INNOVATIVE POLYMERIC WASTE MANAGEMENT SYSTEMS TO ENHANCE CIRCULAR ECONOMY

by

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ABSTRACT

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The increasing difficulties presented by polymeric waste have emphasized the immediate requirement for inventive solutions that may tackle environmental issues while promoting economic viability. This research study explores polymeric waste management systems, specifically examining their ability to enhance the principles of the circular economy. The study wants to gain a full grasp of the latest breakthroughs in polymeric waste disposal technology by performing a rigorous literature analysis and examining case studies. The study evaluates the effectiveness of different methods, including mechanical reuse, chemical recycling, and developing waste-to-energy technologies, in both decreasing environmental harm and boosting resource effectiveness and economic resilience. The research aims to understand the complex factors influencing the acceptance and spread of new polymeric waste management technologies. It takes an interdisciplinary approach, combining environmental science, economics, engineering, and policy studies. The paper provides a clear analysis of the main difficulties and possibilities, offering practical advice to policymakers, business participants, and researchers to speed the goal of speeding up the shift toward an environmentally friendly and sustainable economy. To conduct a comprehensive statistical analysis, the study utilized established commercial statistical programs such as Excel and SPSS.

Various statistical methodologies were considered for this study. However, the selected approaches included regression, analysis of variance (ANOVA), and mean, independent samples t-test, as well as standard deviation. The choice of methodology depended on the specific objectives and hypotheses of the research.

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INTRODUCTION

1.1 Overview

Waste is defined as any substance that must be disposed of since it is inevitable due to industrial or household operations and has no market value (Sridhar and Hammed, 2014; Safavi et. al., 2010). Understanding trash in terms of its "natural disposition, related environmental effect, sanitary disposal practices", and various other aspects is crucial as a significant element (Prasad et. al., 2012; Rani et. al., 2019). Waste comes in diverse forms, such as gaseous, liquid, and solid states, and is produced by various human production processes (Kayode, 2006). Plastic garbage is another category of solid waste (Awasthi et al., 2017). Plastics take a very long time to break down in comparison to other types of waste (Hopewell et al., 2009). Because plastics are usually cheap, individuals often misuse them and cause harm to them. Nonetheless, certain parts of the world—mostly developed nations have accepted the idea of charging for the usage of plastics; plastic bags are now paid for while shopping in malls. Because of their widespread use, plastics are a particularly unique class of materials that attract a lot of interest in the global economy.

Waste materials that are mostly constituted of polymers, which are big molecules consisting of repeating subunits, are referred to as polymeric waste. These polymers might be natural, like starch or cellulose, or synthetic, such as plastics made from petrochemicals like polyethylene, polypropylene, or polystyrene. Due to its persistence in the environment and lack of choices for recycling or disposal, polymeric waste poses environmental issues and makes up a sizable portion of the global municipal solid waste and industrial waste streams. More and more synthetic polymers are produced in large quantities for a range of uses. The proper disposal of old materials is turning into a major issue. Microorganisms are unable to absorb the majority of synthetic macromolecules, in contrast to natural polymers. Even though polymers make up just slightly more than 10% of all municipal garbage, the issue of their nonbiodegradability is brought to attention by ugly litter, overflowing landfills, and contaminated marine waterways. The complementing processes of recycling, burning, and biodegradation are needed for the complete treatment of polymer wastes. The most ideal long-term future option is biodegradation, but before it can be implemented, it needs to undergo extensive study and development. Nonetheless, incineration and recycling can start up quickly enough to help the situation both now and in the foreseeable future (Huang, 1995).

Polymeric waste management systems that are innovative in nature can significantly transform how the circular economy is implemented. In light of the increasing worldwide apprehension surrounding plastic pollution and the exhaustion of finite resources, sustainable approaches to efficiently managing polymeric refuse are imperative. These cutting-edge systems comprise an extensive array of technologies, such as biodegradable polymers, circular design principles, and advanced recycling techniques. By incorporating these technologies into waste management procedures, individuals can optimize the value of polymeric materials over the course of their entire lifecycle while simultaneously reducing their environmental footprint (Park et. al., 2007).

Considerable potential exists for the advancement of the circular economy through the exploration of innovative polymeric waste management systems. Plastics and other polymeric materials are ubiquitous in contemporary society, providing versatility and convenience in a variety of sectors. Marine pollution and land degradation are, nevertheless, severe environmental issues that result from their unlawful disposal. The implementation of novel waste management systems has emerged as a critical necessity to confront these urgent concerns (Ren et. al., 2015). To mitigate the environmental impact and optimize the utilization of resources, these systems incorporate a variety of approaches that are designed to decrease, reuse, and recycle polymeric waste. Sulfur-free raw materials for the production of new goods can be obtained through the utilization of sophisticated recycling techniques, including chemical depolymerization and mechanical recycling. Additionally, by incorporating biodegradable polymers into the design of products, plastics are encouraged to biodegrade, thereby decreasing their environmental persistence (Saldana Duran & Najera Gonzalez, 2019).

1.2 Polymeric Waste

Polymeric waste is defined as discarded substances that are predominantly comprised of polymers, which are large molecules consisting of subunits that repeat. Synthetic or natural polymers may comprise these substances; for instance, petrochemical-derived plastics and biopolymers discovered in organic matter are examples. Polymeric waste comprises a significant proportion of municipal solid waste streams on a global scale. It includes packaging materials, consumer products, and industrial residues, among others.

A growing amount of industrial and municipal trash is composed of polymeric waste materials, such as plastics and rubbers, which are either mishandled or end up in landfills. Because polymeric waste degrades slowly and is persistent in the environment, it presents serious environmental issues. Plastics are particularly infamous for being strong and resistant to breaking down, which causes extensive contamination of the land, rivers, and ocean. The incorrect handling and elimination of polymeric waste led to several environmental problems, such as the devastation of habitats, the entanglement of species, and the discharge of toxic substances into natural environments (da Silva and Wiebeck, 2020).

A variety of tactics are being used to solve the polymeric waste dilemma with the goals of lowering trash output, encouraging recycling and reuse, and creating substitute materials and disposal techniques. Recycling is a crucial strategy for handling polymeric waste because it minimizes the requirement for virgin resources and permits the recovery of important components. While chemical recycling techniques break down polymers into their constituent molecules for reuse or conversion into other materials, mechanical recycling operations sift, shred, and melt plastics to create new goods. Furthermore, programs like composting and waste-to-energy technology can assist in keeping polymeric waste out of landfills and incinerators while producing useful organic materials or energy. Additionally, developments in compostable and biodegradable plastics present viable substitutes that, under certain circumstances, can aid in the breakdown of polymeric waste into innocuous substances, hence reducing the environmental effect of polymeric trash.

Nonetheless, sector-wide coordination is needed for efficient management of polymeric waste, including community involvement, business innovation, government regulation, and consumer education. To create an environment that supports sustainable waste management practices, policies that support extended producer responsibility, waste reduction, and the development of recycling infrastructure are crucial. The appropriate use and disposal of polymeric materials may also be promoted through public awareness campaigns and initiatives, which can influence social attitudes and behaviors toward more sustainable patterns of consumption. Polymeric waste poses complicated problems that are needed for all-encompassing and cooperative solutions. People may reduce the environmental effect of polymeric waste and transition to a more sustainable and circular economy by implementing a mix of trash reduction, recycling, innovation, and legislative actions (Nahil and Williams, 2011).

1.2.1 Sources of Polymer Waste

Plastic waste comprises either discarded plastic resin or plastic products that require further processing or disposal. Milgrom proposes an intricate framework for the categorization of plastic waste. The aforementioned system takes into account various factors such as the production segment from which the waste was generated, convenience of recycling, product category, and physical category:

- Industrial plastics waste comprises plastics byproducts produced by diverse industrial sectors.
- Postconsumer plastics waste consists of consumer-generated plastics.
- Waste plastics that cannot be recycled in the current techno-economic environment are known as nuisance plastics (NP).
- Waste plastics that can be processed again to create plastic items that are suitable for sale are known as scrap plastics (SP).

1.3 Polymeric Waste Management Systems

Waste materials that are predominantly constituted of polymers, such as plastics, may be managed and their environmental impact can be reduced with the use of complete frameworks and techniques known as polymeric waste management systems. These systems use a variety of cutting-edge techniques to minimize environmental contamination, encourage resource efficiency, and reduce waste output. Some of these techniques include recycling technology, circular design principles, and regulatory interventions. Cutting-edge recycling techniques like pyrolysis and chemical depolymerization provide creative ways to turn plastic trash into useful raw materials for new goods (Wróblewska-Krepsztul and Rydzkowski, 2019).

The goal of polymeric waste management is to maximize the recovery and reuse of valuable materials while reducing the discharge of hazardous compounds into the environment. This requires several processes, from collection and sorting to processing and disposal. Polymeric Waste Management Systems are essential in the transition to a circular economy model, where materials are continually recycled and reused, supporting resource conservation and environmental sustainability, by implementing integrated and sustainable solutions.

Furthermore, the incorporation of circular design concepts and biodegradable polymers fosters the creation of ecologically acceptable substitutes for traditional plastics and the uptake of closed-loop systems. The implementation of Extended Producer Responsibility (EPR) programs encourages manufacturers to assume accountability for the management of their goods' end-of-life, hence promoting sustainability and innovation throughout supply chains

(Gubanova et al., 2019). Additionally, educational initiatives and public awareness campaigns are essential for encouraging responsible consumption and behavioral changes.

1.3.1 Innovative Polymeric Waste Management Systems

A progressive strategy for tackling the intricate problems related to polymeric waste, especially plastic trash, is to implement innovative polymeric waste management systems. These systems cover a broad range of tactics and innovations meant to minimize the negative effects of polymeric materials on the environment while optimizing their use of resources. These are a few essential elements of cutting-edge polymeric waste management systems:

a) Advanced Recycling Technologies

Innovative recycling methods, including chemical depolymerization, pyrolysis, and solvent-based procedures, allow plastic waste to be broken down into molecular components. This enables for the development of high-quality recycled materials that may be utilized to manufacture new goods, decreasing the dependency on virgin resources and lowering waste.

b) Biodegradable Polymers

Biodegradable polymers provide an alternative to traditional plastics since they are made to break down naturally in the environment through biological processes. These materials offer a more environmentally friendly substitute for single-use goods and packaging by assisting in the reduction of plastic waste buildup in landfills and oceans.

c) Circular Design Principles

Adopting circular design concepts means reevaluating how things are made, utilized, and planned in order to reduce waste and increase resource efficiency. This covers techniques that allow materials to be constantly recycled and reused inside closed-loop systems, such as designing for disassembly, material recovery, and product lifespan.

d) Extended Producer Responsibility (EPR)

EPR regulations transfer from customers and municipalities to product creators and manufacturers the burden of handling post-consumer waste. Environmental Product Responsibility (EPR) promotes the use of more sustainable materials, designs, and recycling techniques by making manufacturers responsible for the end-of-life management of their goods.

e) Closed-Loop Supply Chains

Closed-loop supply chains include recycling and reuse procedures into the manufacturing and delivery of commodities in an effort to reduce waste and optimize resource recovery. To guarantee the effective collection, sorting, and processing of polymeric waste, producers, retailers, and waste management firms must form partnerships.

f) Public Awareness and Education

Promoting sustainable consumption habits and bringing about behavioral change requires raising public awareness and educating people about the negative environmental effects of polymeric waste. Individuals may be empowered to make educated decisions and take part in waste reduction activities through outreach campaigns, educational initiatives, and community involvement programs.

g) Collaboration and Innovation

Governments, businesses, academic institutions, and non-governmental groups must work together to foster innovation and expand the use of sustainable solutions for polymeric waste management. Through the promotion of collaborations and the exchange of information and materials, interested parties may quicken the creation and execution of creative waste management schemes.

1.4 Innovative Technologies Combating Plastic Waste

The development of long-term strategies to reduce resource depletion and environmental contamination is greatly aided by innovative technology. These cutting-edge solutions to the problem of plastic waste are (Schmaltz et. al., 2020):

a) Little Yellow Dog

Chinese waste sorting and recycling business Little Yellow Dog was founded in 2017. With 12,000 smart recycling equipment, it works out of 45 cities in China. With 6.5 million registered users, it supports a circular economy model of manufacturing and upholds the idea of “no waste in the world.” Consumers may drop off their home garbage at any of the strategically located “smart recycling machines” in the area. From there, the garbage is sorted into appropriate containers by the machines using AI computing powered by the cloud. After that, using current market prices, it can determine the worth of the commodities submitted and pay customers via an app. When machines are operating at capacity, full-time employees pick up garbage.

b) Topolytics

The fact that supply networks are sometimes quite convoluted and opaque is one of the main problems facing waste management. Because of this, the UK data analytics company Topolytics has developed a digital “waste map” that shows the global flow of plastic garbage. Big data and data analytics are used to generate this map. Users may do this to track the path of their plastics and learn more about if their partners are keeping their promises. This product may be used by producers, corporations, governments, and recyclers.

c) Diwama

Inadequate sorting is a major barrier to the recycling of plastic. The contamination of plastic by biological waste materials is one of the main causes of the low worldwide recycling rate of plastic. Diwama offers hardware and software solutions for waste-sorting facilities because of this. Their technique automates garbage analysis through the use of AI-based picture recognition software. This operates by attaching cameras to the front and rear of conveyor belts, using its software to effectively identify the kinds of garbage that are moving by so that personnel may sort it later. This makes sorting quicker and more efficient, increasing the profitability of garbage sorting facilities. Among the several startups utilizing AI for sorting is Diwama. Its application in Lebanon attests to its usefulness for emerging nations.

d) Clearbot Neo

It is commonly recognized that a significant quantity of plastic waste ends up in rivers, posing a threat to aquatic life and lowering water quality. Researchers in Singapore and Hong Kong have created an AI-driven robot to assist with this problem. The device, known as Clearbot Neo, glides across the water's surface and classifies and recognizes trash using machine vision before gathering it. The self-sufficient robot can gather up to 200 kg of waste and 15 liters of oil per day, all thanks to a solar-powered battery. Clearbots may now be purchased for up to 900 USD, although the company hopes to lower this price in the future.

e) The Plastic Flamingo

A social company with its headquarters in the Philippines is called The Plastic Flamingo (PLAF). While riding from France to Cambodia on their honeymoon, Francois and Charlotte, the husband-and-wife team, formed it. The destruction of nature by cheap plastic manufacture and mass consumerism was observed by them directly, and they took action as a result. PLAF is able to transform waste plastic into a variety of items, such as furniture, plastic lumber, complete shelters, and recycled pellets, by using an innovative production technology. Their goal for this year is to gather 2000 tons of plastic garbage for their goods by the end of the year.

f) Wasser 3.0

Contamination by microplastics is a serious worldwide issue. Even worse, very few people are aware that plastic is directly ingested by humans through their food, drink, and breath. The German business Wasser 3.0 is looking at creative, economical, and eco-friendly methods to remove plastic from our drinking water to address a portion of this expanding problem. This is accomplished by adding silica solutions, which promote the development of plastic clumps in water that may be extracted and used for other purposes. Wasser 3.0 is transportable, targeted at industrial and municipal water treatment operations, and compatible with already-existing treatment facilities.

g) Carbios

Businesses that are advocating for circular economies; nevertheless, the plastic recycling sector faces a threat from true circularity. The reason is plastics decay during recycling, necessitating landfill disposal of even reclaimed plastics. Carbios, a French firm, is trying to change that. Its recycling technique used enzymes before anybody else in the world. Enzymes like these may break down PET plastic back into its elements. As a result, it can produce goods with no new materials and is a unique example of “closed loop” recycling.

h) Plastic Bank

Informal employees are essential to the collecting and sorting of rubbish in many developing economies. These employees are leading the charge in addressing the worldwide plastic catastrophe. Despite this, many workers lead unstable lives and do not have access to many necessities, like a place to live and a quality education for their kids. An organization called Plastic Bank works to address this problem. It gathers plastic with the declared goal of preventing garbage from entering waterways, which allows it to sell the plastic to progressive firms for a higher price than social plastic. Higher salaries for collectors and supply chain traceability are made possible by this pricing. Waste collectors might thus anticipate a higher standard of living for themselves and their dependents. encouraging social justice in the circular economy.

i) Rebound Plastic Exchange

The global recycled plastics market is fragmented, dense, and multifaceted, which makes it challenging to obtain dependable, high-quality materials on an international scale. Rebound Plastic Exchange is a UAE-based platform that facilitates the secure and reliable exchange of plastic between consumers and merchants. Rebound Plastic Exchange infuses the supply chain with internationally regarded quality assurance, certification, and standards. Additionally, the platform facilitates connections between manufacturers, recyclers, and waste collectors in nations that lack access to efficient recycling infrastructure, thereby contributing to the improvement of global environmental outcomes and employment. The trading of Rebound commenced in 2022.

j) UBQ (Ubiquitous)

The ease with which valuable plastic materials can get contaminated by biological waste and wind up in a landfill is one of the main problems facing the plastic recycling business. Fortunately, Israeli company UBQ has intervened to address this problem. It is one of the only businesses that can collect unsorted domestic garbage and turn it into pellets using its proprietary, highly guarded UBQ technology. After that, these pellets might be applied to a variety of commercial uses. UBQ asserts that it is the missing piece between the circular economy with waste management. Recently, they have formed partnerships with well-known businesses including “Mercedes, McDonald's, and Pepsi Co”.

1.5 Management Strategies for Plastic Wastes

Plastic waste is generated and disposed of at an accelerated rate as a result of global population expansion and industrial development. Anthropogenic and biodegradable elements (industrial growth, social development, climate, operating sectors) combine to create significant amounts of garbage that are both biodegradable and non-biodegradable. To help the public dispose of used plastic waste appropriately, government towns, social communities, and local authorities have put in place a variety of environmental safety laws, rules, and procedures. A number of these waste management strategies, including landfills, recycling, incineration, and bioremediation, are supported by scientific principles. Establishing these procedures ensures a sanitary environment and effective plastic refuse disposal (David and Joel, 2018).

a) Recycling

Recycling is a method of waste management that involves collecting used materials and repurposing them into new products. Another name for this practice is “renewing or reusing.” The goal is to keep it from having a detrimental impact on society and the environment. Unlike other polymers and goods based on carbon, plastics cannot be broken down by nature. It comprises components like bottles that, when melted, may be used to make other items, such as chairs and tables made of plastic. The six processes of this process are as follows: “gathering waste plastics, classifying or sorting plastics, cleaning to get rid of contaminants, shredding and resizing, classifying and separating plastics, and compounding” (Szostak et. al., 2020).

b) Incineration

Full chemical combustion, which involves burning trash in oxygen, results in the release of water and carbon dioxide into the atmosphere. The process of burning trash is called waste incineration. The byproducts of combustion include ash, several volatile chemicals, and a minute amount of hydrochloric acid. Some plastic trash is too flammable or too resistant to heat with oxygen to be burned. All forms of home garbage don't need to be effectively treated by incineration. To prevent these unplanned explosive incidents, we must exercise caution while choosing which plastics to burn in our incinerator. Fuel, or energy, may also be produced by burning organic molecules. The fuels that power cars and planes can exist in several different solid, liquid, and gaseous forms. This method of incineration has several social advantages rather than only energy production. Plus, it helps a lot with two important things in our modern industrialized world: garbage reduction and waste-to-electricity generation (De Weerdt et. al., 2020).

c) Landfills

The disposal of plastics in landfills after they have been utilized in various trash cans. After use, all disposable plastic waste is disposed of in landfills, which are all locations and regions where it is deposited after being utilized. To prevent secondary side effects such as soil degradation and groundwater contamination, which may result from improper processing, numerous precautions must be taken during this manual disposal procedure. The fundamental objectives of landfill design are to provide a more secure location for the disposal of plastic waste, with the secondary purpose of protecting all parts of the ecosystem, including airspace and aquatic habitats. Extensive community effort is required, such as excavating a deep trench or disposing of refuse at great depths in a landfill while allowing it to decompose. More than a year may be required to conclude this procedure at a glacial pace. Every organic molecule undergoes biodegradation and decomposition throughout the processing sequence at this landfill. Ten to one hundred years may be required for the decomposition of plastic bags and other lengthy polymer residues in landfills (Thiounn and Smith, 2020).

d) Pyrolysis

Pyrolysis is the conversion of gases and fatty oils into hydrocarbons and crude petrochemicals. Recovering crude petrochemicals and creating renewable energy from plastic waste are two further uses for it. The three main categories of pyrolysis are based on the amount of heat energy needed to degrade polymeric connections. Three distinct temperature-dependent media options are available: high, medium, and low. What is considered medium and high temperature depends on the temperature range needed to destroy the plastic structure. The products of plastic pyrolysis depend on several factors, including the kind of reactor used, the amount of time the materials are heated, the content of the polymers, the configuration of the condensation process, the feeding arrangement, and the temperature that is applied (Qureshi et. al., 2020).

e) Bioremediation

It refers to the refuse decomposition process facilitated by microorganisms. Bioremediation may also be characterized as a subfield of biotechnology whose fundamental tenets are decontamination and detoxification through the utilization of microorganisms to biodegrade naturally occurring substances that are amenable to treatment via the biodegradation processes of bacteria, plants, algae, and fungi. Optimal conditions for culture medium, including nutrients, enzymes, pressure, and temperature, must be established to support microbial growth. When any of the aforementioned factors are absent or growth inhibitors are present, the bioremediation process will not function optimally. The biodegradation and segregation of plastic polymers can occur through the interaction with heteroatomic molecules. This is the first step in the biodegradation of trash; extracellular enzymes are also used to break down polymers made of plastic. The bioremediation process relies on enzymes, which act as chemical catalysts by lowering the activation energy and converting the substrate into the product (Asgher et. al., 2020).

