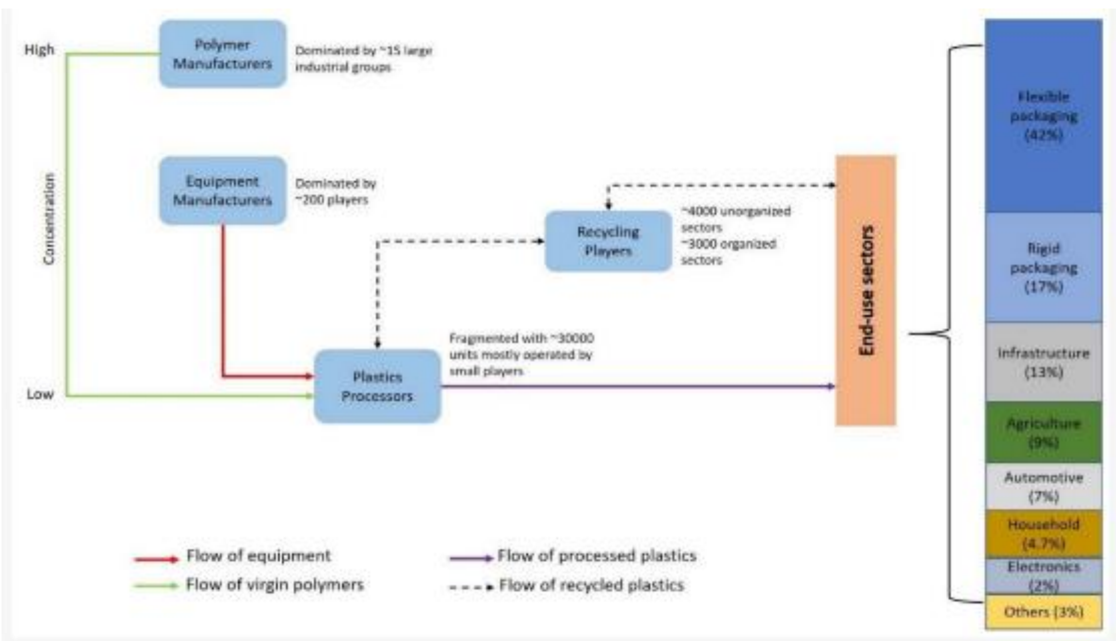

Figure 5. Structure Of The Indian Plastic Industry

The Plastindia Foundation's data[8] show that, excluding engineering plastics and thermoplastics, demand for PP (32%), PE (33%), and PVC (21%) was highest between 2016 and 2018. Figure 6 depicts India's plastic manufacturing capacity by major polymer type. These are the primary sources of polymer waste that accumulate in the built environment at the end of life.

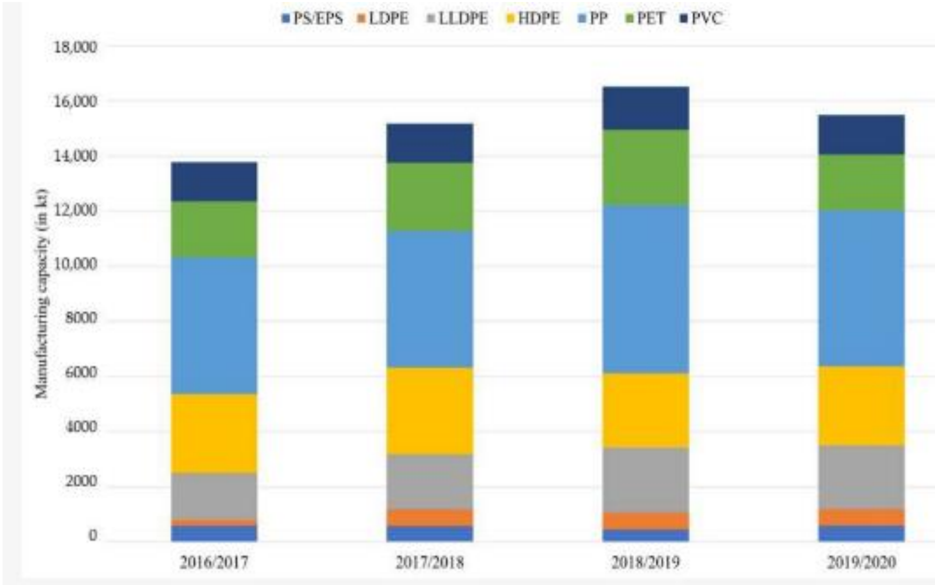

Figure 6. Manufacturing Capacity Of Various Plastic Polymers In India

Figure 6 demonstrates that the primary polymer sources entering the plastic material supply chain are PP, HDPE, LLDPE, and PET. These polymers will eventually end up in the waste stream at significant levels, with some leakages in material flows.

The United States of America is the country that consumes the most plastic, with 109 kg per capita, according to data from 2014–2015 on plastic consumption per capita in developed and developing nations, including India. India consumed 11 kg per person per year, while the global average was 28 kg[8]. India is the second largest producer of plastic polymers in the world—14.17 million tonnes (Mt)—despite its low plastic consumption[1]. As per Makwana[6], it is assessed that each 1 kg/year expansion in per capita utilization will require an extra 1.25 Mt of polymers in India. Due to the COVID-19 pandemic, approximately 2,500,000 sets of plastic-based personal protective equipment (PPE) have been required daily in the healthcare sector in India[8]. During the COVID-19 pandemic, reprocessing capabilities were further restricted by a lack of infrastructure for effective decontamination and reprocessing, as well as consumer behavior and awareness issues[9].