1.6 Global Production of Plastics

Over the past several decades, population growth, urbanization, industrialization, and the pervasive use of plastics in a variety of industries have all contributed to a consistent increase in foreign plastic production. Plastics are highly adaptable materials that find extensive use in a variety of sectors, including construction, electronics, packaging, and automotive. Consequently, the continuous rise in demand for plastics has caused a substantial expansion of production capacity on a global scale. Concerns have been expressed, however, regarding the environmental impact of the rapid expansion of plastic production, specifically about resource depletion, greenhouse gas emissions, and plastic contamination. Mismanagement and disposal of plastic waste have resulted in extensive environmental deterioration, encompassing marine pollution, harm to ecosystems, and risks to human well-being (Wang et. al., 2021).

End-user plastic disposal and the pace of population growth worldwide are correlated proportionally. The United Nations World Population Sensor Report, which was released at the mid-year point in 2019 and showed 7.7 billion people worldwide, supported this. The United Nations projected that there will be 8.5 billion people on Earth in 2030 and 9.7 billion in 2050, respectively. taking into account the projected proportionate rise in the world's plastics output. Global plastic production peaked in 2011 at 280 million metric tons; it then significantly increased to “322 million metric tons” in 2015 and, without accounting for the COVID-19 impact, reached a final projection of “400 million to 414 million metric tons” in 2021 (Sahin and Kirim, 2018). The phenomenal rise in global population is the reason for this surge in demand for plastic. The unusual properties of plastics, such as their extremely high strength-to-weight ratio, strong resistance to physical and chemical deterioration, non-permeability to liquids, and ease of forming into a variety of forms, may also contribute to the material's rapid increase in manufacturing. Because plastics are so inexpensive to produce, they are a significant alternative to more conventional materials like glass, paper, fibers, wood, metals, and concrete. Applications for plastics include consumer items, packaging, construction, electrical, industrial machinery, and transportation. By weight, the most common usage of plastics in other industries is still their use as packaging materials.

Promoting sustainable practices along the whole plastic value chain, such as cutting back on plastic usage, enhancing waste management and recycling facilities, and moving toward circular economy models, has received more attention in response to these difficulties. Governments, corporations, civil society groups, and international initiatives are spearheading efforts to mitigate the adverse effects of plastic manufacturing and use on the environment and human welfare. These efforts are aimed at promoting sustainability and addressing plastic pollution. The usage of plastic has skyrocketed in many households throughout the world, leading some countries, like China, to prohibit the material to curb the quantity of plastic in circulation. This is because polymers have long been proven to be good pollutants in both urban areas and the oceans (Shen et. al., 2020).

1.7 Circular Economy

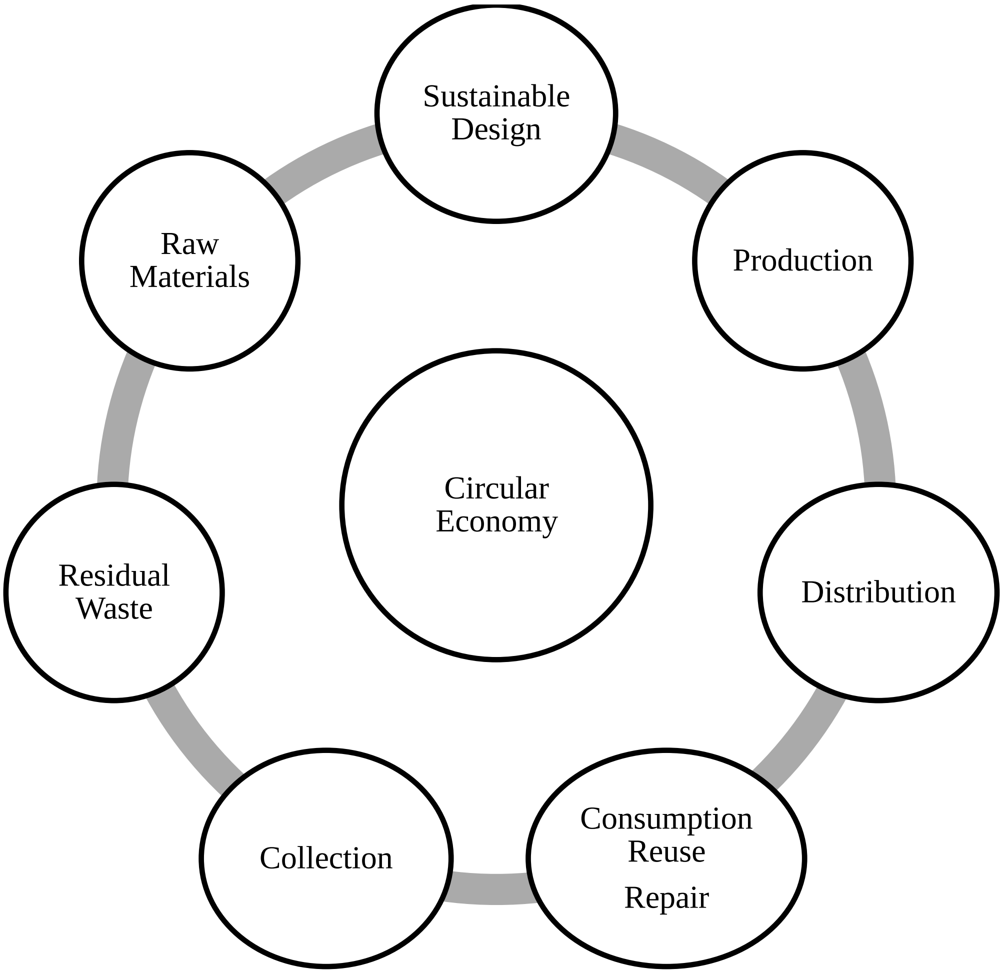
"Circular economy" refers to a model of production and consumption that prioritizes extending the life of existing resources and products by sharing, renting, mending, refurbishing, and recycling. In this approach, the goods' life cycles are extended. A regenerative economic system, the circular economy seeks to maximize the value and utility of resources while minimizing waste, pollution, and environmental damage. The circular economy, as opposed to the conventional linear economy, which uses a "take-make-dispose" paradigm, aims to prolong the life of resources by employing techniques including recycling, remanufacturing, reuse, and repair. It fosters the use of renewable energy sources, stresses the development of goods and processes to maximize resource efficiency, and supports the sharing and leasing of commodities to prolong their lives. It suggests cutting waste as much as possible. When possible, recycling makes sure that resources from items that are getting close to the end of their useful lives are kept in the economy. These could be used effectively again and time again, adding value (Corvellec et al., 2022). This deviates from the traditional linear economic paradigm's take-make-consume-throw-away sequence. This idea depends on a large amount of cheap, easily accessible materials and energy.

The goal of the circular economy and its practices is to ensure that plastics are never wasted (Qu et. al., 2019). Even while the circular economy keeps plastics out of landfills and into useful economic activities, research shows that they are still a big contributor to environmental and societal problems (Geyer et. al., 2017). Still, this is called the grease of globalization. The circular economy (CE), which has had a disastrous impact on the whole planet, may serve as a diversion from the underlying causes of pollution and plastic usage. Although yet in its infancy, the adoption of circular economy model solutions offers highly promising advantages in "low- and middle-income countries" (LMICs). The foundation of this solution-based approach is the heritage of trash separation at the source, enhanced resource consciousness, the emergence of innovative recycling practices, and small-scale plastic recycling programs (Pagliaro, 2020). A "circular economy" can:

- Redirect dry waste from landfills to enhance air quality, minimize microplastics in the food chain, and create a cleaner environment with "20% to 50%" less "carbon emissions" (d'Ambrières, 2019).

- Recognizing their contributions, expanding their access to public benefits and services, and helping them start their businesses in the informal sector are all ways to bring this sector into the formal economy.
- Encourage a paradigm change from “use and throw” to “respect and care for the environment” so that the next generation may build a sustainable economy without destroying natural resources.
- Establish new primary and secondary markets with eco-friendly alternatives to plastics utilized for manufacturing and construction.
- Urge India to fulfill its obligations under the Global Plastics Treaty and advance the SDGs more quickly (2024).
- To facilitate revolutionary change on a worldwide scale, provide an example for the developing economies of Latin America, Africa, and Asia.

Figure 1.1: Circular Economy



Source: https://www.europarl.europa.eu/topics/en/article/20151201STO05603/circular-economy-definition-importance-and-benefits

1.7.1 Benefits of Circular Economy

A circular economy has several advantages that touch on “social, economic, and environmental issues” (Kumar et. al., 2019). Here are a few main advantages:

a) To protect the environment

Recycling and reusing products would slow down the use of natural resources, reduce environmental and ecological damage, and slow down the loss of biodiversity. Reducing annual emissions of greenhouse gases is yet another benefit of the circular economy. Greenhouse gas emissions in the European Union are accounted for by industrial operations and product consumption, with waste management accounting for 3.32%, according to the European Environment Agency. A more sustainable and efficient product line may help reduce energy and resource consumption from the get-go, as the design phase accounts for more than

80% of a product's predicted environmental impact. We need to start using more durable, upgradeable, and reusable products if we want to cut down on trash. More and more people are complaining about packaging, and each year the typical European generates about 180 kilograms of packaging waste. Eliminating unnecessary packaging and improving its design are key to promoting reuse and recycling.

b) Reduced Waste and Pollution

The circular economy helps minimize pollution and lessens the pressure on landfills and incinerators by maximizing the amount of time that resources are put to use and decreasing the amount of garbage that is processed.

c) Resource Efficiency

The goals of the circular economy are to maximize resource use through the promotion of practices like recycling, reuse, and remanufacturing. As a result, less waste is produced, and fewer raw resources are consumed.

d) Reduce raw material dependence

Raw material consumption is growing in tandem with the world's population. However, fundamental necessities have a finite supply. Furthermore, due to restricted availability, certain EU members will have to import their basic materials from other nations. Eurostat reports that import account for almost 50% of the raw materials consumed by the European Union. Exports have grown at a quicker rate than imports, contributing to an almost quadrupling of the value of raw material commerce between the EU and the rest of the world since 2002. Regardless, trade deficits persist within the European Union. The result was a trade deficit of €35.5 billion in the year 2021. Reducing supply-side issues including price volatility, availability, and dependence on imports is achieved via recycling raw materials. In the case of electric engines and batteries, two technologies crucial to achieving climate objectives, this is especially true for the raw materials needed to make them.

e) Create jobs and save consumers money

A transition to a circular economy may generate employment opportunities, foster innovation, and stimulate economic expansion. Innovation in various economic sectors could be stimulated by redesigning products and materials to be circular in nature. Long-lasting cost savings and elevated quality of life will result from the provision of consumers with innovative and more resilient products.

1.8 Polymer Circular Economy

The term “polymer circular economy” is a sustainable strategy used by the plastics sector to maximize the value of polymer resources while reducing their negative effects on the environment. In a closed-loop system, the polymers the building blocks of plastics—are used, reused, and recycled, which lowers the need for virgin feedstock and the production of plastic waste. Important tactics include building long-lasting and recyclable products, putting in place effective systems for gathering and sorting waste, and making investments in cutting-edge recycling technologies like chemical and mechanical recycling. To further lessen dependency on fossil fuels and minimize pollution, the polymer circular economy also encourages the development of bio-based and biodegradable polymers (Sobkowicz, 2021).

The Polymer Circular Economy seeks to solve these issues in the framework of the circular economy by putting policies into place that maximize the lifespan of polymer materials. This entails abandoning the take-make-dispose model in favor of circular principles, which include designing products with durability and recyclability in mind, encouraging the reuse and refurbishment of products made of polymers, and creating effective recycling procedures to recover and repurpose polymers into new products.

1.8.1 Components of the Polymer Circular Economy

Key components of the polymer circular economy include:

a) Design for Circular

With a focus on material recovery, extended lifespan, and simple deconstruction, packaging and product development involving polymer-based materials are prioritized. This calls for the incorporation of recycled content into new products, the selection of recyclable materials, and the reduction of additives and complex multi-material designs.

b) Recycling Infrastructure

To efficiently collect, classify, and treat polymer waste, substantial recycling infrastructure investment is necessary. This entails developing improved technologies for sorting and processing various polymer streams, enhancing collecting systems, and growing recycling facilities.

c) Advanced Recycling Technologies

Creating and expanding cutting-edge recycling processes, such depolymerization and chemical recycling, to turn waste polymers into premium feedstock for new goods. By closing the loop on polymer waste streams, these technologies provide the possibility to recycle polymers that are now challenging to recycle using mechanical procedures.

d) Market Demand and Consumer Education

Encouraging the market for products made of recycled polymers by means of regulations, rewards, and public awareness initiatives. Creating a sustainable Polymer Circular Economy also requires encouraging behavior changes including appropriate recycling and responsible consumption, as well as educating customers about the environmental advantages of selecting recycled goods.

e) Collaboration and Stakeholder Engagement

Promoting cooperation between producers, retailers, waste management firms, regulators, and consumers as well as other stakeholders in the polymer value chain. Overcoming obstacles to circularity, exchanging best practices, and enacting systemic changes that lead to a more sustainable use of polymer resources all need collaborative efforts.

1.9 Importance of Effective Waste Management in Achieving Circular Economy Goals

Effective waste management is crucial to the realization of circular economy objectives because it enables the shift from a sequential “take-make-dispose” paradigm to one that is more regenerative and environmentally sustainable. Circular economy practices aim to maximize the life of resources while minimizing waste by implementing techniques like remanufacturing, recycling, and reuse. To close the cycle of material flows, recover valuable resources from waste streams, and lessen the environmental impact of resource extraction and production, proper waste management is essential. Through the adoption of all-encompassing waste management strategies including source separation, collection, sifting, recycling, and disposal economies can maximize the utilization of resources, preserve energy, and minimize pollution (Di Foggia and Beccarello, 2021). In addition to offering job possibilities in the recycling and circular economy sectors, efficient waste management also supports innovation in waste processing technology and opens up new markets for recovered materials. Effective waste management also fosters environmental resilience and sustainability by lowering the environmental cost of disposing of garbage and decreasing dependency on scarce resources. Ensuring the health of communities and ecosystems for future generations, promoting sustainable growth, and achieving the full potential of the circular economy all depend on the integration of efficient waste management solutions.

Implementing a circular waste management system has several positive environmental effects. There is less of a demand for fresh materials when resources are repurposed. When thinking about non-renewable resources, this is very crucial. Because these resources are limited, circularity encourages us to use them more sparingly. In addition, circularity reduces waste. Zero waste is, in reality, the ultimate aim of circularity. Utilizing every resource to the utmost degree possible helps achieve this. The maximum amount of materials may be recycled or reused, and those that cannot be recycled are turned into energy sources. Landfills and other places where garbage is left to fester are no longer necessary in a completely circular economy. Rather, it is utilized to its fullest potential. Reducing emissions is another benefit of circularity. In a circular economy, more resources are retained inside the economy, reducing the requirement for transportation and the need for imports of raw materials. Nations can balance their waste production when garbage is managed cyclically. By doing this, trash is transformed from a problem that is endangering our planet to a useful resource that helps nations and communities live sustainably while conserving resources, generating new employment, and fostering economic growth (D'Adamo et. al., 2022).

New industries and employment might be generated by a circular waste management system. In Australia alone, the commercial value of the prospects presented by this kind of technology is projected to be as high as $4.5 trillion. This kind of system necessitates sorting, recycling facilities, and creative material utilization—all of which present numerous opportunities for employees and company owners. Keeping materials inside national economies is another benefit of more resource efficiency for nations and communities. For areas with little resources of their own, this is particularly crucial. By using a circular economy, they may reduce their dependency on other nations and organizations for those resources by recycling and reusing their materials. Circularity provides advantages of its own from a commercial standpoint. Today's customers demand that the companies they patronize employ sustainable methods. They could be more inclined to choose your business over the competition if it has a circular waste management system and is moving toward a zero-waste system (Popović and Radivojević, 2022).

1.10 Digitization in the Circular Economy

The role of digitization in facilitating the shift towards a circular economy is growing in significance. Organizations can maximize resource utilization, increase supply chain transparency, and facilitate the reuse, recycling, and repurposing of materials through the implementation of data-driven solutions and digital technologies. Smart manufacturing and product design practices constitute a critical element of digitization within the circular economy. Data collection on product performance, utilization patterns, and end-of-life scenarios can be accomplished by manufacturers via the implementation of real-time monitoring systems, Internet of Things (IoT) devices, and sensors. This allows them to incorporate durability, reparability, and recyclability into product design, consequently prolonging the products' operational lifespan and mitigating waste. Additionally, by bringing together buyers and sellers of secondhand items, allowing the interchange of excess resources, and fostering the sharing economy, digital platforms and marketplaces are emerging as critical enablers of circularity. These platforms make use of machine learning and algorithms to balance supply and demand, improve logistics, and guarantee effective resource distribution. In addition, blockchain technology is being investigated as a way to improve traceability and transparency across the value chain, allowing stakeholders to monitor the provenance, ownership, and lifespan of materials and products. This guarantees adherence to moral and ethical norms as well as aids in the prevention of fraud and counterfeiting (Agrawal et. al., 2022).

Digital innovations, or DIs, are the creation and incorporation of new technology into existing systems to solve issues and improve productivity, accessibility, dependability, and sustainability. The Internet of Things (IoT), smart mobile devices, big data, blockchain, cloud storage, artificial intelligence (AI), and three-dimensional (3D) printing are a few examples of digital tools and technologies for innovation. A multitude of African economic sectors have benefited from DIs. For instance, "precision agriculture" which uses sensors, satellites, and artificial intelligence (AI) to assist agronomic solutions has been employed to promote sustainable agriculture and has provided smallholder farmers (SHFs) and their communities with several advantages (Ciriello et. al., 2018). In addition to mobile banking, DIs have proved effective in other industries. It has paved the way for crowdsourcing and peer-to-peer lending, two novel approaches to funding, as well as cheap money transfers. Thanks to these technological advancements, the African payment environment has undergone a sea change, and fresh perspectives on the financial value chain have emerged. Improving the administration of dispersed power networks and allowing for the adjustment of demand in real-time are two ways in which digital technologies, such as GIS platforms and embedded systems, have transformed the energy industry (Annunziata et. al., 2015).

The adoption of “digital tools and technologies” in Africa is accelerated by several factors, including the continent's demographic profile, in which nearly 60 percent of the population is under 25 years old. In addition, internet penetration in Africa is the highest in the world, and substantial investments have been made in digital platforms there, including the “Google AI hub in Ghana and the Facebook hub in Kenya”. Furthermore, numerous technology innovation centers have emerged throughout the continent, providing numerous young individuals with the chance to become deeply involved in cutting-edge technologies that generate innovations that contribute to progress. More and more technology centers are springing up throughout Africa, helping budding digital entrepreneurs with both the technical know-how and physical space they need to use DI in novel ways. Tech hubs provide a variety of tools, including incubators, accelerators, maker spaces, technology parks, co-working spaces, and innovation centers that are run by universities. The tech centers are vital in creating an environment that supports digital innovation (DI) companies and a robust digital ecosystem, where entrepreneurs may connect with like-minded innovators and share ideas. In addition, tech centers provide electricity and rapid internet access, which are both essential (Giuliani and Ajadi, 2019).

Additionally, DIs have proven to be able to support Africa's CPE by stepping in to cover the infrastructural gap caused by inadequate garbage collection and management. Several enhancements have been made to better identify, collect, transport, sort, process, and reuse plastic to turn the plastic value chain into a clever, inventive, and sustainable value network. The use of IoT-based automated communication between homes and garbage collection companies to monitor, collect, and recycle plastic waste as well as support centralized disposal. Such a model may be taken into consideration with other DIs as IoT becomes more commonplace on the African continent (Singh, 2019). As a technical advancement, smart sensors can help Africa's waste management and environmental pollution problems. Remote sensing layers and geographic information systems (GIS) can be used in municipal garbage management. Blockchain and artificial intelligence (AI) have the potential to improve recycling efficiency. They contend that the intelligent and successful sorting of plastic waste, which would otherwise be a convoluted and ineffective process—can be ensured by applying artificial intelligence (AI). Additionally, they propose the use of blockchain technology as a “trust-based platform between plastic waste segregators, recyclers, and recycled feedstock buyers (manufacturers)” to facilitate information exchange and validation amongst the various value chain participants, thereby facilitating partners' access to pertinent data regarding plastic waste and the most effective ways to reduce or recycle it (Chidepatil et. al., 2020).

1.11 Emerging Technologies for The Recycling of Polymeric Waste

Several novel technologies have the potential to enhance the recycling of polymeric waste, tackle issues related to conventional mechanical recycling techniques, and facilitate the efficient exploitation of various polymer streams (Valerio et. al., 2020). Some of these technologies include:

a) Chemical Recycling

Chemical recycling, often referred to as feedstock recycling or advanced recycling, is the process of using different chemical processes, such as pyrolysis, depolymerization, or gasification, to break down polymer waste into its constituent monomers or other useful chemical intermediates. These procedures can treat polluted or mixed polymer streams that are challenging to recycle mechanically, potentially recovering high-quality feedstock for the synthesis of other chemicals or new polymers.

b) Solvent-Based Recycling

To recover pure polymer fractions, solvent-based recycling processes employ solvents to dissolve and separate polymers from complicated combinations. This method is effective for recycling polymers with varying characteristics and compositions, such as composite or multilayered materials, and it provides chances for the selective extraction and purification of certain polymer kinds.

c) Enzymatic Recycling

By using the catalytic activity of enzymes, enzymatic recycling breaks down polymer waste and transforms it into simpler molecules that may be utilized as a feedstock for new compounds or materials. Because enzymes can target particular polymer types selectively, they may be used to recycle complicated polymer blends and produce high-quality recovered products with little energy use and no negative environmental effects.

d) Biodegradable Polymers and Composting

Biodegradable polymers are a sustainable substitute for conventional plastics because they decompose into natural components in the right conditions and may be efficiently composted to create organic fertilizers or soil additives. New innovations in the manufacture of biodegradable polymers and composting systems help to decrease the amount of plastic waste that ends up in landfills and the ocean, encouraging circularity and environmental sustainability.

e) Mechanical Recycling Innovations

The effectiveness and caliber of recovered polymer materials are enhanced by advancements in mechanical recycling technology, such as sophisticated sorting systems, fine grinding methods, and melt filtering procedures. These developments facilitate the integration of recycled materials into a variety of applications while lowering the demand for virgin resources by enabling the recycling of a larger range of polymer types and improving the mechanical qualities of recycled products.

f) Additive Manufacturing with Recycled Polymers

With additive manufacturing, often known as 3D printing, it is possible to create sophisticated, personalized goods with intricate geometries by employing recycled polymers as feedstock. Manufacturers may lower material waste, energy consumption, and environmental impact while encouraging circularity and resource efficiency in product design and manufacturing by integrating recycled polymer filaments or powders into additive manufacturing processes.

1.12 The Challenges Associated with Polymeric Waste Management

Polymeric waste management introduces numerous complexities that threaten to ease the way for a more sustainable and circular economic transition. A notable obstacle lies in the extensive variety and intricacy of polymer materials employed across different sectors, each characterized by unique chemical compositions, properties, and end-of-life factors. Due to this diversity, standardized recycling processes are challenging to implement, necessitating the development of individualized approaches for various polymer types and applications. Moreover, the recycling process is frequently complicated by the extensive utilization of multi-layered or composite materials, which are notoriously challenging to effectively separate and process (Moharir and Kumar, 2019). The challenges pertaining to the management of polymeric waste are as follows:

a) Limited Availability of Quality Material

There are 7 main types of plastic in a typical waste stream, and each kind degrades differently. Due to a lack of such knowledge, companies blend all of the compounds throughout the production process. As a result, the recycling process becomes challenging, resulting in incineration, a significant waste of important resources.

b) Gap in Demand & Supply

Lack of awareness poses difficulties to collecting plastic debris. garbage pickers struggle to gather plastic garbage and frequently neglect specific plastic wastes owing to poor payment value. To overcome this gap, we have created a digital platform called Recykal Marketplace, where you can discover the best rates to purchase or sell your recyclable materials.

c) Lack of waste segregation at source

Sorting garbage by hand is the earliest and most basic way of plastic separation. In underdeveloped nations such as India, each form of plastic must be manually separated before it can be recycled. This results in an inefficient and inconsistent sorting process.

d) Lack of Proper Technology

Recycling has made significant strides in numerous nations. However, numerous nations (particularly developing nations) continue to fall behind in technological advancements. The recycling process is ultimately impacted by the lesser levels of technological sources.

e) Lack of Proper Industrial Expertise

Workers encounter many obstacles as a result of insufficient industrial understanding about the recycling of plastic trash. It has become a complex system due to the introduction of new technologies and the uncertainty of our knowledge. In fact, here is where a big issue with plastic recycling management starts.

1.13 Solutions for Effective Plastic Waste Recycling

Recycling plastic waste effectively necessitates a multipronged strategy that includes business accountability, public awareness campaigns, regulatory initiatives, and technical innovation. Improvements in technology are essential for increasing the effectiveness and scalability of plastic recycling procedures. Technological advancements including chemical recycling methods, biodegradable polymers, and sophisticated sorting systems provide viable answers to the problems posed by plastic waste (Gradus, 2020). The following are some solutions for enhancing the recycling of plastic waste:

a) Provide information to producers on hundreds of polymer alternatives, distinct chemical features, and the many kinds of plastics. Additionally, the quantity of plastic production techniques that have been created to meet the needs of plastic applications.

b) Raising the necessary awareness and giving the garbage pickers a structured job opportunity. Recykal developed the innovative platform RISE for the benefit of the community in the unorganized sector in response to this problem. Team Recykal has all the alternatives covered, from job to long-term financial stability.

c) An operations manager with hands-on expertise in the plastic recycling business can make a significant impact. Employees can improve their abilities by learning how to operate new machinery and how it works.

d) Carrying out a range of varied efforts to inform the unorganized sector about the idea of employment. Providing a higher standard of living and recruiting for the necessary position in the six-plastic recycling process.

e) Identifying a qualified person who can improve the workers' abilities would aid in overcoming the lack of industrial experience. Operational management may be used to describe how new equipment functions and how it will improve the results of recycling plastic trash.

1.14 Enhancing the Circular Economy by Innovative Polymeric Waste Management Systems

Worldwide, plastic production exceeds 350 million tons per year, creating a massive problem with plastic trash. Unfortunately, the concerns surrounding the polymers' end-of-life are hardly addressed. A staggering 9 percent of all plastics used for mass production were recycled in 2015 (Geyer et. al., 2017), with regional variations reaching double digits. As an illustration, in 2018, the predicted rate of plastic recycling in the US was 8.7 percent. In comparison, landfills received 23% of Europe's postconsumer plastic waste in 2020, while recycling facilities received 42%. There is a dearth of resources available to poor countries for plastic recycling, in contrast to the more well-known and published information in affluent nations. The statistics on recycling municipal solid waste, particularly plastics, vary greatly between developing nations; stakeholders' collaboration and engagement are key components. To add insult to injury, affluent countries with well-established systems for collecting and classifying plastics are more likely to see more plastics recovered than used (Van Beukering and Van den Bergh, 2006).

The greatest market for plastic is found in plastic packaging, where commodity thermoplastics such as “polyethylene (PE) (both high and low density), polypropylene (PP), polyethylene terephthalate (PET), and polystyrene (PS)” are often employed.3. Because it is usually single-use, 95% of the value of the plastic packaging material is lost, and as a result, this industry produces a significant quantity of plastic trash each year. While efforts are concentrated on moving plastics from linear to circular economies, reduction, reuse, and recycling are prioritized since they are more effective waste management techniques than landfill and improper disposal (Fagnani et.al., 2020). Reducing the weight and thickness of the packaging without sacrificing functionality is one way to reduce the amount of plastic used in food packaging, as is the case with avoiding overpackaging and excessive packing. These two methods lower related CO2 emissions, lower the costs of distribution, processing, and transportation, and increase sustainability. Rather than the ingredients, production, processing, or transportation, a life cycle assessment found that carbonated beverage packaging accounted for 59% to 77% of environmental impacts. The potential for PET bottles to contribute to climate change may be reduced by 32–48% if recycling rates reach 40–60% (Amienyo et. al., 2013).

Reuse is suggested as a way to eliminate single-use plastics for food packaging and progress toward a circular economy. It is now feasible in some locations, mostly through local trial programs. However, considering that goods may be reprocessed into differently shaped things, recycling is a fantastic option for plastics in general and offers versatility when compared to reuse. The collection and sorting of plastic packaging waste into high-quality streams for reprocessing has become the biggest challenge to efficient plastic packaging recycling because reprocessing different commodity thermoplastics can lead to problems when making new goods. The increasing public demand for packaging containing a greater proportion of recycled materials has also prompted several governments to pass legislation intended to spur innovation in this area. Companies in the United Kingdom will be subject to a new tax beginning in 2022 if their packaging does not contain at least 30% recycled content by weight, a criterion meant to discourage the use of virgin plastics in favor of recycled materials (Clark et. al., 2019).

Innovative polymeric waste management solutions are crucial for improving the circular economy and tackling the mounting environmental issues caused by plastic trash. By optimizing polymeric material collection, sorting, recycling, and reuse, these systems reduce their detrimental environmental effects. They achieve this by utilizing cutting-edge technology and tactics. Creating cutting-edge technology for recycling and sorting is a crucial component of creative polymeric waste management systems. With the use of these technologies, a greater variety of plastic materials may be recycled by effectively separating various polymers and impurities. The limits of conventional mechanical recycling procedures may be overcome, and the total recyclability of plastic trash can be increased, with the help of techniques like near-infrared spectroscopy, robotic sorting, and chemical recycling.

Innovative polymeric waste management methods also emphasize a change in plastic manufacturing and consumption toward a more circular and sustainable model. This involves taking steps to make items recyclable, putting in place closed-loop recycling systems, and offering incentives for using recycled materials in production. By completing the circle between the manufacture and use of plastic, these systems lessen the need for virgin plastics and the quantity of plastic trash that ends up in landfills and the ocean. Furthermore, cooperation and collaborations across several industries are needed to advance the circular economy through creative polymeric waste management methods. Collaboration among government agencies, industrial players, research institutions, and civil society groups is necessary to create and execute efficient waste management regulations, allocate resources towards research and development, and encourage sustainable practices across the whole value chain. All things considered, moving toward a more sustainable and circular economy requires creative polymeric waste management solutions.

1.15 Adoption of Plastic Waste in Different Sectors

The various industries have various rates of adoption of plastic waste management techniques, and each has its potential and constraints. Recycled plastic is becoming more and more popular in the packaging sector for use in product packaging. Businesses are using more and more recycled content in their packaging materials to lessen their dependency on virgin polymers and their environmental effect. Furthermore, advances in technology and package design seek to decrease the overall amount of plastic used and increase recyclability (Steenmans et. al., 2021).

a) Concrete admixtures

The integration of plastic waste into concrete admixtures yields a multitude of advantageous outcomes. To begin with, plastic waste functions as an infill or supplementary cementitious material (SCM), thereby aiding in the mitigation of cement usage in concrete mixtures. Concrete production's environmental impact can be mitigated in part by reducing cement content via the utilization of plastic waste, given that cement manufacturing is energy-intensive and produces substantial carbon emissions. As an admixture, plastic refuse can enhance the workability and durability of concrete. By functioning as micro-reinforcements within the concrete matrix, plastic particulates can increase the material's tensile strength, resistance to impact, and resistance to cracking. In addition, plastic admixtures can enhance the rheological characteristics of concrete, thereby simplifying the pumping and placement processes, particularly in areas with dense reinforcement or intricate formwork arrangements (Anum et. al., 2019).

b) Column casting and bricks molding

Plastic bottles are being creatively used by construction engineers for a variety of project components, including “fences, columns, bricks, warehouses, schools, entertainment areas, residential buildings”, and many more. The “Butakoola Village Association for Development”, or “BUVAD,” in Uganda launched the initiative in 2010 that resulted in the construction of the continent's first plastic bottle-built home. The challenges that multiple farmers in that community were having with plastic's detrimental effects on the soil's fertility, which continued to lower agricultural output year, gave rise to this creative remedy. This problem was found in a 2009 BUVAD study conducted among the farmers in the Kayunga village. First, they turned all of the plastic bottles into honeycomb-shaped bricks. That amounted to almost 1.8 million pounds of discarded plastic. The project's overall cost was around one-third that of the traditional buildings. Over time, it has been shown that plastics are a superior material to replace modern bricks for building constructions (Dadzie et. al., 2020).

c) Plastic bottles in agriculture

Over time, plastic refuse vessels have developed an exceptionally high level of toxicity towards all living things due to their formidable resistance to biodegradation. Some PET bottles that are discarded at random after use wind up on farmland due to erosion or flooding caused by precipitation; however, these bottles do not undergo decomposition even when submerged in the soil. Furthermore, this has played a role in the depletion of soil fertility, which has a detrimental impact on the rate of crop productivity on the agricultural land. To address, minimize, or eradicate these deficiencies, plastic waste vessels are presently undergoing a redesign process to function as a support structure for the cultivation of “flowers, vegetables, and other appropriate commodities”. This is accomplished by slicing the PET bottles into configurations that correspond to the quantity of soil necessary for the plant's “germination and survival”. Additionally, it provides design flexibility about the alignment and arrangement of the bottles when employed in horticultural flower planning.

d) Plastics in 3D printing

“Filament extrusion” from plastic waste, which is already commercially accessible in some forms, has increased plastics' importance in 3D printing, in keeping with the principle of the circular economy. A variety of filaments are available for use in 3D printing, including “nylon, acrylonitrile butadiene styrene (ABS), polylactic acid (PLA), and polyethylene terephthalate (PET)”. The majority of ABS filaments come from refrigerator HIPS, car dashboards, and automotive components. The producer's desire and the parameters of the available technology determine the materials used to manufacture 3D printing filament. Because of their demonstrated ability to provide savings of up to 80%, extruders are beneficial for all 3D printer users, guaranteeing end users self-sufficiency and happiness. Because of their compact size, straightforward operation, and incredibly low price, extruders are easy for anybody to use, regardless of their level of experience. The mechanical strength of PLA is diminished during recycling. Polydopamine (PDA) covering the recycled polymer filament might be the solution to this problem (Zhao et. al., 2018).

1.16 Reasons for Circular Economy Roadmap for Plastics is necessary in India

A “Circular Economy Roadmap” for Plastics is required in India for several strong reasons. India, first and foremost, faces a formidable task in managing its plastic trash. Being one of the world's top manufacturers and users of plastic, the nation's fast-paced urbanization and economic growth have only made the issue worse. In the absence of appropriate controls, the buildup of plastic trash presents major threats to human health and the environment, including soil erosion, water body pollution, and harm to marine life. In addition, there is no long-term sustainability to the linear model of plastic consumption and disposal, which involves the manufacturing, usage, and eventual disposal of items. In the process of making virgin plastics, it results in the depletion of resources, energy use, and greenhouse gas emissions. By placing a higher priority on recycling, reuse, and resource efficiency, the shift to a circular economy model for plastics can help reduce these problems (Hossain et. al., 2022).

The creation of a Roadmap to assist in accelerating the conversion of India's plastic waste business into a circular economy was largely spurred by the government's commitment to addressing the problems associated with plastic waste and the ensuing worries about its effects on human health and the environment. Governments at the state and local levels have traditionally handled the management of plastics through regulatory tactics like bans and penalties, as well as through education and awareness campaigns headed by members of civil society. From a waste management standpoint, these initiatives have mostly focused on changing individual behavior and have had some degree of effectiveness (Sakthipriya, 2022).

India recognized the scope and complexity of the plastic waste issue in 2016, as well as how it was related to the world's ocean plastic pollution and worries about global warming. Since then, a number of policies aimed at commercial, residential, industrial, and municipal actors have been adopted. These actions have included “bans, fines, municipal and social enterprise models for collection, segregation, and recycling, education and awareness campaigns for a variety of stakeholders, rules for Extended Producer Responsibility (EPR), and tracking and monitoring the issue at the municipal level”. These actions are spearheaded by the Plastic Waste Management (PWM) Rules. The majority of operational interventions focus on ending the use of plastic, and there are several inconsistencies between the intentions and the design of policies, which are made worse by numerous obstacles to execution (Talwar et. al., 2021). The challenges encompass deficiencies in data flow and transparency that impede the monitoring and development of efficient strategies, technological constraints in recycling, remanufacturing, and environmentally sustainable manufacturing, insufficient infrastructure for end-of-life product collection, market and pricing impediments for “secondary plastic-based products and alternatives” to single-use plastics, insufficient knowledge capacities among “stakeholders, and business models” that fail to account for the potential of sustainable practices. The necessity for a holistic perspective of the complete value chain of the “plastics economy” and the provision of systemic suggestions to tackle the challenge are the driving forces behind the development of the road map.

There is always opportunity when a hurdle is overcome. The roadmap is a strategic approach to achieving the Sustainable Development Goals (SDG) and net zero targets. It is driven by the ambition to provide opportunities throughout the shift to a more equitable, sustainable, and circular economy. Like other emerging economies, India has the chance to move past the trade-offs between growth and the environment, as well as between transition losers and winners. These potentials include improving resource security through material recovery, driving market and industry shifts toward low-embodied carbon goods through creative solutions, and creating new jobs and green jobs through inclusive business models. In keeping with the Government of India's planned action for the LiFE - Lifestyles for Environment intervention, which was presented at COP26 on November 1, 2021, this project promotes sustainable living and excellent health (Madan et. al., 2023)

This Roadmap acknowledges that the issue is dynamic and that, although certain actions must be taken immediately, other approaches and solutions will develop gradually over time and with the involvement of stakeholders from all facets of the plastics industry. Consequently, a Roadmap should be an evolving document outlining research-based recommendations for commercial and policy endeavors, technology interventions, community and social action, and other related areas. Managing the ever-changing plastics business in India is a top priority, as is resolving pressing global, national, and local concerns related to climate change, resource depletion, pollution, and people's ability to make a living.

Lastly, the Roadmap can help industry groups and the Indian government respond to the demands of the "Global Plastics Treaty", which is anticipated to come into effect by 2024. The roadmap delineates the methodical measures that various stakeholders must undertake in the short, medium, and long run to effectively address "environmental and human health risks" within the plastics industry. The roadmap may inspire and spearhead revolutionary change on a global scale since technical, commercial, and industry-wide solutions that are effective in India have a great deal of potential to inform and replicate in growing economies of the "Asia Pacific, Africa, and Latin America".

1.17 Relaunching Efforts for a Circular Economy in Plastics

There is a rising awareness of the need to shift to more sustainable forms of production and consumption due to growing worries over plastic pollution, environmental deterioration, and resource constraints. Reconsidering the "take-make-dispose" model and encouraging the recycling, reuse, and repurposing of plastics throughout their lifespan are key components of the circular economy strategy, which presents a possible alternative. Many parties, including governments, businesses, consumers, and civil society, must work together to accomplish this shift. Governments are essential in establishing the incentives and legislative framework that promote the adoption of circular economy ideas. This might involve investing in infrastructure for garbage collection, sorting, and recycling as well as enacting laws requiring enhanced producer responsibility and eco-design requirements (Dumée, 2022).

For more than thirty years, “plastic pollution” has been a problem for both “Indian governments and residents”. Numerous local efforts have focused mostly on changing individual behavior. The Plastics (“Manufacture, Usage, and Waste Management”) Rules of 2009 brought about a more robust reaction, and starting in 2016, broader reactions from commercial, residential, and industrial players accelerated.

Now, as part of the “Australia-India Comprehensive Strategic Partnership”, six leading research organizations three from India and three from Australia have joined forces to begin this massive rule initiative. Policymakers, regulators, and industrialists can rest assured that the report has done its homework by consulting with plastics value chain stakeholders, assessing recycling technology, going over all relevant data, reports, and working papers, and finally, drawing conclusions about action gaps, obstacles, opportunities, and challenges. Its goal is to help everyone involved in India's plastics circular economy, which is working to reduce pollution and the quantity of virgin materials produced from extracted natural resources (Ghisellini and Ulgiati, 2020).

Furthermore, the advancement of best practices, innovation, and knowledge in circular economy techniques is greatly aided by academic institutions, research facilities, and civil society groups. These stakeholders may aid in the creation of practical plans and solutions for addressing the plastic waste challenge by encouraging cooperation, exchanging knowledge, and pushing for systemic change. Resuming the plastics industry's efforts to move toward a circular economy necessitates a comprehensive, cooperative strategy that covers the whole value chain, from manufacturing to consumption to disposal.

1.18 Plastic Waste Management in the Healthcare Sector

The healthcare industry faces distinctive obstacles in its management of plastic waste owing to the paramount importance placed on hygiene and safety protocols. Daily, healthcare facilities such as hospitals, clinics, and tubing produce a significant volume of single-use plastic waste, predominantly originating from medical equipment, packaging, and supplies including syringes, gloves, and tubing. It is crucial to ensure the appropriate disposal and management of this waste to mitigate health risks and prevent environmental contamination that may result from improper handling. A variety of approaches are utilized to effectively handle plastic waste within healthcare environments. Before anything else, it is critical to separate waste from its source, including plastics, so that it can be disposed of or recycled appropriately. Biomedical waste is frequently segregated according to facility-specific protocols to prevent contamination and guarantee safe management (Karuppiah and Mathivanan, 2021).

Furthermore, recycling programs are a major factor in lessening the harm that medical plastic waste does to the environment. To recycle particular types of plastic waste, such as packaging materials or non-hazardous plastics from medical devices, many healthcare institutions collaborate with recycling firms. However, in certain areas, obstacles including pollution, a lack of infrastructure for recycling, and legal restrictions may make recycling activities difficult. To reduce their usage of plastic, certain healthcare institutions are also progressively using sustainable procedures and alternative materials. This entails utilizing environmentally friendly packaging, cutting out needless plastic packaging, and switching to biodegradable or reusable substitutes where practical (Gunawardana, 2018). The following are the plastic waste management in the healthcare sector:

- Hospitals make extensive use of plastics. The daily generation of plastic detritus includes “glucose vials, LV. sets, disposable syringes, B.T. sets, cannulas, catheters, and other similar devices, as well as disposable plastic aprons”.
- Although plastics may be functional and easy to incorporate into our daily lives, their adverse health effects cannot be disregarded. Plastic waste continues to accumulate on a global scale and substantially contributes to waste generation on account of its non-biodegradable characteristics.
- Plastic waste management has also enabled “healthcare facilities” all over the world to create a significant proportion of non-infected plastic garbage. Only a limited amount is recycled, however. Typically, old plastics are either discarded in landfills or burned poorly. These behaviors affect the ecosystem. Because of their flexibility, plastics are a crucial component of the medical business.
- Medical plastic recycling is severely limited by the difficulties associated with sorting and cleaning. Medical plastic waste can only be recycled when the recycling industry and the healthcare sector work together effectively. Sustainably adopting innovative recycling technology is crucial.
- Furthermore, plastics used in “medical applications” should be designed with recycling in mind. There are usually four common pathways for recycling plastic after the waste plastic has been collected, sorted, and cleaned.

- Primary recycling- It discusses repurposing plastic waste to create goods that are largely identical to the original material.
- Secondary recycling- Mechanical recovery is another name for the mechanical recovery of plastic refuse. Steps in the mechanical recycling procedure include material collection, sifting, and cleansing to eliminate organic or other contaminants.
- Tertiary recycling- Transforms polymeric materials into smaller molecules, usually gasses or liquids, that are utilized as feedstock in a process that creates chemicals and fuels.

1.18.1 Difficulties in the Management of Plastic Waste from the Healthcare Sector

Managing plastic waste in the healthcare sector presents substantial issues. First, the nature of healthcare operations frequently results in the development of a wide spectrum of plastic trash, including contaminated objects such as discarded needles, gloves, and other medical equipment. Ensuring the proper storage and disposal of these items without risking contamination or infection transmission is a difficult undertaking that necessitates strict rules and specialized facilities. Another difficulty is the massive amount of plastic garbage created by healthcare institutions, which can overwhelm existing waste management systems. Limited storage capacity, insufficient infrastructure for waste segregation, and the necessity for specific disposal technologies hinder the management process.