The majority of plastic production in India is related to HDPE, LDPE, and PP [9]. Both plastic production and consumption are expanding at a very rapid rate. In 2013, 47% of India's plastics were consumed in the western region, while 23% and 21% were consumed in the northern and southern regions, respectively[2]. In recent years, there has been a significant rise in the consumption of various other kinds of plastics as a result of the expanding industrial base for manufacturing and production. In 2018-2019, utilization was 913 kilotonnes (kt), which expanded to 964 kt in 2019-2020, with a year on year development pace of 5.5%[8].

Conclusions And Outlook

In India, PW management and recycling are the most pressing issues, and implementing EPR is the most pressing requirement. Product design that is focused on recycling ought to be the top priority for these stakeholders due to the fact that EPR requires manufacturers and importers to interact directly with the supply chain. In addition, the system as a whole is frequently overwhelmed by plastic flows from abroad, necessitating careful monitoring to determine the quantity and quality of waste entering the country. States and local councils along coastlines must actively work to reduce the amount of plastic waste that enters land and marine ecosystems and has an effect on the environment.

The legitimate parts of waste ought to give a more exact and brief viewpoint with respect to the PW store network's job and obligations. Integrating informal recyclers into formal collection and recycling channels and implementing a novel recycling technology for multiplayer plastic polymers deserve special consideration. Along with regulatory, economic, awareness, and voluntary interventions, the baseline assessment of poorly managed single-use plastic is essential.

In addition, governments focusing on PW, particularly HDPE, LDPE, and PP, should prioritize capacity development, infrastructure development (material recovery facilities at the micro-level in the country, proper collection, segregation, and transportation of discarded plastic material), and financial support (incentives and innovative economic model) for chemical and biological recycling. When drafting the PW rules, rural areas require special attention to capacity building. Another aspect that requires additional investigation is scaling up and commercializing bio-based plastic. This is because the market share of such products will significantly rise in the coming years, necessitating close collaboration between researchers and new businesses in the industry. Upstream material management is essential for resource management and the circular economy rather than seeking comprehensive solutions at the downstream end. This makes consumer awareness and the mindset toward the acceptability of recycled products equally important.

References

[1]. Liang, Yangyang, Quanyin Tan, Qingbin Song, and Jinhui Li. "An analysis of the plastic waste trade and management in Asia." Waste Management 119 (2021): 242-253.

[2]. Hossain, Rumana, Md Tasbirul Islam, Riya Shanker, Debishree Khan, Katherine Elizabeth Sarah Locock, Anirban Ghose, Heinz Schandl, Rita Dhodapkar, and Veena Sahajwalla. "Plastic waste management in India: Challenges, opportunities, and roadmap for circular economy." Sustainability 14, no. 8 (2022): 4425.

[3]. Geyer, Roland, Jenna R. Jambeck, and Kara Lavender Law. "Production, use, and fate of all plastics ever made." Science advances 3, no. 7 (2017): e1700782.

[4]. Fishery, F. A. O., and Aquaculture Statistics. "Global Aquaculture Production 1950–2020 (FishStatJ)." FAO Fisheries and Aquaculture Department: Rome, Italy (2022).

[5]. Tiseo, I. "Distribution of Plastic Production Worldwide in 2018, by Type." (2021).

[6]. Oberoi, Garima, and Ankush Garg. "Single-Use Plastics: A Roadmap for Sustainability?." Supremo Amicus 24 (2021): 585.

[7]. United Nations Environment Programme. "Single-use plastics: A roadmap for sustainability." Addressing Single-Use Plastic Products Pollution Using a Life Cycle Approach (2018).

[8]. Benson, Nsikak U., David E. Bassey, and Thavamani Palanisami. "COVID pollution: impact of COVID-19 pandemic on global plastic waste footprint." Heliyon 7, no. 2 (2021): e06343.

[9]. Westerbos, M. "How the Sustainable Development Goals Can Help Fight 'Plastic Soup'." (2021).

[10]. Wang, Weisha, Tingting Mo, and Yichuan Wang. "Better self and better us: Exploring the individual and collective motivations for China's Generation Z consumers to reduce plastic pollution." Resources, Conservation and Recycling 179 (2022): 106111.

[11]. Jacobsen, Lina Fogt, Susanne Pedersen, and John Thøgersen. "Drivers of and barriers to consumers' plastic packaging waste avoidance and recycling–A systematic literature review." Waste Management 141 (2022): 63-78.

[12]. Galati, Antonino, Leonardo Salvatore Alaimo, Teresa Ciaccio, Demetris Vrontis, and Mariantonietta Fiore. "Plastic or not plastic? That's the problem: Analysing the Italian students purchasing behavior of mineral water bottles made with eco-friendly packaging." Resources, Conservation and Recycling 179 (2022): 106060.

[13]. Roy, Deborah, Emma Berry, and Martin Dempster. "“If it is not made easy for me, I will just not bother”. A qualitative exploration of the barriers and facilitators to recycling plastics." Plos one 17, no. 5 (2022): e0267284.

[14]. Barrowclough, Diana, and Carolyn Deere Birkbeck. "Transforming the global plastics economy: the role of economic policies in the global governance of plastic pollution." Social Sciences 11, no. 1 (2022): 26.
[15]. Vedantam, Aditya, Nallan C. Suresh, Khadija Ajmal, and Michael Shelly. "Impact of China's National Sword Policy on the US Landfill and Plastics Recycling Industry." Sustainability 14, no. 4 (2022): 2456.