Furthermore, recycling healthcare plastics might be more difficult and expensive since they are sometimes made of many components or tainted with chemical or biological residues. If contamination is not adequately managed, it can lower the quality of recycled materials and pose concerns to the environment and human health. Furthermore, managing plastic waste in the healthcare industry is made much more difficult by regulatory compliance. Strict laws that regulate the processing, transportation, and disposal of medical waste must be followed by healthcare facilities. These laws differ between jurisdictions and may call for specific personnel certifications and training.

Furthermore, managing and properly disposing of medical plastics can be expensive, especially for smaller hospitals with tighter resources. Purchasing sophisticated waste management equipment, such as autoclaves or waste-to-energy systems, may come with a hefty upfront cost as well as continuous operating costs. Ultimately, altering staff and healthcare professionals' practices and increasing awareness is an ongoing problem. Adopting sustainable measures, such as cutting back on plastic usage or raising recycling rates, frequently need support from stakeholders at all organizational levels and may run against ignorance or opposition. Healthcare plastic waste management is a complicated, multifaceted issue that calls for cooperation, funding, and creativity on many fronts. A comprehensive strategy that takes stakeholder participation, resource allocation, technical improvements, and regulatory compliance into account is necessary to properly address these challenges.

1.19 Statement of the Problem

The burgeoning global production and consumption of polymeric materials, particularly plastics, have resulted in profound environmental challenges, including pollution, resource depletion, and ecological degradation. Conventional waste management practices, characterized by linear models of production and disposal, have exacerbated these issues, leading to the accumulation of plastic waste in landfills, oceans, and ecosystems worldwide. Despite increased awareness of the environmental impact of plastics, existing waste management systems often lack the capacity and infrastructure to effectively manage and recycle polymeric materials. Furthermore, the complexity of plastic waste streams, coupled with limitations in recycling technologies and market demand for recycled plastics, presents significant barriers to achieving a circular economy for polymeric materials. Thus, the problem statement revolves around the need to develop and implement innovative polymeric waste management systems that can effectively address these challenges and enhance the circular economy. Specifically, this involves identifying sustainable strategies for the collection, sorting, processing, and recycling of polymeric waste, as well as promoting eco-design principles, material innovation, and stakeholder collaboration to foster a systemic shift towards circularity in the plastics value chain. Addressing these issues is crucial to mitigating environmental pollution, conserving resources, and advancing sustainable development goals in the pursuit of a more resilient and regenerative future.

1.20 Research Objectives

Obj-1. To identify the impact of challenges, such as technological limitations, regulatory barriers, and market constraints, faced by industries in effectively managing polymeric waste within the circular economy framework.

Obj-2. To Evaluate the environmental, economic, and social impacts of implementing innovative polymeric waste management systems.

Obj-3. To Examine consumer attitudes, behaviors, and awareness regarding polymeric waste and circular economy initiatives, and their influence on adoption rates of innovative waste management solutions.

Obj-4. To investigate emerging technologies for the recycling of polymeric waste.

Obj-5. To explore how innovative polymeric waste management can be integrated into a circular economy framework.

1.21 Chapter Plan

i. **Introduction -** The chapter provides an overview of “innovative polymeric waste management systems to enhance circular economy”. This chapter describes the concept of polymeric waste management systems and their importance. The chapter also describes the innovative polymeric waste management systems that offer holistic solutions that encompass the entire lifecycle of plastic materials, from production and consumption to disposal and recovery.

ii. **Literature Review -** The chapter will describe the previous studies related to “innovative polymeric waste management systems to enhance circular economy”.

iii. **Research Methodology -** The chapter will discuss the “research technique and categories of data, sampling, research area, number of participants, and data-gathering methods and methodologies.” The main data collection will comprise field observations and questionnaires.

iv. **Result Analysis -** The chapter will describe “statistical tools and statistical techniques” for data collection and will examine the study’s “hypothesis, validity, dependability, and objectivity.”

v. **Conclusion -** In this section, based upon the study conducted so far inferences will be drawn and future scope will be discussed for further research.

CHAPTER II:

REVIEW OF LITERATURE

2.1 Overview

Innovative polymeric waste management systems aimed at enhancing the circular economy involve the investigation and application of sophisticated methods and approaches to efficiently handle polymeric waste, while simultaneously advocating for the principles of a circular economy. Polymeric waste, such as plastic and other synthetic substances, presents substantial environmental difficulties because of its long-lasting nature and harmful effects on ecosystems. In an attempt to tackle this problem, novel strategies are being devised to reduce the production of waste, optimize the extraction of resources, and promote a more environmentally friendly and efficient use of materials. An essential element of such systems is the implementation of cutting-edge recovery methods, such as chemical reuse and pyrolysis, that allow for the transformation of polymer waste into important raw materials as well as feedstocks for the production of new products. These technologies provide a hopeful substitute for conventional mechanical recycling by enabling the restoration of polymer with properties that are equal to those of virgin materials. In addition, advanced polymeric waste management techniques frequently include concepts in their designs for recycling and circular design, to maximize the lifespan of the item, material retrieval, and recyclability. This entails the creation of environmentally friendly and readily recyclable materials, along with the establishment of collecting and sorting systems that streamline the effective separation and processing of garbage. Incorporating digital technologies, including blockchain as well as artificial intelligence, into polymer waste management systems is becoming more common. This integration aims to enhance accountability, transparency, and efficiency across the supply chain. These digital solutions provide enhanced surveillance of waste streams, recognizing optimization possibilities, and the implementation of incentives to encourage sustainable habits. To reduce waste, increase resource efficiency, and support the shift towards a more resilient and environmentally friendly future, modern polymeric waste management methods are vital to the advancement of the circular economy agenda.

Literature reviews generally offer a comprehensive and enlightening summary of a certain subject. Literature reviews can offer a brief overview or summary for current scholars. These periodicals are essential tools that offer experts up-to-date information on the newest advancements in their respective fields. The breadth and intricacy of the literary analysis demonstrate the author's scholarly proficiency in their discipline. A literature review serves as a robust basis for analyzing research.

2.2 Literature Review

2.2.1 Review related to the challenges faced by industries in effectively managing polymeric waste

Santos, G., et.al., (2024) examined how often plastics were used in construction, CRD (construction, renovation, and demolition) plastic rubbish must be treated. CRD plastic waste was disposed of in landfills due to a lack of rules, risk aversion, and low recycling knowledge. This hindered the circular economy and crude oil independence efforts. To secure a sustainable future, end-of-use product recycling must be economically viable. Due to its contamination and low value, CRD waste plastic recycling was not commercially viable. This study covered CRD plastic recycling's existing state, technology, challenges, opportunities, and activities. This study addressed the structures and technological innovations needed to achieve large-scale commercial recycling. The study stressed the importance of a strong collection network, financial signals to encourage landfilling and legislation to require manufacturers to take on end-of-life duties. The study provided insights and suggestions on manufacturing, reuse, recycling, policy formulation, benchmarking, and implementation to benefit the plastic construction industry. It emphasized these activities' environmental and economic benefits.

Kibria, M.G., et.al., (2023) analyzed how the contemporary world was confronted with the task of effectively managing and reclaiming the vast quantity of plastic garbage. The primary causes of this extensive accumulation of plastic trash were a deficiency in technical expertise for handling hazardous waste, inadequate infrastructure for recovery, and recycling, and, most importantly, a lack of awareness regarding the norms and regulations. The magnitude of plastic pollution has a detrimental impact on the surroundings and the entire ecosystem. This study presented a thorough examination of the development of plastic garbage and its impact on both humans and the natural system. It specifically focused on identifying the sources of plastic waste in industrialized and developing countries. The study provided a comprehensive analysis of the current waste-to-energy and product methods of conversion. Furthermore, the study highlighted sustainable waste management protocols and identified the primary obstacles to implementing efficient strategies for reducing the adverse effects of plastic trash.

Hossain, R., et.al., (2022) observed that plastic production contributed to world oil consumption and garbage growth. Given the growing scarcity of fossil fuels, understanding how to recover, reuse, and remanufacture virgin plastic from fossil fuels was crucial. After analyzing Australia's plastic waste management system, this study systematically reviewed the literature. The goal was to assess circular economy challenges and opportunities. Despite the enormous rise in plastic consumption, Australia's recycling rate is 11.5%. High-density polyethylene (HDPE) produced the most plastic waste, followed by PET and LDPE. Residential houses generate 50% of plastic waste. Biodegradable plastics industry growth was disappointing. PET processing requires additional facilities; however, most recycling plants use mechanical recycling. Buildings use the most recycled plastics, yet just 10% of Australian industries employ locally recovered materials. Energy was also generated from plastic waste. Local governments, recyclers, community engagement, and national, regional, and worldwide programs determined plastic waste disposal in the future.

Chen, H.L., et.al., (2021) observed that the problem of plastic waste was a major concern worldwide, and Malaysia has held the title of the greatest importer of disposable plastics since 2017. Malaysia's system for managing waste faces substantial issues due to this. The study provided an overview of the present condition of plastic waste generation and control in Malaysia, encompassing possibilities for disposal, recycling, and incineration. This emphasized the magnitude and dangers associated with plastic trash, encompassing microplastics, disposal in landfills, and the process of incineration. This study discussed important governmental measures in plastic waste management, including the use of biodegradable alternatives, and explores the limitations associated with these projects. Internal restrictions encompass the irregular enforcement of policies by state authorities and a deficiency in public awareness and engagement regarding household recycling. The study presented a paradigm for managing plastic based on the circular economy model and the handling of the solid waste hierarchy. Efforts to reduce plastic trash in Malaysia need to be consistently maintained across several levels, but there was some optimism based on successful experiences in other nations.

Vanapalli, K.R., et.al., (2021) analyzed the demand for food and dishes that were packed in plastic has increased because of the COVID-19 epidemic, which has worsened the problem of plastic waste management. Plastic waste mishandling and environmental damage could be worsened by the current inefficiencies in the waste management system. To lessen the likelihood of transmission, it was essential to prioritize scientific sterilization and sealed containers for the secure disposal of polluted plastic trash. During times of crisis, plastic trash might be better managed with investments in circular technologies, such as feedstock recycling and infrastructure improvement. To prevent future pandemics, it was crucial to switch to eco-friendly materials such as bioplastics and implement new sustainable technologies. International engagement in reducing pollution through summits and goals can postpone implementation, just as short-term repeals of plastic that were only used once banned can impede long-term objectives. Giving priority to policies that promote changes in individual and societal behavior, can reduce plastic pollution and increase the use of sustainable waste management systems. For these changes to be implemented, public-private initiatives in study, infrastructure, and marketing are important, and incentives for circularity and sustainable behaviors were also necessary.

Evode, N., et.al., (2021) observed the rising utilization of plastic-based goods has resulted in a substantial quantity of plastic garbage. This waste was generated through the biological processes of polymerization or polycondensation. If not adequately treated, it could have detrimental effects on the environment. This study examined the life cycle of different plastic materials, such as PVC-U, polypropylene, HDPE, polystyrene, and PETE. Additionally, it tackled the issues raised by insufficient handling of plastic trash and proposed remedies to promote a healthy environment and mitigate climate change. The objective of the study was to raise awareness about the diverse range of plastic-based goods and their potential for environmental consequences. Effective governance and heightened consciousness regarding the utilization of polymers were crucial for the attainment of a viable and enduring future.

Lange, J.P., (2021) observed that throughout time, the petrochemical sector has created a wide range of polymers that are actively enhancing the welfare of mankind. Incorrect disposal of utilized plastic has resulted in the accumulation of trash, which pollutes the environment, causing harm to species, and squandering important resources. This study provided a thorough analysis of the difficulties and potential advantages associated with transforming plastic trash into raw material for the industry. The study covered the topics of plastic waste quantity, quality, and sorting. It also explored mechanical recycling methods such as extraction or dissolution/precipitation. Additionally, it addresses chemical recycling processes that convert plastic waste into monomers and feedstock, as well as other chemicals. Lastly, it touches on trash disposal methods including incineration, landfill, biodegradation, and the issue of microplastics. It expanded the conversation on circularity by incorporating life-cycle assessments (LCA), designing for recycling, and the potential use of regenerated carbon as a feedstock.

Kumar, A. and Agrawal, A., (2020) aimed that the exponential increase in population, high urban density, cultural diversity, and evolving dietary preferences have resulted in a substantial challenge in the management of Municipal Solid Waste (MSW) in India. This study provided an overview of the present condition of Municipal Solid Waste Management (MSWM), highlighting the difficulties and possible remedies. The issues encompass unsorted solid waste, societal stigmas, deficient evaluation, insufficient methods, disorganized informal waste sectors, unprepared fiscal policies, and ineffective government policy implementation. The study found that it was necessary to implement effective treatment and recycling systems to address the composition of solid waste in India. The ramifications of these solutions, both at centralized and decentralized levels, must be emphasized through scientific therapeutic procedures. Collaboration between informal sectors, municipalities, and private agencies was necessary to foster opportunities and ensure the long-term sustainability of Municipal Solid Waste Management (MSWM) in Indian cities.

Ayeleru, O.O., et.al., (2020) stated that while there has been increased awareness about the problems caused by land-based plastic and their effects on marine ecosystems, there was a lack of comprehensive studies on how the production of plastic waste and inadequate management practices specifically affect the well-being of humans and the environment. The situation was particularly worrisome in sub-Saharan Africa, as there was substantial potential for advancements in plastic waste control. Urbanization and various other reasons led to the development of plastic garbage. In 2019, a staggering 180 million tons of waste were generated daily, with 70% openly dumped. This amounts to an annual total of 17 million tonnes. This study sought to offer a comprehensive examination of the plastics lifecycle and the challenges related to managing plastic waste in sub-Saharan Africa. It included several aspects such as existing practices, public engagement, and governmental legislation. Additionally, it emphasizes the environmental and financial benefits of effective handling of plastic waste and serves as a foundation for suggesting methods to reduce the adverse effects of plastic trash.

Sharma, H.B., et.al., (2020) observed that the COVID-19 epidemic had greatly changed the dynamics of global garbage generation, requiring governments to respond flexibly and adaptively. This study emphasized the difficulties encountered by the disposal of solid waste during the epidemic and the potential to address current deficiencies. The study emphasized the significant concerns surrounding the management of biomedical waste, plastic trash, and food waste. The lack of involvement from citizens in handling the mixture of virus-infected biomedical waste and conventional solid trash presents substantial health and safety concerns for sanitation workers. The utilization of disposable plastic was expected to increase again as a result of concerns regarding cleanliness and sanitation. The generation of household food waste may decrease as a result of heightened awareness of purchasing non-perishable products during the lockdown and concerns about food shortages. Nevertheless, there was a possibility of heightened food wastage resulting from supply chain disruptions, such as instances where food products become stranded on transportation routes due to limitations on vehicle mobility and a shortage of personnel in storage facilities. The study highlighted the importance of establishing resilient supply chains at the local level to effectively address similar issues in future pandemics.

Tripathi, A., et.al., (2020) observed that by December 2019, Wuhan, China, emerged as the focal point of the first-ever coronavirus, which led to a global COVID-19 pandemic. As it reached mid-2020, there have been notable shifts in waste generation patterns, with houses, roads, and medical facilities emerging as the main contributors to waste production. The utilization of protective clothing by frontline employees and the extensive adoption of masks has caused a change in the production of trash. The proliferation of disposable plastic items has contributed to a resurgence in the pandemic, and projections indicated that the pandemic was deteriorate with time. In addition, lockdown measures have resulted in a decrease in garbage pickup and recycling, resulting in an accumulation of waste. Nevertheless, numerous countries were adopting measures to disrupt the transmission of the virus by reducing interpersonal interactions. This study investigated the influence of COVID-19 on the production, recycling, and disposal of solid waste. It also emphasized the measures taken by different countries to limit the spread of the virus through solid waste.

Paletta, A. et.al., (2019) analyzed that Global polymer production reached a staggering 320 million tons in 2017, presenting a significant risk to both human health and the environment. Immediate measures were required to decrease plastic consumption and enhance its recyclability. This study examined plastics-converting firms in Italy, with a specific emphasis on revolutionary advancements in business models that can stimulate transformations in production methods. The results showed a direct correlation between company strategy and the use of non-virgin plastic materials. The European Plan for Polymers in the Circular Economy sought to attain ambitious plastic recycling goals by 2025. To address obstacles in legislation, economy, technology, and society, it was crucial to adopt a systemic thinking approach. Transitioning from a small-scale to a medium-scale examination can facilitate the development of effective management strategies for both environmental and economic benefits, particularly in the European plastics conversion sector, where small and medium-sized enterprises (SMEs) dominate. This study offered essential insights into the plastic business, emphasizing the necessity of new solutions and significant endeavors by decision-makers, manufacturers, recyclers, producers, retailers, and consumers.

Rajmohan, K.V.S., et.al., (2019) observed plastics as a prominent source of environmental pollution due to their cost-effective and adaptable properties, which contribute significantly to human existence. Nevertheless, it undergoes a lengthy degradation process, which results in the release of detrimental substances such as dioxides and phosgene into the environment. Microplastics, which are harmful waste materials, infiltrate food chains and water ecosystems, resulting in health problems such as birth defects and cancerous tumors. Plastic polymers emit highly durable organic pollutants that can be deadly, leading to the development of tumors and neurological harm in people. Insufficient waste management techniques are a major cause of extensive plastic pollution in water bodies, with trash frequently accumulating on beaches, diminishing their visual appeal and recreational worth. This study examined the process of extracting resources from waste plastic, the ecological impacts of plastics, and the existing safety laws. The study also examined scientific literature on approaches for addressing plastic pollution, advocating for continued progress by authorities and scholars.

Das, S., et.al., (2019) investigated that solid waste management (SWM) was essential to environmental management. Focusing on "reduce", "reuse", and "recycle" (3R), Single White Male (SWM) methods have become increasingly practical and effective for promoting sustainability. This study examined a wide range of Solid Waste Management (SWM) options to achieve the following goals: This study aimed to (i) explain the latest advances in technology, strategic innovations, and evaluation tools, (ii) provide an overview of current waste management situations in various countries, (iii) determine the functions of life cycle assessment (LCA) and other modeling tools in solid waste management (SWM), and (iv) present practical methods for environmentally friendly recycling and use of solid waste. The present analysed showed that country geography and economic conditions strongly influence rubbish characteristics. Future business workers can use economic and life cycle assessment (LCA) models to identify and evaluate disposal strategies. Additionally, this study includes a variety of innovative techniques for implementing intelligent and environmentally friendly waste management programs in many nations.

Moharir, R.V. and Kumar, S., (2019) noted that the obstinate nature of plastics was a significant worry since its growing demand had complicated the problem of plastic waste management, leading to new obstacles in addressing plastic deterioration. In recent years, there has been a significant increase in the demand for plastics and a growing concern for their proper disposal. As a result, there has been a heightened focus on biodegradable plastics and the process of plastic biodegradation. The breakdown of plastics was an effective and environmentally benign method for treating these persistent plastics. This study examined the latest advancements in the field of biodegradation, focusing on the most appropriate microbial species for addressing the problem of recyclable plastic disposal. This study primarily addressed the difficulties encountered in the procedure of plastic breakdown, the typical treatments employed for treating these plastics, the most effective methods of biodegradation, and the resulting repercussions on society and the environment.

Hahladakis, J.N. and Iacovidou, E., (2019) determined recycling plastic garbage from consumers after use was increasingly popular as a method to build a circular economy. This process entails the transformation of plastic trash into recyclable materials that can be utilized in the production of new components and goods. However, the study on the environmental consequences, economic ramifications, and technological aspects of PCPW recycling has primarily concentrated on a single facet of the plastics value chain. When trying to progress in research, it was imperative to comprehend the difficulties and compromises involved in expanding the scale of PCPW recycling. This study investigated the various dimensions involved in achieving a closed-loop system for plastic, encompassing design, manufacture, collecting, and sorting. It also explored the compromises that come from the recycling of post-consumer plastic waste (PCPW). Assessing these compromises was essential for gauging the enduring viability of such systems.

Horodytska, O., et.al., (2018) investigated that flexible films were becoming more widely utilized in various fields due to their lightweight nature and adaptability. Plastic films accounted for 34% of the overall packaging made of plastic in the UK in 2014. Nevertheless, there was a growing trend in the production of flexible film trash, with films accounting for approximately 50% of home garbage in developed nations. Annually, around 615,000 tons of crop-related flexible waste are produced within the European Union. This study examined the technology used to handle plastic film trash from both industrial and consumer sources. Post-industrial trash undergoes recycling utilizing either open-loop mechanical or closed-loop methods, with ongoing research aimed at enhancing environmental advantages by closing the loops. It was necessary to develop delamination and compatibilization techniques to facilitate the recycling of multilayered films. The review also examined Life Cycle Assessment (LCA) research on waste management.

Singh, N., et.al., (2017) observed the disposal of plastic solid waste (PSW) composed of polymers such as high-density (HDPE), low-density polyethylene, or (LDPE), Nylon, and others, is currently posing significant scientific issues. An abrupt increase has been noted in the manufacturing of various products utilizing diverse plastic materials. The substantial rise in plastic goods also led to an increase in waste production, hence presenting new obstacles. Several researchers have documented their efforts in the area of PSW management, employing various recycling techniques. This study consolidated the various research endeavors conducted by scholars in the domain of recycling and advancements in the retrieval and control of post-consumer solid waste (PSW) through several approaches, including the following: primary, tertiary, secondary, and quaternary, as well as the diverse strategies employed for identification and separation. This research examined the impact on the characteristics of virgin and reused HDPE/LDPE/Nylon PSW when various reinforcements such as sand, fiber, metals powder, etc. are used.

Pietzsch, N., et.al., (2017) employed a comprehensive analysis of existing literature on the idea of Zero Waste (ZW) to gain insights into its advantages, difficulties, and key variables for achieving success. The review conducted a comprehensive analysis of 102 published publications to gain a deeper understanding of the concept and its effects on society as a whole, financial and economic aspects, environment, and industry. The benefits were categorized into four categories: financial-economic, environmental, community, and industrial and stakeholder benefits. Obstacles were recognized in both the larger-scale and intermediate-scale surroundings, encompassing governmental and cultural impediments. The study revealed crucial variables for success and activities for the implementation of ZW. Future research should prioritize conducting empirical investigations on the deployment of ZW, with a specific emphasis on its application in educational settings to facilitate changes in user behavior. The study emphasized the necessity for further investigation into the implementation of ZW and its execution.

Moh, Y., (2017) analyzed that the solid waste management system in Malaysia was encountering difficulties in the areas of source separation and recycling. These issues include prevalent practices of open dumps and illegal dumping, inadequate disposal sites, and limited efforts in recycling source separation. Act 672 has been enacted by the government to enforce mandatory source separation. This technique involves both federalization and privatization and is being implemented in eight states. SWCorp Malaysia has adopted a SWCorp Strategic Plan for 2014–2020 to advance environmentally friendly waste management services. The plan prioritized mentality, organizational capacity, culture, collaboration, policy, law enforcement, behavior, delivery system, and technology. Nevertheless, the general perception of the adoption of separation of sources and recycling as a regular practice continues to be a significant obstacle. To attain Malaysia's objective of achieving a rate of recycling of 22% by 2020, unwavering dedication and involvement by the government, the private sector, and the general public are vital. This initiative facilitated Malaysia's transition towards becoming a zero-waste country and enhanced its waste management methodologies.

Väisänen, T., et.al., (2016) observed that Natural fiber-polymer composites (NFPCs) were used more and more in various applications due to their eco-friendly and cost-effective nature, making them a viable alternative to traditional materials generated from petroleum. However, there was a significant amount of organic matter and leftovers from agricultural and industrial operations that were not being fully utilized as energy sources of low economic value. Organic materials were frequently discarded or treated using conventional waste management techniques, such as composting, landfilling, or anaerobic digestion. Utilized organic waste and residual materials in non-food plant crops (NFPCs) offered an environmentally sustainable and significantly more valuable alternative. This study provided a thorough analysis of the potential use of organic matter and residues as reinforcements or additions for NFPCs, based on recent research in this area.

Joshi, R. and Ahmed, S., (2016) investigated that the deplorable conditions and difficulties in managing municipal solid waste (MSW) in urban India serve as the driving force behind the current investigation. Urbanization led to increased production of municipal solid waste (MSW) and improper management of MSW deteriorates the urban environment and poses health risks. This study aimed to assess the key characteristics of Municipal Solid Waste Management (MSWM), as well as provide a thorough analysis of waste generation, its characterization, collection, and treatment methods currently employed in India. The present condition of Municipal Solid Waste Management (MSWM) in several Indian states and significant cities of India was documented. The study discussed the requirements for maximizing the advantages of public-private partnerships, as well as the associated problems. It also highlighted the often-overlooked function of rag-pickers. The study suggested that in developing nations like India, it was crucial to implement decentralized solid waste processing facilities in metro cities/towns and establish a formal recycling industrial sector.

Siddiqui, J. and Pandey, G., (2013) observed that plastics were commonly used in food and water packaging because of their inherent qualities, such as being chemically inactive and having low density, which make them acceptable for transportation and provide minimal danger of contamination. The use of plastic bottles and packets has become widespread throughout the country, especially in urban areas. The absence of an effective plastic waste management system has resulted in a packaging crisis, leaving numerous cities in India plagued by the presence of plastic garbage. This has led to unsightly visual disturbances and other health issues within the population. The increasing recognition of environmental concerns and the diminishing capacity of landfills have given rise to the implementation of plastic recycling initiatives in the majority of developed nations. Presently, meanwhile, a mere 5% to 25% of the plastic garbage was effectively recycled. The study examined the potential of waste management initiatives. Unless long-term corrective measures are implemented for waste plastic management in the country, the current rate of environmental degradation was expected to persist.

2.2.2 Review related to implementing innovative polymeric waste management systems.

Sharma, H.B., et.al., (2021) investigated that a circular economy strategy for solid waste management could assist in accomplishing the United Nations Sustainable Development Goals (UN-SDGs), even though the COVID-19 pandemic has impeded progress toward these goals. Public health, environmental protection, resource significance, and economic growth are all tenets of the United Nations Sustainable Development Goals, which were in line with waste management practices. The post-COVID economic strategy should highlight the use of the circular economy to attain these goals. Nevertheless, challenges related to public engagement, technology, and legislation could impede the transition to the CE model. Green jobs generated by waste management, the formalization of informal trash pickers, and an emphasis on training and education for informal workers might all contribute to niche growth. Concerns about climate change could be addressed via investments in recycling infrastructure. Designs for products and business models centered around CE prioritize intelligent manufacturing, product lifecycle extension, and multifunctional items. To meet the UN-SDGs, it was recommended to implement strong policies including decentralizing solid waste systems, localizing the supply chain, reuse and recycling, green recovery, sharing information, and collaborating internationally.

Okan, M., et.al., (2019) stated the widespread manufacturing of polymer products, specifically plastics, presents a peril to life on Earth as a result of their inherent benefits. Polymer recycling is usually regarded as an extensively adopted remedy for the escalating volume of plastic trash. Nevertheless, it encountered obstacles such as the need for separation, sorting, and cleaning procedures, the absence of financial assistance, the volatility of selected rubbish separation initiatives, and the high expenses associated with transportation and electricity. Notwithstanding these difficulties, society and authorities were in consensus regarding the significance of recycling in safeguarding the environment, preserving natural ecosystems, securing resources for the next generation, conserving raw materials, minimizing energy usage, lowering the production of municipal solid trash, and mitigating greenhouse gas emissions. Recycling initiatives encompass activities such as refurbishing, mechanical reshaping, treatment with chemicals, and thermal utilization. Emerging techniques such as carbon capture and carbon nanostructure synthesis from plastic waste are currently under investigation. This study focused on sustainable strategies for mitigating the environmental consequences of plastic trash.

Singh, P., and Sharma, V. P. (2016) stated that plastics had a vital role in many aspects of civilization, including packaging, agriculture, autos, and biomedicine. However, issues come up when substances don't break down and produce harmful fumes during burn. The production of accurate and effective polymeric goods using renewable raw resources was being advanced by recent technology. Due to careless disposal, marine pollution was raised, and research and development studies were investigated into how eating seafood is affected by plastic waste. Pollution's biological consequences were associated with financial losses, therefore in developing nations, sustainable development calls for accessible, efficient waste management techniques. Every year, more than 300 million metric tons of plastic were manufactured; half of this amount was thrown away within a year. Waste made by plastic clogs rivers, seas, and land, which harms biodiversity. Future polymer adhesives and implantation should be strong, biocompatible, and offer surface treatment choices to minimize wear and friction. It should also address the complete replacement of joint features for patients with varying age ranges and problems. Encouraging green chemistry and putting international standards into practice was crucial for plastic products that were environmentally benign. Modern scientific applications should be used to develop, promote, and uphold integrated waste management processes.

2.2.3 Review related to consumer attitudes, behaviors, and awareness regarding polymeric waste.

Tang, K.H.D., (2023) observed that pollution from plastic was a worldwide problem that had generated growing demands for regulation. Nevertheless, the ongoing pattern of plastic usage and the inadequate management of garbage demonstrate minimal signs of being reversed. This review analyzed social perceptions of plastics, finding obstacles in human behavior that hinder efforts to decrease pollution and formulating strategies to overcome them. The study examined new material regarding attitudes and behaviors concerning pollution from plastic, consumption, and management. It also explored the ecosystem and economy of plastics recycling. The study indicated that participants usually held unfavorable opinions about the pollution caused by plastic and were inclined to take action against it by endorsing campaigns, purchasing eco-friendly alternatives, and supporting government initiatives. The primary obstacles to behavioral adjustments were the inconvenience caused by the limited availability of plastic objects and the difficulty in breaking established behaviors. Governments should use these views to effectively address plastic pollution by implementing a comprehensive strategy that promotes the methodical replacement of traditional plastics with eco-friendly alternatives and enhances the circular plastics economy.

Sunita, C., (2023) analyzed that as an eco-friendly substitute for conventional plastic packaging, sustainable packaging was becoming more and more well-liked because it lowers carbon emissions and extends the lifespan of both humans and the environment. Because most things offered on e-commerce platforms were packed in plastic, these platforms had a large negative environmental impact. As a result, e-commerce businesses had to reconsider their approaches and implement sustainable practices that give eco-friendly packaging priority. The industry's detrimental effects on the environment were to be lessened through this move toward sustainable practices. The purpose of this study was to use the Factor Analytic Approach to examine how consumers perceive sustainable packaging on e-commerce platforms. The study pinpointed important variables affecting consumers' perceptions of environmentally friendly packaging and provided suggestions for eco-friendly packaging options for online retailers. The study's analysis of consumer perceptions enabled e-commerce businesses to better understand the factors influencing their customers' choices for eco-friendly packaging. This understanding enabled businesses to implement environmentally friendly packaging practices that satisfy consumer preferences, lessen their environmental impact, and highlight their brand's support for ecological sustainability.

Walker, T.R., et.al., (2021) observed that plastic that was only used for food packaging contributed significantly to global solid waste. The food business was working to eliminate single-use plastic packaging, but it needs to understand consumer views. As consumer knowledge of single-use plastic trash exceeds private sector procedures, this study examined personal motivation, government legislation, and inventive solutions for plastic food packaging. This Canada-wide study examined 1014 customers' willingness to pay more for environmentally friendly food packaging or motivation to minimize single-use plastic waste. The majority (93.7%) were personally inspired to decrease disposable plastic food packaging. Canadians wanted to minimize disposable plastic food packaging but weren't prepared to pay for environmentally friendly alternatives. Despite not wanting to pay for sustainable packaging, Canadians preferred it to plastic bag bans because environmental issues were more important than food safety. Limitations, recommendations, and further study suggested using several influencing variables on consumer behavior and sentiments about single-use plastic food packaging.

Kautish, P., et.al., (2021) stated that the global production and consumption of plastic have resulted in substantial amounts of plastic trash, which poses a huge risk to the environment, as well as the well-being of humans and animals. This study investigated the connections between concerns about the environment, perceived consumer efficacy, connectivity to nature, affection for nature, as well as plastic consumption decision-making. The study carried out through an online survey including 745 participants from India, discovered that environmental concern and the perception of consumer efficacy are the main factors that influence the connection to and affection for nature. Among these factors, perceived consumer effectiveness was identified as the most crucial element. Environmental considerations do not have a direct impact on decision-making, but the perception of consumer effectiveness does. The connection between environmental concern, perceived consumer effectiveness, and choice behavior for the consumption of plastic in an emerging economy was influenced in part by a connection to and love of nature.

Parajuly, K., et.al., (2020) analyzed that over the past several years, there has been a significant focus on the sustainability of electrical and electronic items (e-products) due to their increasing demand, reliance on crucial resources, and the difficulties in effectively handling the associated trash (e-waste). The notion of the circular economy, which aimed to eliminate waste through improved products, practices, and business models, was highly applicable to e-products. The inherent characteristics of circular systems necessitate a collaborative endeavor involving companies, customers, and governments. Although there has been significant focus on the techno-economic aspects of a circular economy in the past few years, the impact of consumer behavior, which played a crucial role in determining the long-term viability of environmentally friendly manufacturing and consumption programs, has received less attention. This research examined the possibility of incorporating insights from behavioral science to support the implementation of circular economy principles in the management of electronic waste. This study provided an overview of well-known behavioral theories and how these might be used for sustainable consumerism and pro-environmental actions. Ultimately, the study highlighted potential avenues for behavioral interventions to enhance e-waste management and promote a more sustainable circular economy.

Ketelsen, M., et.al., (2020) examined the reactions of customers towards eco-friendly food packaging, identifying obstacles to buying and suggesting possible strategies to overcome them. After conducting a comprehensive analysis of 46 scientific articles in journals, three primary obstacles have been identified. Firstly, consumers required assistance in identifying environmentally friendly packaging. Secondly, there was a lack of awareness regarding new packaging materials, such as bio-based packaging. Lastly, numerous studies indicated that factors like price and quality are deemed more significant than environmentally friendly packaging. Several studies indicated that consumers were more inclined to purchase and pay for environmentally conscious packaging and products with less packaging, as opposed to normal packaging. This suggested a favorable attitude towards such products. Nevertheless, the examination of existing literature uncovers other areas in research that have not been well addressed. These include the insufficient comprehension of how customers react to environmentally conscious food packaging while making actual purchases, as well as the absence of strategies to overcome current obstacles. The study sought to offer a thorough comprehension of consumer views regarding eco-friendly packaging.

Khan, M.S., et.al., (2020) observed that NASA reports the average surface temperature of the planet has grown to 1.62°F during the late 19th century as a result of higher levels of emissions caused by human activities. The COVID-19 pandemic has resulted in a pollution reduction, particularly in India and China, where considerable declines have been observed. This emphasized the accountability of humanity for the escalation of pollution in the world. The objective of the study was to evaluate the efficacy of a model in influencing customer behavior toward environmentally friendly practices. There was an increasing inclination towards environmental protection through legislation, specifically in the reduction of plastic bag usage.

Nevertheless, plastic bags continue to be the prevailing and favored means of keeping possessions, making purchases, and carrying food and beverages. Analysis of data collected from consumers in Cyberjaya and Bangkok revealed that both knowledge and attitude have a substantial influence on consumer green behavior. Additionally, the implementation of a plastic bag ban had a beneficial effect on green behavior. This underscored the necessity of governmental initiatives to mitigate ecologically detrimental conduct, as consumers' understanding of the hazards was insufficient.

Boz, Z., et.al., (2020) examined the concepts of packaging sustainability had developed as sustainable development principles have been increasingly integrated into industry and organizational platforms. Nevertheless, the packaging sector was impacted by various difficulties, including pollution, waste related to packing, deteriorating water, air, and soil quality, and climate change. Companies may be deterred from adopting more sustainable packaging due to obstacles such as intricate value chains and unfavorable consumer perceptions. To inspire the future generation to adopt sustainable solutions, it was crucial to have a comprehensive grasp of consumer dynamics regarding environmental product choices, willingness to pay, recycling, and the other elements that influence sustainable behaviors. This study investigated the definitions, influence of environmentally friendly packaging in the worth chain, theories of consumer behavior, existing practices, factors that influence sustainable behaviors, and methodologies for consumer testing. The study also included three case studies that examined customer tastes and value judgments for bio-based cellulose products. It also explored the influence of on-label claims or pre-evaluation education. This study identified the areas where research was lacking and potential areas for further investigation in consumer research. Additionally, it proposed techniques for stakeholders to effectively convey the concept of packaging sustainability to consumers.

Rhein, S. and Schmid, M., (2020) noted that plastic pollution was widely regarded as one of the most significant global concerns. The utilization and frequently unregulated disposal of disposable plastic packaging was considered a significant environmental peril. While there has been extensive discussion on the involvement of businesses and politics in tackling this issue, there has been limited attention given to the role of customers. This study examined the level of consumer awareness of plastic packaging using an inductive as well as nuanced approach. Study findings indicated that consumers link plastic packaging with a multitude of issues beyond only environmental concerns. There are five distinct categories of consumer awareness. Results facilitated the acquisition of a comprehensive comprehension of consumers, hence aiding in the formulation of more efficient methods that empowered consumers to utilize plastic more sustainably.

Khan, F., Ahmed, W. and Najmi, A., (2019) investigated that the increasing worldwide plastic consumption has resulted in a substantial surge in trash and environmental hazards. Recycling can aid in mitigating these problems. The objective of the study was to determine the factors that affect consumers' intentions to return or recycle plastic waste. The concept of planned behavior was utilized to assess the factors that influence recycling behavior. A survey questionnaire was used to collect data from 243 households, which was then subjected to hypothesis testing using PLS-SEM. The study findings indicated that subjective norms, understanding of effects, and convenience are significant factors that strongly influence individuals' intention to return or recycle. Attitude-perceived behavioral regulation and moral norms had no significant effects. The act of returning items has a beneficial effect on behaviors such as reselling, reusing, disposing, and donating. The intention to recycle was the most anticipated outcome. This study was a valuable contribution to the existing body of knowledge on reverse logistics. It provided insights for governments and organizations to better comprehend consumers' intentions and develop effective methods to enhance consumer participation in recycling efforts.

Heidbreder, L.M., et.al., (2019) The overabundance of plastic manufacturing and use has significant repercussions on both the surroundings and human well-being. The diminishment of plastic had so emerged as a significant worldwide endeavor. Given that technical solutions alone may not be adequate to address the problem, it was necessary to adopt a worldview that emphasizes the influence of human behavior. The present literature review offered a comprehensive summary of the current social-scientific research on plastic, encompassing topics such as risk perception, consumer preferences, factors influencing usage behavior, as well as political and psychological intervention tactics. Through a comprehensive analysis of existing literature, our objective is to pinpoint relevant variables that might be targeted in future initiatives aimed at mitigating plastic usage. The analysis of the 187 studies revealed that individuals highly value and regularly utilize plastic, although becoming well-informed about the accompanying issues. Habits, conventions, and situational circumstances appear to have a particularly strong influence on plastic consumption habits. Both political and psychological treatments have the potential to be helpful, although the long-term outcomes are typically unpredictable. The study concluded by highlighting the importance of behavior-based approaches and future research that integrated interdisciplinary approaches and considers cultural variations.

Khan, F., et.al., (2019) noted that the increasing process of urbanization has resulted in a mounting apprehension regarding the appropriate handling of waste, specifically plastic waste. The objective of this study was to comprehend the elements that impact consumers' recycling patterns of conduct plastic garbage. A total of 243 inhabitants of Karachi, Pakistan were surveyed using partial lowest square-structural equation modeling to gather data. The study results indicated that various customer characteristics and attitudes elicit distinct forms of recycling activity. The influence of family and friends, along with the individual's perception of their ability to regulate their conduct, motivates them to resale waste plastic products. On the other hand, the individual's understanding of the negative repercussions and their attitude towards proper trash disposal encourage them to either reuse or donate the waste plastic products. Obtaining a comprehensive understanding of these consumer traits can significantly influence and shape behavioral results, leading to improved waste disposal management. This study provided valuable insights for policymakers, company managers, government/municipal, and academics/researchers who were interested in solution-focused research.

Arı, E. and Yılmaz, V., (2017) examined customer attitudes and behavior towards the utilization of plastic and cotton bags in Eskisehir, Turkey. To achieve this objective, a model of structural equations was suggested. The model incorporated latent factors such as environmental awareness regarding plastic bag usage, societal influence, advocacy for plastic bag bans, the goal to utilize cloth bags, and efforts to minimize plastic bag usage. In the structural model, the use of cloth bags and the reduction of plastic bag usage were considered endogenous latent variables. The study's findings revealed that consumers who possess a strong environmental awareness and experience societal pressure are inclined to decrease the usage of bags of plastic and instead opt for cloth bags.

Afroz, R., et.al., (2017) investigated the level of awareness, knowledge, as well as mindset toward plastic trash in Kuala Lumpur, Malaysia. It also explored the elements that motivate households to engage in the "No Plastic" program. The study utilized a model of logistic regression and determined that 35% of homes expressed willingness to participate. Individuals who possess a greater amount of knowledge and have higher levels of trust in their knowledge tend to hold a more favorable disposition toward recycling. The survey also identified reducing landfill use as the most significant motivation for plastic recycling, while generating money for charity was shown to be the least significant cause. The study findings proposed solutions for the governing body and households to promote engagement in the "No Plastic Bag" initiative.

Chow, C.F., et.al., (2017) stated that the global rise in plastic garbage was a direct consequence of economic progress and the evolving consumption and production habits of individuals. Disposing of plastic garbage has a detrimental impact on the environment and presents a significant risk to human health. Therefore, there was a strong inclination to decrease the amount of plastic garbage. Education has a crucial role in minimizing plastic waste by influencing people's understanding, mindset, and actions related to managing plastic trash. This study investigated the efficacy of three instructional methodologies (direct instruction, experiential learning, and simulation game-based instruction) in fostering changes in students' attitudes, knowledge, and behaviors regarding the management of plastic trash. This study provided a comprehensive analysis and discussion of the results.

2.2.4 Review related to the emerging technologies for the recycling of polymeric waste.

Formela, K., et.al., (2022) employed the growing emphasis on sustainable growth for the production and recycling of blends of polymers and composites can be attributed to the limited availability of petroleum sources, appropriate regulatory regulations, and heightened awareness within society. This study intended to document recent progress in the development of eco-friendly and cost-effective polymer materials using waste generated after production and use. The study provided a comprehensive description of the environmentally friendly development of three material groups: wood polymer composite materials, polyurethane foams up, and rubber recycling goods. Particular emphasis was placed on instances of commercially viable technologies that have been developed in Poland within the past five years. Additionally, the discussion also included the present patterns and constraints in the future advancement of environmentally friendly waste-derived polymer materials.

Kijo-Kleczkowska, A. and Gnatowski, A., (2022) stated that the progress of civilization necessitates technological advancements and the fulfillment of people's demands. However, it was also intrinsically linked to the escalating generation of garbage. In this study focused on the second aspect, specifically examining the recycling of plastic waste. This process involved two methods: mechanical recycling, which involves processing the waste without altering its chemical structure, and chemical recycling, which involves changing the chemical structure of the trash. Thermal recycling was a type of chemical recycling. Mechanical recycling entailed the process of shredding waste materials to obtain recyclate or granulate that conforms to precise quality standards. Chemical recycling involved breaking down the material into smaller compounds using methods such as hydrolysis, glycolysis, methanolysis with solvents, and thermal processes like hydrocracking, gasification, pyrolysis, and combustion. This allowed for the recovery of gases and liquid hydrocarbons, which can be used as fuel in the amount of energy and cement-lime industry. It also enabled the recovery of thermal energy stored in plastics. The research specifically examined thermal techniques for recycling plastics, which have gained significance as a result of legal restrictions on trash disposal in landfills. The study also examined the characteristics of polymers and their manufacturing processes in European settings.

Neo, E.R.K., et.al., (2022) stated that environmental difficulties have arisen due to the worldwide mishandling of plastic garbage, and chemical analysis has emerged as an effective method for increasing recycling rates. This study examined recent studies that utilize chemometric techniques to sort the purpose of sorting plastic garbage. It introduced spectroscopic methodologies and chemometric instruments, including mid-infrared spectroscopy (MIR),laser-induced breakdown spectroscopy (LIBS), near-infrared spectroscopy (NIR),and Raman spectroscopy. The analysis uncovered four primary discoveries: (1) Broadening the range of plastic waste by considering various types, levels of contamination, and degradation to gain a deeper understanding of its possible uses in the reuse and recycling industry; (2) Employing hybrid spectroscopic techniques to overcome the limitations of individual methods; (3) Creating a publicly accessible uniformed database of plastic trash spectrum to advance the field further; and (4) Utilizing innovative machine learning tools such as deep learning sparingly for plastic sorting purposes.

Khalid, M.Y., et.al., (2022) examined that the overutilization of artificial substances has resulted in a transition towards environmentally friendly resources and the adoption of the circular economy approach. Composite materials were extensively utilized in diverse industries, resulting in a substantial accumulation of plastic waste. End-of-life (EOL) procedures were essential for plastic composites due to their limited disposal. Polymer composite recycling approaches have two primary benefits: the ability to regulate waste consumption and the use of less energy in comparison to traditional manufacturing techniques. Thermal recycling is the optimal method for recycling glass fibers and carbon fibers due to its compatibility with the qualities of recycled materials and its lower energy requirements compared to chemical recycling. Mechanical recycling also necessitates minimal energy use. The utilization of composite substances in various industries was only justifiable provided the recycling and reutilization of composites were given equal weightage. Recycling composites made of polymers enhanced the circular economy as well.

Jiang, J., et.al., (2022) employed the accumulation of plastic garbage on a global scale has been increasing at a concerning pace for several decades. Nevertheless, conventional landfill and incinerator methods can result in air pollution and the wasteful use of precious land. Researchers have attempted to recycle plastic trash using chemical, biological, and mechanical methods to promote sustainability. Chemical recycling had garnered greater interest in comparison to mechanical and biological processes due to its ability to selectively transform plastic waste into valuable goods such as refinery feedstock, gasoline, and monomers. Chemical recycling can be categorized as gasification, pyrolysis, and solvolysis based on the specific solvent, catalyst, and product involved. This review focused on the recent advancements in chemical recycling technologies. The strong correlation between the end products and the parameters under which the reaction takes place, such as the type of reactor, catalyst, and temperature, was thoroughly explained. Concurrently, a comprehensive assessment was conducted to evaluate the environmental effectiveness and impact of chemical recycling. Eventually, the study presented the suggested obstacles and upcoming patterns in the chemical compound recycling of plastic waste. These insights assisted in the creation of catalyst and recycling systems that were relevant to the industrial sector.

Krauklis, A.E., et.al., (2021) stated that the growing demand to promote environmentally friendly composite recycling solutions had been intensified by notable occurrences, including Germany's prohibition of composite dumping in 2009, the End-of-Life (EoL) of composite wind farms, the accelerated decommissioning of aircraft due to the COVID-19 pandemic, and the increasing use of composites in mass production cars. The pressure was anticipated to intensify during the 2020s as other nations emulate Germany's prohibition of landfill alternatives and escalate the volume of expired composite end-of-life trash. Fiber-reinforced composite materials have a vital role in the future, especially in aerospace, wind energy, construction, automotive, and marine industries, to minimize environmental effects and fulfill demand. This study presented a thorough examination of recycling techniques for fiber-reinforced composites at various Technology Readiness Levels (TRL), encompassing both low and high levels. The study suggested the identification of the most efficient recycling techniques for various types of fiber-reinforced composites. The objective was to establish precise instructions for sustainable both economic and environmental solutions for the disposal of these materials at the end of their useful life, as well as to promote the advancement of recycling methods for fiber-reinforced composites.

Davidson, M.G., et.al., (2021) aimed to recycle chemicals in plastic had grown over the past decade, with Life Cycle Assessment (LCA) being essential for environmental effect analysis. The recycling of chemicals and feedstock recycling were commonly used interchangeably to refer to plastic waste pyrolysis, gasification, hydrocracking, and depolymerization. This caused literature discrepancy and hiddenness. A critical review of nine chemical recycling LCA articles indicated two modeling approaches: comparing chemical recycling systems to mechanical recycling or modeling them with other mixed plastic waste treatment methods. Chemical recycling recycles waste plastic, that was not mechanically recycled, so comparing them is pointless. LCA has been used to model pyrolysis, the most explored and frequent method, however, higher-quality data may introduce bias. Depolymerization, gasification, and hydrocracking of plastic waste study were needed to increase LCA modeling comparison data availability and quality.

Soni, V.K., (2021) observed that the increasing need for plastics has resulted in a substantial quantity of plastic garbage, which was worrisome because traditional methods for dealing with plastic waste were not sufficient. The extraction of primary resources for the synthesis of polymers additionally contributed to the exhaustion of finite petroleum reserves and the formation of trash. Scientists utilized sophisticated thermochemical recycling methods to create intermediate substances in the petrochemical sectors, including fuels, value-added goods, and monomers. These processes have the potential to contribute to the establishment of a circular economy. This study focused on current advancements in the field of waste plastics pyrolysis, specifically discussing the reactivities of the process, the distribution of products, the roles of catalysts, and the operational parameters involved. The study also examined the practice of combining plastic trash alongside radioactive substances, heavy petroleum residue, and biomass. The review also examined the motion and mechanistic features of plastic pyrolysis, as well as its used as a fuel or fuel additive. Additionally, it compared several chemical recycling systems that were available.

Hasan, M.M., et.al., (2021) observed that the included up-to-date information on the process of extracting energy from municipal solid waste (MSW) utilizing pyrolysis technology. Pyrolysis is an innovative and straightforward method of generating energy by turning municipal solid waste (MSW) into biofuel. The rotary pyrolysis process was widely employed for municipal solid waste (MSW) pyrolysis because of its efficient heat transmission capabilities and low use of energy. The primary focus of research in MSW pyrolysis was the temperature parameter, as it has been observed that intermediate temperatures tend to result in the highest bio-oil outputs. The interplay of several parameters might influence the pyrolysis process. Pyrolysis facilities ought to be outfitted with emission control devices to ensure that the operation is environmentally sustainable. In general, the process of MSW pyrolysis produces approximately 43% bio-oils, 27% biochar, as well as 25% syngas. Therefore, pyrolysis has been promised as a viable and environmentally benign method for producing biofuel and other valuable products from municipal solid waste (MSW).

Chanda, M., (2021) employed that recycling polymers was a favored method for reducing waste and landfill use, as well as for recovering valuable materials. Tertiary methods of recycling, specifically chemical recycling, have been thoroughly examined. Each recycling pathway was carefully evaluated based on its chemical foundation and potential usefulness. The recycling challenges associated with commonly used commodity polymers, including polyesters, polyamides, polyurethanes, epoxies, poly(vinylchloride), polystyrene, and polyolefins, have been examined in detail. Both conventional and unconventional methods with promising potential, such as microwave irradiation, ionic liquids mediation, enzymatic degradation, and treatment in supercritical liquids and superfluids, have been discussed individually. Furthermore, this study emphasized the current focus on novel and developing technologies that were being extensively studied. These methods included tandem hydrogenolysis/aromatization, cross-alkane metathesis (CAM), dynamic covalent bonding, and trimer-based recycling.

Adegoke, S.O., et.al., (2021) stated that as fossil fuels deplete, their uncertain sustainability. Biofuel from plastic and biomass solid wastes was another option. Much research has examined these alternatives' implementation. Thus, the study integrated multidisciplinary research to advance the production of biofuel for sustainable energy. This study covered biofuel production scientists' needs, including government legislation, feedstock selection, conversion methods, and ASTM biodiesel property criteria. For massive biofuel production, microbiologists, biochemists, and engineers must collaborate to discover innovations, cultivate cells, comprehend algae strain genetic engineering and optimize biofuel production. The plastic solid waste recycling and reuse process was reviewed. This ensured that using plastic solid waste for energy will not waste energy. The study evaluated ASTM bio-oil standards for property analysis. The plastic trash not used in biofuel production can be examined to reduce environmental pollution.

Zhang, F., et.al., (2021) stated that the conventional methods for treating non-biodegradable plastic waste (NPW) include landfill and incineration. However, these methods encountered obstacles and were not able to adequately address NPW issues. Consequently, numerous sophisticated NPW methods of treatment have been documented. This review provided a comprehensive overview of the latest advanced technologies for NPW treatment. It examines their mechanisms and present stage of development and offers insights into their potential industrial applications by considering the gap between their current development state and the requirements of the industry. The technologies were categorized into two main strategies: recycling and degrading. Recycling technologies can be divided into three subtypes: energy recovery, resource recovery, and physical recycling. Degradation technologies can be classified into two types: oxo-biodegradation, and biodegradation. Oxo-biodegradation can be classified into two categories: biotic degradation, and abiotic degradation. Abiotic degradation encompasses several strategies such as thermodegradation, mechanochemical degradation, photodegradation, and other degradation methods. This study provided a thorough summary of the mechanisms involved in pyrolysis and photodegradation. The objective of the study was to offer readers a thorough introduction to several modern NPW treatment technologies, allowing them to grasp the current state and prospects of the technology.

Thiounn, T. and Smith, R.C., (2020) observed that the worldwide production and use of plastics have surged at a concerning pace in recent decades. The proliferation of widespread and enduring plastic garbage has correspondingly escalated in both landfills and the natural surroundings. The urgent and imperative challenges posed by plastic waste/pollution necessitate prompt and resolute measures. Only nine percent of plastic garbage in the USA was effectively recycled in 2015. The primary recycling methods now prioritize mechanical devices recycling of plastic trash. Nevertheless, this process was constrained by the need to select and pretreat plastic waste, as well as the deterioration of plastics that occurs during the process. The recycling of chemicals in plastic waste offered a viable alternative to traditional mechanical techniques. An effective chemical recycling process would enable the creation of raw materials for a range of applications, such as fuels and chemical feedstocks, as substitutes for petrochemicals. The study specifically examined the latest developments in the chemical recycling of three primary polymers frequently encountered in waste plastic: PET, PE, and PP. The study discussed commercial methods for recycling hydrolyzable polymers such as polyamides, polyesters, polyolefins, and mixed waste streams.

Solis, M. and Silveira, S., (2020) observed that chemical recycling showed great potential in minimizing waste and emissions of greenhouse gases, while also fostering a circular economy. The European Union (EU) has set a goal to achieve complete recycling of all plastics by the year 2030. However, it was important to note that domestic packaging waste was frequently of inferior quality and did not perform as well. This research assessed the efficacy of chemical recycling methods and determined the most appropriate methods for recycling home plastic waste. The cost and attractiveness of a chemical process were evaluated by comparing eight technologies based on their sensitivity to feedstock contamination, process temperature, and polymer breakage level. Each technology undergoes a Technology Readiness Level (TRL) examination. Based on the investigation, it has been determined that pyrolysis, catalytic cracking, and conventional gasification are the most appropriate technologies for chemical plastic recycling. Nevertheless, the economic viability of these ventures was hindered by the scarcity of both suitable projects and reliable data. The study findings were essential for governments and developers who were establishing recycling goals and contemplating investment in study and chemical plastic recovery facilities.

Vollmer, I., et.al., (2020) stated that to enhance the flow of recycled plastic, a method beyond the conventional process of melting and re-extrusion was required. Several chemical recycling methods showed significant potential for improving recycling rates. This Review provides a concise overview of several chemical recycling methods and evaluates them using life-cycle analysis. Additionally, it included a comprehensive compilation of procedures established by companies involved in chemical recycling. We demonstrate that each of the presently accessible methods is suitable for particular plastic waste streams. Therefore, the issue of plastic waste could only be effectively tackled through the integration of several technologies. Research should prioritize the study of waste streams that were both more realistic and more contaminated, as well as those that were mixed. Additionally, efforts should be made to enhance the collecting and sorting infrastructure, which can be achieved through the implementation of stronger regulations. The study was to encourage scientific and innovative efforts in producing plastic recycling methods that result in higher quality and value products. These products should be appropriate for reuse or valorization, hence creating the economic and environmental incentives needed to promote a circular economy.

Fatima, Z., (2019) observed that the global consumption of plastic products was increasing steadily, leading to a significant rise in solid waste management as a serious environmental issue worldwide. The strategy for the utilization and disposal of polymers was not sustainable due to their high durability. Microplastics, which were partially digested remnants of these plastics, were collected as waste in landfills and natural ecosystems due to their long-lasting presence in the surroundings for a million years. The widespread availability, affordability, and versatility of plastics make them highly desirable polymers. However, their proper disposal through specialized technology appears to be the only viable solution to reduce pollution in the next decades. Recycling, as a waste management tactic, offered the potential to decrease the utilization of petrochemical products and enhance environmental conditions. Utilizing large plastic waste in solid and Wood Plastic Composites (WPC) presents an intelligent strategy for addressing the issue of waste disposal. The advancement of novel construction materials with recycled plastics was crucial for both the construction and plastic recycling sectors.

Raheem, A.B., et.al., (2019) examined different chemical depolymerization methods for recycling chemically synthesized polyethylene terephthalate (PET) bottles of plastic trash and proposed strategies to mitigate the environmental issues arising from its use and disposal in the environment. The awareness to remove pollutants from the environment and make it more environmentally friendly required the recycling and processing of materials such as PET bottles, glycolate, unsaturated poly resins, epoxy resins, composites, and other related items. Controlling this required several reprocessing processes, with chemical recycling being the most successful one, as it transforms PET into monomer/oligomer. This study provided a comprehensive analysis of the latest developments in PET chemical recycling by the glycolysis method. The study focused on the ongoing development of reaction conditions, depolymerization agents, reaction dynamics, catalysts, reprocessing products, and potential applications. The advantages of PET recycling and glycolysis, as well as the criteria and parameters used to determine their effectiveness as the primary technique and sub-method, were emphasized. The potential for transforming glycolate into various products through PET recycling technologies was demonstrated. The recycling of PET was determined to be a partial answer to waste management, as well as promoting the preservation of natural petrochemical resources and energy.

Zhao, Y.B., et.al., (2018) examined the beginning of synthetic plastic, the worldwide manufacturing and utilization of plastic have been steadily on the rise. However, due to the durability and slow degradation of plastic materials, they persist as waste for a significant amount of time. Excessive usage, improper disposal, and indiscriminate littering of plastics lead to pollution, hence resulting in significant environmental repercussions. Currently, only a small portion of waste plastics gets repurposed and processed for recycling. Recycling plastics is indeed a significant issue due to technical obstacles and very inadequate financial returns, particularly when dealing with mixed plastics. This evaluation examines a process that is both ecologically friendly and has the potential for profitability. The method involved separating and recovering polymers and extracting solvents. The methods used were dissolution/reprecipitation and supercritical fluid extraction, both of which yielded recovered plastics of excellent quality that were similar to virgin materials. The following approaches were summarized and described using manufactured plastics (PC, PET, PS, ABS, PVC, and Polyolefins) as specific examples. The technology was exploited by elaborating on the standard and effectiveness of solvent extraction. The solvent extraction technology was more viable and environmentally friendly for addressing plastic concerns and polymer markets as it overcomes these technological obstacles.

Kaiser, K., et.al., (2017) aimed to combine polymer performance, multilayered packaging materials are often polymer-based. Through this method, packaging concepts were customized to safeguard sensitive food goods and improve shelf life. Multilayers were burnt or landfilled due to their poor recyclability, hindering the circular economy and petroleum products' independence attempts. The European multilayered packaging market and Germany's postconsumer multilayer waste from packaging end-of-life were covered in this review. The primary section provides an overview of multilayer packaging system material recycling research. One subsection discussed delamination or selective dissolution–reprecipitation methods for component separation, and the other discussed compatibilization of non-miscible polymer types for recycling. Packaging delamination has not been researched as much as compatibilization and dissolution–reprecipitation. All the proposed techniques can recycle multilayered packaging but have limitations or significant energy costs.

Datta, J. and Kopczyńska, P., (2016) observed that plastics were extensively utilized because of their robustness, convenient manipulation, lightweight characteristics, and cost-effectiveness in manufacturing. Nevertheless, their inability to decompose naturally makes them a significant environmental concern. The amount of plastic trash generated by consumers after use has increased, and potential solutions for managing this waste include redesigning products, reprocessing the garbage, and recycling it. Recycling aided in the preservation of resources from nature, as polymeric substances were derived from petroleum and natural gas. The four primary recycling methods were recycling, reusing chemical recycling, mechanical recycling, and recovery of energy. Mechanical recycling transforms discarded polymers into fresh goods, whereas chemical recycling converts discarded polymers into raw materials for the manufacturing of chemicals, monomers, or fuels. At now, chemical recycling is the predominant method for recovering polymers. The manuscript provided a comprehensive literature analysis of chemical recycling techniques for different polymers, such as polypropylene, polyethylene poly(ethylene terephthalate), polycarbonate, and polyurethane. The study examined the impact of the parameters of the reaction on the outcomes, the catalysts and agents employed, and the equipment utilized in particular chemical recycling techniques. This offered an extensive examination of the current advancements in chemical recycling techniques for different types of polymers.

Zhang, L. and Xu, Z., (2016) The advancement of recycling methods for WEEE, or waste electrical and electronic equipment, has evolved from basic disassembly and sorting to more sophisticated usage technologies that offer significant value. Over the last ten years, there have been advancements in technology that have allowed for the extraction of metals from WEEE (Waste Electrical and Electronic Equipment) through modification and innovation. Conventional recycling methods encompass pyrometallurgical technology and the use of moderate extracting agents such as ammonia ammonium, chloride medium, and non-cyanide lixiviants. These technologies provide substantial advancements in environmental conservation, enabling the extraction of more than 98 percent of copper and 70 percent of gold. Electrochemical, supercritical, and vacuum metallurgical technologies are also utilized for the recycling of WEEE. The combination of supercritical water oxidation with electro-kinetic technology achieves recovery rates of 84.2% for copper and 89.4% for lead. Additional emerging technologies were ultrasonic technological advances, molten salt oxidation technology, and mechanochemical technology. Nevertheless, these advances in technology were relatively singular and restricted as a result of the intricacy of WEEE. The report examined the limitations and flaws of each technology in terms of technological advancement and environmental conservation.

Lombardi, L., et.al., (2015) examined energy recovery from waste thermal treatment employing gasification, combustion/incineration, and pyrolysis. MSW, RDF, SRF, and some industrial wastes are also included. Synthesizing studies on energy conversion efficiency for thermal operations and waste types was the goal. Incineration with steam cycle energy recovery dominated thermal treatment. Syngas was burned in a heating system to create steam for recuperating energy in waste gasification. Energy recovery is improved via cogeneration, especially for small units. Large plants can achieve 30-31% net electrical efficiency, whereas small-medium plants can achieve 20-24%. Pyrolysis, plasma gasification, and gasification with syngas utilization in internally fueled devices were less prevalent or explored at the pilot or demonstration size and provided similar or lower energy efficiency.

Oliveux, G., et.al., (2015) examined different methodologies for reusing fiber-reinforced polymers, with a specific emphasis on the reutilization of valuable materials and the technological challenges involved. Recycled glass fibers had the potential to substitute tiny quantities of new fibers in goods but were not economically or environmentally feasible when used in large proportions. Reclaimed carbon fibers obtained from high-tech applications cannot be reintegrated into the same applications, thereby requiring the identification of new suitable applications. Materials that contain recycled fibers have distinct mechanical qualities because of their unique characteristics. This required the creation of specialized guidelines and solutions to help those who reuse these materials. The assessment also examined the process of recovering and reusing valuable products from resins, as well as the advancement of recycling thermoset resins. The financial and environmental implications of recycling composite substances are examined using the Life Cycle Assessment.

Cimpan, C., et.al., (2015) stated that the waste management of the European Union prioritized strict material recovery goals and required the implementation of elaborate programs to successfully meet these objectives. This study examined scholarly literature, case studies, and pilot projects related to the centralized sorting of recyclable items present in household garbage. The study enhanced comprehension of the evolution of substance recovery from a geographical and historical perspective. The technology for physical processing and sorting has reached an advanced stage of development, and many quality problems related to cross-contamination caused by mixing different items have been effectively resolved. Modern sorting facilities see advantages in cost efficiency and advancements in automated systems and process management. Sorting technology used for separating mixed recyclables from different collections is now being applied to improve the processing of residual municipal solid waste (MSW) in facilities. The primary incentive for centralized sorting was evident in regions where the separation of sources and distinct collection pose challenges, particularly in densely populated urban areas.

Wang, C.Q., et.al., (2015) observed the significant rise in plastic waste leads to substantial social and environmental burdens. Recycling, as a currently accessible and efficient method, serves as one of the most rapidly evolved sectors in the plastics business, effectively mitigating the adverse effects of plastic trash. Froth flotation was a viable technique for addressing the primary challenge in the recycling process, which was the segregation of plastic mixtures. This review provided an overview of the most recent research on plastic flotation. It specifically examined the distinguishing characteristics of plastic flotation in comparison to the flotation of ores. The review also discussed various tactics, methods, and principles employed in plastic flotation, as well as the flotation apparatus used. Additionally, it addressed the current issues associated with plastic flotation. Plastic flotation, as a separation process, can be categorized into four main techniques: modification of the surface, reagent adsorption, physical regulation, and gamma flotation.

Wang, R. and Xu, Z., (2014) examined substantial amounts of E-waste, or waste electrical and electronic equipment, are metallic fractions (MFs). Recycling MFs has become more popular as a result of the expanding global WEEE waste. But WEEE's non-metallic fractions (NMFs), which were contaminated with heavy metals and other harmful materials, present serious environmental dangers. Environmental protection required research on the safe removal of NMFs from WEEE and the repurposing of resources. The intractable NMFs are the main focus of this paper's evaluation of technology and methods for recycling glass and plastics from WEEE. For plastics, the pyrolysis technique uses the least amount of energy; nevertheless, because of BFRs, pyrolysis extraction of oil was troublesome. Although it uses more energy, supercritical liquids and gasification technologies have less of an impact on the environment. Recycling LCD glass is profitable for precious metals; however, recycling CRT funnel glass requires the removal of lead. Before industrial production, an environmental assessment was essential, and this included an examination of dust and noise levels.

Zare, Y., (2013) aimed the increased utilization of polymer products led to the generation of significant amounts of waste materials, which has raised public apprehension over the environment and human well-being. Nanotechnology is widely regarded as a crucial technology in the present century. Lately, numerous researchers have endeavored to advance the field of polymer recycling. This study examined the utilization of various nanofillers in recycled polymers, including PET, PP, HDPE, PVC, and others, as well as the resulting composites and blends. The study fully discussed the created nanocomposites' morphological, rheological, mechanical, and thermal characteristics, as well as the future issues associated with them. This study assessed the current state of nanotechnologies in polymer recycling, guiding future research in this promising sector.

2.2.5 Review related to the integration of polymeric waste management circular economy framework.

Pacheco-López, A., et.al., (2023) examined the imperative to transition economic models to adopt a circular resource utilization approach, given the pressing issue of waste accumulation. Constantly, new trash-to-resource alternatives were arisen to effectively complete material loops. Consequently, there was a want for technologies that could discover the most advantageous synergies for upcycling trash. A method had been created to find and evaluate waste-to-resource processing methods that were not currently being used on an industrial scale to make garbage more valuable. Ontologies for managing knowledge, graph theory and short-path methods for path generation and pre-process assessment, a Mixed-Integer Linear Programming (MILP) approach to structure optimization, and the rigorous layout, simulation, and optimization of the substitutes that showed the best performance across the previous steps are all interconnected modules that make up the proposed framework. An analysis of the management of mixed plastic trash demonstrates that chemical-based recycling and the generation of pyrolytic fuels were potentially advantageous alternatives, both from an environmental and economic perspective.

Di Vaio, A., et.al., (2023) observed the shift toward the circular economy was a multifaceted undertaking that necessitated a forward-looking approach. This study investigated the accounting and accountability practices related to the circular economy and trash management. It uncovered quantifiable economic benefits as well as various difficulties faced by both firms and governments. The study employed the diffusion of the theory of innovation and the PRISMA protocol to examine 78 publications from 2012 to 2021. The study included reports from the European Commission, Ellen Macarthur Foundation, the Council of the Environment and Infrastructure, SUN IZA, the UN Global Compact, and the Brundtland Commission. The study findings emphasized the significance of implementing sustainability, waste management, accountability, management accounting techniques, and circular economy to establish an ecosystem and accomplish the sustainable development goals outlined in the United Nations 2030 Agenda. The study examined both the theoretical and practical ramifications.

Johansen, M.R., et.al., (2022) investigated the existing linear model of plastic production, utilization, and disposal presents substantial hazards to human well-being as a result of the release of greenhouse gases and contamination of the environment. In response to these concerns, the concept of a plastic economy that circular was gaining traction, to minimize waste by implementing strategies such as the reduction, reuse, and recycling of all plastic materials. The shift to circular design, production, consumption, and waste management should be implemented throughout the whole plastics value chain. This study analyzed the current scientific research on the complete plastics value chain, with a specific emphasis on design, manufacture, usage, the end of life, and value chain. The study findings indicated that a significant amount of literature focuses on the end-of-life stage, implying that other stages were now overlooked. The study emphasized the necessity for modifications throughout the whole value chain and cross-sector coordination to guarantee comprehensive transparency. Future research should embrace a comprehensive approach, which included meticulous analysis of consequences, active participation of stakeholders, and cooperation.

D'Adamo, I., et.al., (2022) observed the European Union has incorporated waste regulations into its Horizon Europe work program sustainability in industrial sectors. The primary effect was enhanced utilization of resources. Nevertheless, waste streams exhibit variations in terms of their volume, composition, and the policies used for their management. A study was undertaken to determine the most crucial elements for each trash category. The study findings indicated that the implementation of end-of-waste solutions was of utmost significance for the categories of WEEE (Waste Electrical and Electronic Equipment) and ELV (End-of-Life Vehicles), whereas societal transformation plays a crucial role in addressing the challenges associated with MSW (Municipal Solid Waste). Hence, it was imperative to regard end-of-waste initiatives and social change as catalysts for the adoption of recycling and reusing activities. Policymakers must prioritize these policy consequences to tackle the socio-economic problems resulting from delays in implementing climate change mitigation efforts and avert more environmental disasters. This helped mitigate socio-economic problems resulting from delays in making decisions regarding climate change mitigation.

Ranjbari, M., et.al., (2021) examined the objective of this study was to present a comprehensive overview of waste management (WM) within the framework of the circular economy (CE) during the past 20 years, highlighting emerging themes, patterns, and possible avenues for further investigation. The following research questions were addressed using a mixed-method approach: how has work on work on WM changed within the CE area, what were the primary themes and patterns in WM inside the CE, and what were the potential avenues for future work on WM in the CE context? For 962 journal articles included in the Web of Science database, the synthesized bibliometric networks were examined. One bio-based waste management (WM) topic, one CE transition topic, three electronic waste topics, four municipal solid waste topics, five environmental effects and lifecycle assessment topics, six plastic waste topics, and seven demolition, and construction WM study themes were selected. In addition to supporting WM policy-makers and practitioners in the CE transition, the inclusive research landscape of WM systems can operate as a guide for future research directions. To further situate WM research efforts within the CE framework as a waste reduction strategy, additional study directions were given.

Mihai, F.C., et.al., (2021) observed that rural areas experienced significant environmental contamination as a result of industrial and agricultural operations, inadequate waste and sanitary management techniques, and subpar waste and sanitary management. These regions faced challenges in attaining each of the United Nations' Sustainable Development Goals (SDGs) as outlined in Agenda 2030. Rural communities played a dual role in the release of plastic pollution into the natural environment, both as sources and recipients. Nevertheless, there was a scarcity of research examining rural populations, emphasizing the necessity for doing a proxy evaluation of peer-reviewed literature. The study examined the impact of plastic pollution on rural populations, the sources of plastic pollution originating from rural areas, the establishment of waste management systems in countries with low or middle incomes, and the potential for implementing circular economy strategies to mitigate plastic pollution in rural regions. To mitigate risks to the environment and society and promote circular activities in rural areas globally, it was imperative to engage rural populations in future research, thereby enabling decision-makers to make informed choices.

Adami, L. and Schiavon, M., (2021) noted the implementation of concepts associated with the circular economy (CE) had resulted in a rapid proliferation of research in various disciplines. Nevertheless, there potential for improvement in the sustainability of CE initiatives, and the scientific community must give this problem more attention. This study intended to fill this void by introducing an innovative idea called circular ecology (CEL) and demonstrating its practical use in the area of waste management. The study provided a comprehensive analysis of the challenges associated with CE and offered examples of research investigations that apply the concepts of CEL. The study emphasized that CEL concepts were extensively utilized in several areas of waste management, indicating encouraging prospects for transferring the findings to different geographic situations. If governments provided support, the implementation of CEL techniques had the potential to address numerous environmental issues simultaneously, resulting in significant economic, time, resource, and emission reductions.

Priyadarshini, P. and Abhilash, P.C., (2020) stated that the global acknowledgment of a circular approach in the management of the environment increased due to the rapid depletion of resources and the harmful impacts of climate change. The study aimed to investigate the connections between sustainable development (SD) and circular economy (CE) by analyzing the impact of the sustainable energy (RE) and waste management (WM) sectors in CE, along with the implementation of policies and frameworks that promote the integration of circularity principles in the Indian context. The results indicated that research focused on energy recovery from garbage in India does not have sufficient integration with sustainable development. Additionally, the research showed that while India was highly committed to achieving the Sustainable Development Goals (SDGs), there was a need for significant efforts to incorporate Circular Economy (CE) ideas into administration. This was particularly important because the legislation for municipal, plastics, and e-waste management does not currently fit with CE principles. Combining waste management (WM) and resource efficiency (RE) strategies into a comprehensive circular economy (CE) strategy would greatly enhance the achievement of circularity and sustainable development (SD) across the Indian economy.

Tsai, F.M., et.al., (2020) aimed the methodical analysis of bibliometric data on the management of municipal solid waste, to establish the goal of establishing a basis for a circular economy. The existing literature remained incomplete due to the intricate nature of the associated notion and knowledge. Conventional bibliometric analysis cannot filter out significant words for additional directions, and the frequencies of keywords are presented in numerical form. This study utilized the entropy weight approach to transform frequencies into weights and conducted regional comparisons using a database. As a result, this study made a valuable contribution to the existing literature by offering potential avenues for future research. The database has a total of 413 published publications, with a listing of 41 indicators. The outcomes were utilized to ascertain relevant indications for enhancement and offered a regional comparison of the highest quality. The five primary indications for future investigation included incineration, life cycle evaluation, plastic trash, sorting garbage, and sustainability. A bibliographic coupling study suggested that Africa as well as North America have a lower number of research compared to other locations.

Shanmugam, V., et.al., (2020) aimed at a concise overview of the circular economy, which involves reuse and recycling in the field of additive manufacturing, or AM, of polymers. Recently, there has been a significant increase in the creation of a wide range of polymer products using additive manufacturing (AM). Additive manufacturing (AM) can offer a potential solution to enhance productivity and environmental responsibility in the circular economy by improving manufacturing processes. Applying the principles of a circular economy to AM can create efficient promotions for recycling and reutilization of polymers. Consequently, it was imperative to examine the potential for recycling and reusing polymers in additive manufacturing (AM). Ongoing research endeavors to reconstitute polymers using recycled resources. A proper end-of-life treatment was necessary because polymer waste posed a major hazard to the environment. The purpose of this study was to offer a comprehensive perspective on the reuse and recycling of additive manufacturing materials. A review was recently conducted on studies that examined remanufactured feedstock materials, polymers, and composites. The study findings indicated that there were substantial prospects for utilizing recyclable polymers in the creation of additive manufacturing products.

Ruiz, L.A.L., et.al., (2020) stated that the management of construction and demolition waste (CDW) was a pressing global concern due to its large quantity and insufficient handling, resulting in negative environmental impacts and poor rates of product recovery. The Circular Economy (CE) was a promising approach that focused on optimizing the use of resources and energy, minimizing waste, and reducing environmental harm. The objective of this study was to determine the elements that have an impact on the adoption of Circular Economy (CE) practiced in the building and demolition industry. A comprehensive literature study was done to get insights into the approaches for establishing integrated circular strategies. This study presented an economic model for the development of the circular economy for the building and demolition sector. The framework included 14 methods that may be applied across all five lifecycle phases of building and demolition operations. The framework prioritized the efficient management of waste and the reuse of materials that were recovered for secondary purposes in construction.

Mastellone, M.L., (2020) aimed the management of plastic trash as a serious worldwide problem that called for the application of circular economy principles. The field of plastic products includes industries, such as construction, biomedical, and packaging. An industrial network with sustainability, adaptability, dependability, usefulness in the industry cycle, and the capacity to provide the market with marketable goods was required to handle plastic waste. Only a small percentage of these requirements were met by conventional procedures like recycling and recovery of energy, so their effects on a circular economy must be evaluated. Plastic goods can be used thermochemically in a way which was more sustainable than using conventional techniques. The study findings demonstrated that it was possible to convert an expensive and ineffective system for managing plastic trash into a manufacturing system with inherent financial sustainability and a distinct place in the plastics value chain. By releasing valuable goods instead of low-quality materials, reducing the amount of waste that ends up in landfills, reducing greenhouse gas emissions, and maximizing resource savings, incorporating the present system with the manufacturing of petroleum-based goods can enhance the overall economic performance of the waste system.

Tomić, T. and Schneider, D.R., (2020) stated that with the "Closing the Loop" idea, which was a part of the Circular Economy Package, the EU aimed to create a resource-efficient and sustainable economy. This strategy focused on recovering and avoiding waste generation. The waste management system's structure must alter significantly to meet the new aims, which could result in higher costs for system users. The garbage, materials, and energy flow tracking framework based on the Time-dependent life cycle assessments modified to evaluate these changes. Waste management facilities' yearly cash flow was equal to zero when all revenues and costs were included. System users were assessed a system gate cost which was computed. The study findings indicated that energy recovery had lower total system costs and produced more revenue than material recovery. Scenarios that integrated both energy and material recovery and outsource this service to avoid investing in ultimate disposal/recovery facilities yield the lowest system costs. This method was a helpful tool for decision-makers and had not been applied before to evaluate the economic and social environmental sustainability of systems for managing waste.

Luttenberger, L.R., (2020) noted that although Croatia joined the European Union in 2013 and made significant investments in waste management centers that used mechanical-biological treatment to process mixed waste into refuse-derived fuel, municipal waste continues to be primarily disposed of in landfills, including regions where these centers were located. The waste management system in Croatia required significant reform to attain conformity with the circular economy. In 2016, Croatia made an effort to implement a strategic waste control document to meet circular economy goals. However, the document was significantly altered during the adoption process, ultimately preserving the original concept that was developed fifteen years ago. The study provided waste as well as circularity indications for Croatia, examined national policies, targets, accomplishments, and EU recommendations, and suggested measures that would expedite Croatia's progress towards a circular economy, the efficiency of resources, reducing marine litter in the Adriatic, and the bio-economy. The model was suitable for other countries undergoing transition and those that continue to depend on landfilling and the linear economy idea.

Smol, M., et.al., (2020) observed that the European Commission (EC) had prioritized municipal waste management, with a special emphasis on the transition toward a circular economy (CE), which was a key focus of the EU's economic policy. Poland faces challenges in meeting European trash recycling standards due to its limited infrastructure and lack of public understanding while having a low waste per capita. The study outlined suggested measures to facilitate the transformation of municipal waste management towards a circular economy (CE). These measures were categorized into the following six pillars of circularity: Loop, Regenerate, Virtualize, Optimize, exchange, and Share. Governments and residents should take certain actions to address the issue. These actions included remediation of landfills, utilizing municipal waste fractions for financial gain, sharing products with co-users, recovering waste, remanufacturing products or components, implementing virtual strategies to reduce the production of waste, and replacing household appliances with higher energy-class items. Implementing these measures has the potential to have a positive impact on the transition towards a Circular Economy in Poland and can also be extended to other nations and areas.

Sarc, R., et.al., (2019) examined that the circular economy sought to optimize resource utilization by adopting Industry 4.0 strategies in waste management. The K-project, known as Recycle and Recovery of Waste 4.0 or 'ReWaste4.0', was centered around the implementation of digitalization and robotic technology in the field of waste management. The project disseminated findings in four specific domains: Collecting and Logistics, which was Machinery and treatment of waste plants, Business models, and Data Tools. The emphasis is on methods that have the potential to be employed in forthcoming waste treatment facilities or devices to enhance the efficiency of waste treatment. Robotic technologies have a specific focus on the task of sorting mixed garbage. Smart bins equipped with sensors for substance identification or level measurement, advanced digital image processing techniques, and innovative business models have been created. These technologies frequently depend on substantial quantities of data to enhance efficiency within industrial facilities. The online market study provided a summary of managing waste industry companies' perspectives on waste management 4.0 or 'electronic readiness'.

Kerdlap, P., et.al., (2019) noted that Zero waste manufacturing (ZWM) was an approach that sought to shift countries towards a circular economy by creating technologies and systems that eradicate waste throughout the whole waste value chain through the processes of reuse and recycling. Implementing Zero Waste Management (ZWM) in densely populated urban areas such as Singapore poses difficulties due to limited land availability, low productivity, and a paucity of staff. A proposed framework is presented to tackle these problems, consisting of six key areas: zero waste design, intelligent waste audits and reduction planning, efficient waste collection, advanced processing of valuable mixed garbage, a collaboration platform for industry symbiosis, and conversion of waste into resources through recycling. A thorough literature study analyzes industrial technologies and research related to these issues to assess their potential to help ZWM. This study investigated the technological constraints of adopting ZWM (Zero Waste Management) technology in highly populated urban areas and suggested potential future research to address these obstacles.

Cobo, S., et.al., (2018) observed that lifestyle's constant degradation of natural resources cannot continue indefinitely. This challenge can be addressed in two main ways: first, by implementing waste prevention policies; second, by switching from traditional linear Integrating Waste Management Systems (IWMSs), which treat municipal solid waste (MSW) exclusively, to circular IWMSs (CIWMSs), which combined waste and materials management and encourage resource circularity. The system analytic techniques used in the design and performance evaluation of linear IWMSs were examined to pinpoint the shortcomings of these approaches, the challenges associated with using them in CIWMSs, and the areas in which more study and standardization are needed. The study results of the served as the foundation for the development of a methodological framework that was based on extending the boundaries of a typical IWMS to encompass the upstream subsystems, which represent the change of resources and their connections to the waste management subsystems, to analyze CIWMSs.

Iacovidou, E., et.al., (2017) examined operational decision-making and evidence-based policy are necessary for the shift to a circular economy. The generation and dispersion of systemic and multifunctional value spanning social, economic, environmental, and technical domains cannot be adequately addressed by existing methodologies like LCA, LCSA, and CBA. To evaluate the production, damage, and distribution of complicated value in recovering resources from waste systems, this study suggested a novel conceptual framework. This methodology offered a complete analytical framework for the shift to a resource-efficient future by fusing scientific and engineering approaches with a socio-political narrative. By combining top-down and bottom-up methods, this framework facilitated the assessment of recovering resources from waste systems while addressing systemic issues with flexibility and openness. In addition, it took into consideration the non-linear and dynamic nature of infrastructure provision and commodity flow, opening the door to a circular economy and establishing the groundwork for the next computational and assessment techniques in RRfW (Resource Recovery from Waste).

2.3 Research Gap

A notable area for future research in the field of "Innovative Polymeric waste management systems to enhance circular economy" is the creation of comprehensive frameworks that combine novel polymeric waste management techniques with various facets of the circular economy. Although the concepts of the circular economy and creative waste management techniques are gaining popularity, there are still few comprehensive strategies that successfully combine these two domains. Research on the viability and scalability of integrating polymeric handling waste systems into current circular economy frameworks is particularly needed. This entails evaluating the social, environmental, and economic viability of implementing these systems on a bigger scale. to maximize resource efficiency and traceability, there are also several research looking into the incorporation of cutting-edge technology like blockchain and artificial intelligence into polymer waste management plans. In addition, not much study has been done on how to foster interdisciplinary partnerships between government, business, academia, and civil society to jointly design and execute cutting-edge polymeric waste management strategies. Closing these gaps would help us get closer to a more circular society while also advancing our knowledge of environmentally friendly waste management techniques.

2.4 Chapter Summary

This chapter explores different facets of polymeric waste management, including the difficulties encountered by industry, inventive management systems, consumer perspectives, developing recycling technologies, and the incorporation of a circular economy framework. The initial segment focuses on the difficulties faced by industries in efficiently handling polymeric waste, with a particular emphasis on problems such as insufficient infrastructure, restricted recycling technology, and regulatory obstacles. Continuing, the analysis examines new and creative methods for managing polymeric waste, such as innovative recycling procedures, sophisticated sorting systems, and sustainable packaging options. This study provided an in-depth examination of consumer opinions, actions, and knowledge surrounding polymeric waste. It explores the elements that impact consumer decision-making, recycling practices, and the significance of awareness efforts. The chapter subsequently explores novel technologies for recycling polymeric waste, including recycling chemicals, polymers that degrade, and modern materials recovery procedures, emphasizing their capacity to transform waste management practices. The study examined the incorporation of a circular economy model into the management of polymeric waste and highlighted the significance of resource effectiveness, closed-loop systems, and increased producer accountability in establishing an environmentally friendly waste management ecosystem.

CHAPTER III:

RESEARCH METHODOLOGY

3.1 Overview

The research methodology refers to the scientific procedure that is utilized to conduct a systematic study to achieve results that are accurate and thorough in a research endeavor. The research methodology serves the objective of delineating and appraising diverse methodologies employed in scientific investigation. Therefore, it is crucial to establish the fundamental assumptions of these methodologies. To address a research problem, the appropriate data must be collected using the appropriate procedures, and conclusions must be made based on the results (Murthy & Bhojanna, 2010).

The chapter represents the research methods that were used to gather the data as well as the multiple tests so that the obtained data could be used to empirically analyze the hypotheses that were developed from the literature review as per the study's objectives. The current chapter contains a description of the methods that the study utilized to carry out the specified study task. It provides information in great depth regarding the sample design, research design, source of data, and analytical methods that were utilized in the study. The study has been conducted in India. The country's innovative policies for waste management make it an ideal place to study how these innovations in polymeric waste management systems help to enhance the circular economy.

3.2 Operational Terms

3.2.1 Polymeric Waste

Polymeric materials, such as plastics and rubbers, are becoming a bigger component of the trash found in landfills due to inadequate management and accumulation. Due to their resistance to decomposition, the disposal of waste polymers is a significant and enduring environmental issue. Most plastics slowly break down into microparticles, eventually reaching the oceans (da Silva & Wiebeck, 2020).

3.2.2 Circular Economy

A circular economy involves creating market systems that provide incentives for the reuse of items rather than disposing of them and extracting new resources. In this type of economy, all types of garbage, including clothing, scrap metal, and outdated electronics, are either reintegrated into the economy or utilized in a more effective manner (Corvellec, et al., 2022).

3.2.3 Polymeric Waste Management

Polymeric waste management encompasses the methods and techniques employed to efficiently handle, recycle, and dispose of polymer-derived substances, usually referred to as plastics. The escalating consumption and production of plastics on a global scale has led to a notable environmental issue, which is the persistence of polymeric waste in the environment and its harmful impacts on ecosystems and human health (Fink, 2018).

3.2.4 Sustainability

Sustainability refers to the enduring feasibility of a community, a collection of social institutions, or a societal practice over an extended period of time. Sustainability is commonly defined as a principle of intergenerational ethics. It entails that the environmental and economic decisions made by current individuals should not limit the potential of future individuals to experience comparable levels of wealth, utility, or well-being (Farley & Smith, 2020).

3.3 Objectives and Hypothesis

3.3.1 Objectives of the study

Obj-1. To identify the impact of challenges, such as technological limitations, regulatory barriers, and market constraints, faced by industries in effectively managing polymeric waste within the circular economy framework

Obj-2. To assess the environmental, economic, and social factors influencing the adoption of innovative polymeric waste management systems.

Obj-3. To Examine consumer attitudes, behaviors, and awareness regarding polymeric waste and circular economy initiatives and their influence on adoption rates of innovative waste management solutions.

Obj-4. To investigate emerging technologies for the recycling of polymeric waste.

Obj-5. To explore how innovative polymeric waste management can be integrated into a circular economy framework.

3.3.2 Hypothesis of the Study

H1: There is a significant impact of challenges, such as technological limitations, regulatory barriers, and market constraints, faced by industries in effectively managing polymeric waste within the circular economy framework.

H01: There is no significant impact of challenges, such as technological limitations, regulatory barriers, and market constraints, faced by industries in effectively managing polymeric waste within the circular economy framework.

H2: There is a significant impact of environmental, economic, and social factors on the adoption of innovative polymeric waste management systems.

H02: There is no significant impact of environmental, economic, and social factors on the adoption of innovative polymeric waste management systems.

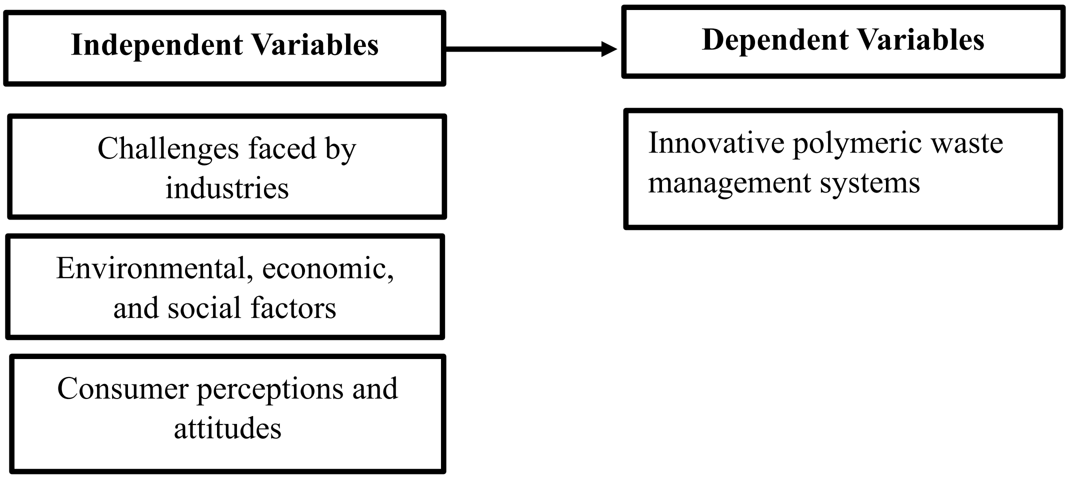
H3: Consumer perceptions and attitudes regarding polymeric waste and circular economy initiatives significantly influence the adoption rates of innovative waste management solutions.

H03: Consumer perceptions and attitudes regarding polymeric waste and circular economy initiatives do not influence adoption rates of innovative waste management solutions.

3.4 Conceptual Framework

The conceptual framework visually represents the connections and interactions among variables. It defines the important objectives of the study and illustrates dependable and cohesive results. Figure 3.1 represents the conceptual framework for the study:

Figure 3.1: Conceptual Framework



Source: Created by the Author based on Research

3.4.1 Independent Variables

An independent variable in a study is modified or manipulated to examine its effects on the dependent variables. Its independent status denotes the fact that it is unaffected by any other study variables. The independent variables in the study are the “environmental, economic, and social factors, challenges faced by industries and consumer perceptions and attitudes”.

3.4.2 Dependent Variables

The variable that is evaluated and altered as a consequence of the operation is known as the dependent variable. The dependent parameter's behavior is influenced by the independent parameter. Anytime a thing depends on an independent variable, it is said to be dependent. A dependent variable alters when an independent variable changes. In statistics, dependent variables and response variables are commonly used interchangeably. The dependent variable is “innovative polymeric waste management systems” in the study.

3.5 Research Design

The research design of a study refers to the methodical and comprehensive plan for gathering, analyzing, and interpreting the results. The study has employed a mixed-methods research design, which provides an integrated and adaptable approach to integrating both quantitative and qualitative methods. It has allowed for a comprehensive understanding of the “innovative polymeric waste management systems to enhance the circular economy.

3.6 Target Population and Sample

The term "target population" encompasses the complete set of individuals, items, or features that satisfy specific criteria that are of relevance to the researcher. Manufacturers and consumers of the polymer industries have been targeted to study the “innovative polymeric waste management systems aimed at enhancing the circular economy” due to their pivotal roles as manufacturers influence waste generation through production practices, while consumers directly contribute to it through consumption habits.

The population being studied in the present study is not specified, however, the characteristics of the population have been clearly defined. To determine the sample size, Cochran's (1977) formula has been used:

$$n = \frac{z^2}{4e^2}$$

$$n = \frac{(1.96)^2}{4(0.05)^2} = 384.16$$

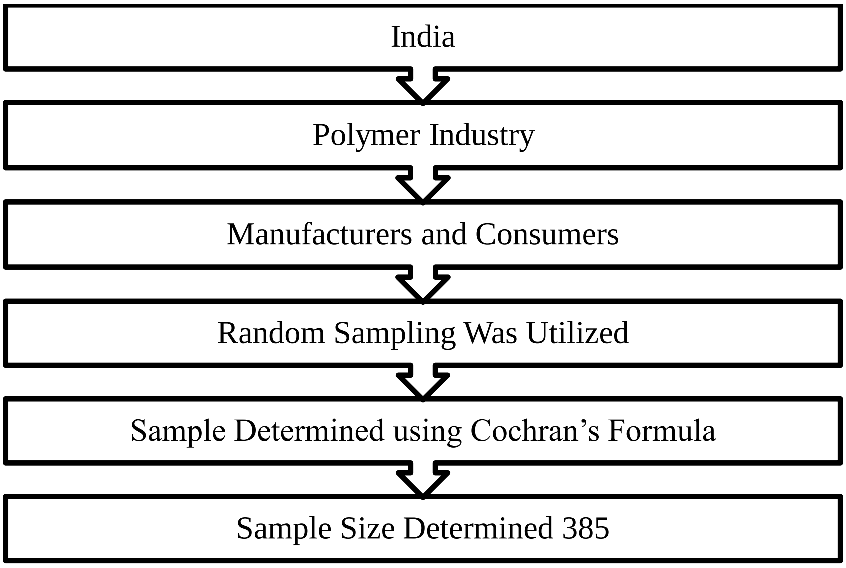
Where, n = “Sample size.”

e = “The desired level of precision (i.e., the margin of error).”

z = “Z-value (1.96 for 95% confidence level)”

Based on the formula, the study utilized a total of 385 respondents. The study employed a sample size with a "95% confidence level and a 5% margin of error".

Figure 3.2: Sample Process



Source: Created by the Author based on Research

3.7 Participant Selection

Participant selection includes the process of selecting individuals or groups to participate in a study based on certain criteria. “Random sampling method,” has been used for choosing the respondents from the target population. The intent of the statistical method known as "random sampling" is to guarantee that each participant of the larger population has an equal opportunity of being chosen from among all of the participants.

3.8 Instrumentation

An instrument for gathering, measuring, and analyzing data related to research objectives is called a research instrument. For the current study questionnaires have been utilized for the collection of the primary data. A questionnaire is an instrument used in surveys and statistical studies to collect data from respondents. It consists of a list of questions.

a) Based on Personal Information

In the personal information section, respondents are required to provide information about themselves, including their age, educational background, gender, location, income and awareness of the circular economy.

b) Based on Variables

Questions intended to collect data from respondents that examine the study's hypothesis and objective are included in this section, the current set of questions was derived from the following variables:

- Adoption of innovative polymeric waste management systems.
- Challenges faced by industries.
- Environmental, economic, and social factors.
- Consumer perceptions and attitudes.

3.9 Data Collection Sources

Data collection involves obtaining and evaluating information on relevant factors in a methodical manner to address particular research inquiries, test hypotheses, and evaluate outcomes. The primary and secondary sources are the two sources of the information. Primary data collection involves gathering data firsthand for specific study objectives. Secondary sources are already collected data that has been used for a different purpose by another researcher.

The study collected data from both primary and secondary sources, with the questionnaire serving as the major source of primary data, and secondary data has been sourced through annual reports, financial databases, company websites and press releases, journals, books, and study-related websites.

3.10 Data Analysis

3.10.1 Statistical Tool

The statistical tools utilized in the current study were Excel from Microsoft and SPSS 26 (Statistical Package for Social Science) from IBM.

a) Excel

Microsoft spreadsheets are a method for arranging data and numbers using calculations and activities. Businesses use Microsoft Excel assessment to create their financial statements worldwide. Data organization and financial analysis are two frequent uses of Excel. It helped in organizing the responses gathered from the respondents of the questionnaires.

b) SPSS 26

Statistical data are analyzed using a statistical data analysis program, such as "IBM SPSS Statistics (Statistical Package for the Social Sciences)." Despite its roots in the social sciences, SPSS is used today in various other data-driven businesses. In many different industries, including marketing, education, and medical research, SPSS is frequently utilized. SPSS may handle a variety of different data types.

3.10.2 Statistical Techniques

There were many statistical techniques available, but the ones that were selected included mean, SD, and regression based on the objectives.

a) Mean

The mean, often known as the average, is a frequently used statistic. The general trend in the data may be determined with relative ease by calculating the mean. Dividing the sum of all the data points by the total value of the data set yields the average.

$$\frac{Addition\ of\ all\ Values}{Number\ of\ values}$$

b) Standard Deviation

Another extensively used statistical technique is the calculation of standard deviation. It calculates how far each data point is from the overall average. It indicates the degree to which the data in the collection are dispersed around the mean.

$$\sigma = \sqrt{\frac{\sum x_i - \mu^2}{N}}$$

c) Regression Analysis

A linear relationship between X, the predictor factors, and Y, the result variables, can be examined and established by regression analysis.

$$Y = mx + b$$

3.11 Research Limitations

- It is impossible to completely assure the possibility that respondents remain unbiased in their opinions.
- The study will be limited to 385 participants only.
- The study will be limited to manufacturers and consumers of polymer industries only.

3.12 Research Metrics

Table 3.1: Research Metrics

Research Objective	Hypothesis	Data Required	Data Method Collection	Data Analysis
To identify the impact of challenges, such as technological limitations, regulatory barriers, and market constraints, faced by industries in effectively managing polymeric waste within the circular economy framework	**H1:** There is a significant impact of challenges, such as technological limitations, regulatory barriers, and market constraints, faced by industries in effectively managing polymeric waste within the circular economy framework. **H01:** There is no significant impact of challenges, such as technological limitations, regulatory barriers, and market constraints, faced by industries in effectively managing polymeric waste within the circular economy framework.	Respondents' Feedback	Primary	Mean, SD, Regression
To assess the environmental, economic, and social factors influencing the adoption of innovative polymeric waste management systems.	**H2:** There is a significant impact of environmental, economic, and social factors on the adoption of innovative polymeric waste management systems. **H02:** There is no significant impact of environmental,	Respondents' Feedback	Primary	Mean, SD, Regression

	economic, and social factors on the adoption of innovative polymeric waste management systems.			
To Examine consumer attitudes, behaviors, and awareness regarding polymeric waste and circular economy initiatives and their influence on adoption rates of innovative waste management solutions.	**H3:** Consumer perceptions and attitudes regarding polymeric waste and circular economy initiatives significantly influence the adoption rates of innovative waste management solutions. **H03:** Consumer perceptions and attitudes regarding polymeric waste and circular economy initiatives do not influence adoption rates of innovative waste management solutions.	Respondents' Feedback	Primary	Mean, SD, Regression
To investigate emerging technologies for the recycling of polymeric waste.	-	Descriptive	Secondary	-
To explore how innovative polymeric waste management can be integrated into a circular economy framework.	**-**	Descriptive	Secondary	-

Source: Created by the Author based on Research

3.13 Chapter Summary

The chapter provides a detailed overview of the systematic approach employed to investigate innovative polymeric waste management systems within the framework of enhancing the circular economy. By delineating fundamental assumptions and objectives, the chapter underscores the importance of employing appropriate methodologies to achieve accurate and thorough results. Through a mixed-methods research design, incorporating both qualitative and quantitative methods, the study aims to comprehensively understand the dynamics of polymeric waste management and its integration into the circular economy. By targeting manufacturers and consumers within the polymer industries in India, the research seeks to assess the impact of various challenges and factors on the adoption of innovative waste management solutions. Utilizing Cochran’s formula, a sample size of 385 participants is determined for the study, with random sampling ensuring representation from the target population. The data collection process involves both primary and secondary sources, with questionnaires serving as the primary instrument for gathering firsthand information. Statistical tools such as Excel and SPSS are utilized for data analysis, employing techniques such as mean, standard deviation, and regression. Despite certain limitations inherent to the research design, the study aims to contribute valuable insights into the effective management of polymeric waste within the circular economy paradigm.

CHAPTER IV:

DATA ANALYSIS AND INTERPRETATION

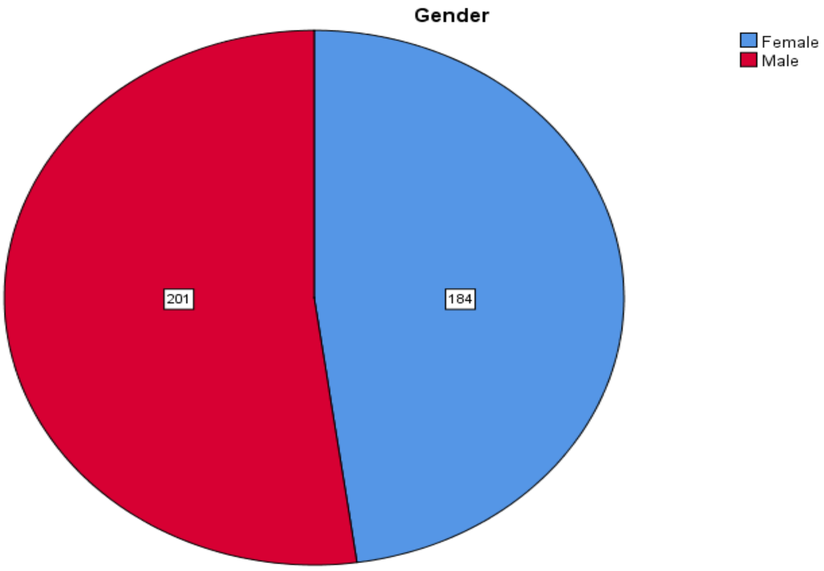
4.1 Results Based on Demographic Characteristics

Table 4.1: Gender of the respondents

Gender					
		Frequency	Percent	Valid Percent	Cumulative Percent
ssssss Valid	Female	184	47.8	47.8	47.8
	Male	201	52.2	52.2	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.1: Gender of the respondents



Source: Created by the Author based on Research

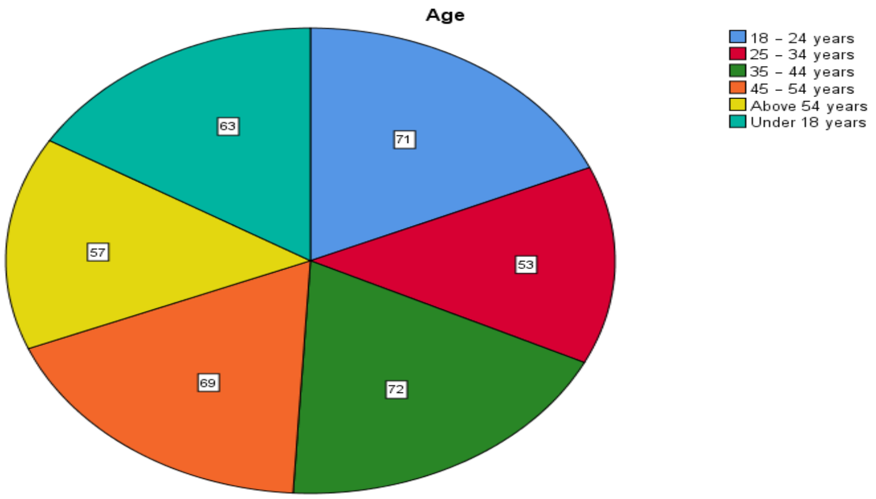
The above table 4.1 and pie chart (figure 4.1) define the gender of the respondents. According to Table 4.1, it is observed that, out of 385 respondents selected for the study, 201 are males who constitute 52.2%, and 184 are females who form 47.8% of the total sample respondents.

Table 4.2: Age of the respondents

Age					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	18 – 24 years	71	18.4	18.4	18.4
	25 – 34 years	53	13.8	13.8	32.2
	35 – 44 years	72	18.7	18.7	50.9
	45 – 54 years	69	17.9	17.9	68.8
	Above 54 years	57	14.8	14.8	83.6
	Under 18 years	63	16.4	16.4	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.2: Age of the respondents



Source: Created by the Author based on Research

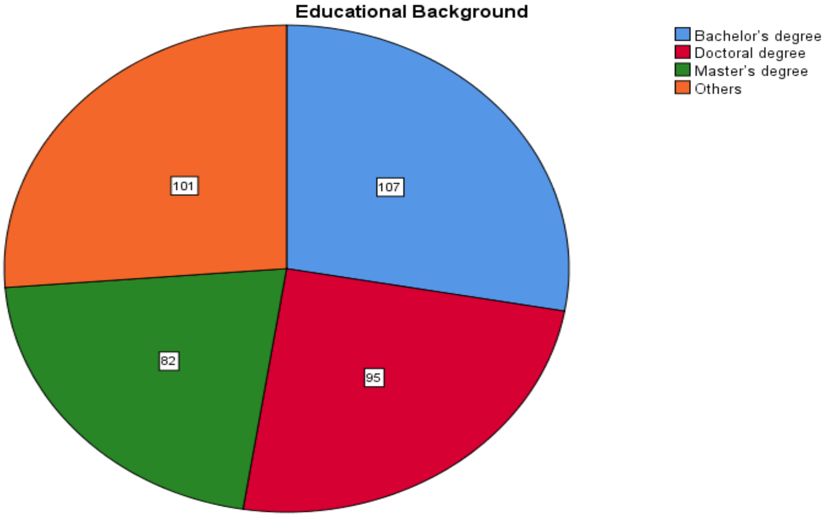
The above table 4.2 and pie chart (figure 4.2) define the age of the respondents. According to table 4.2, it is observed that, out of the 385 respondents selected for the study, 16.4% of the respondents are from the age group of under 18 years, 18.4% of the respondents are from the age group of 18 – 24 years, 13.8% of the respondents are from the age group of 25 – 34 years, 18.7% of the respondents are from the age group of 35 – 44 years, 17.9% of the respondents are from the age group of 45 – 54 years, and the remaining 14.8% of the respondents are from the age group of above 54 years. The age group is between 35 – 44 years with the highest (18.7%) of the sample respondents.

Table 4.3: Educational background of the respondents

Educational Background					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Bachelor’s degree	107	27.8	27.8	27.8
	Doctoral degree	95	24.7	24.7	52.5
	Master’s degree	82	21.3	21.3	73.8
	Others	101	26.2	26.2	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.3: Educational background of the respondents



Source: Created by the Author based on Research

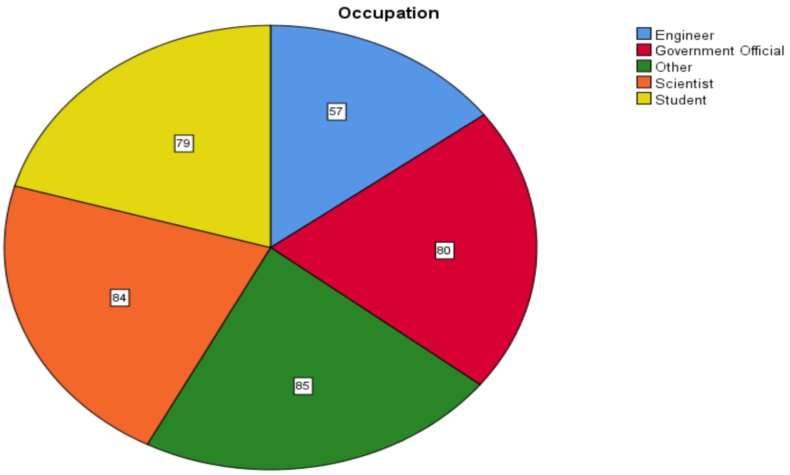
The above table 4.3 and pie chart (figure 4.3) define the education background of the respondents. It is observed from table 4.3 that out of 385 respondents, 27.8% of the respondents are bachelor’s degree holders, 21.3% of the respondents are master’s degree holders, 24.7% of the respondents are Doctorates, and the remaining 26.2% of the respondents are other degree holders. It is understood that the majority of the respondents are bachelor’s degree holders (27.8%).

Table 4.4: Occupation of the respondents

Occupation					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Engineer	57	14.8	14.8	14.8
	Government Official	80	20.8	20.8	35.6
	Other	85	22.1	22.1	57.7
	Scientist	84	21.8	21.8	79.5
	Student	79	20.5	20.5	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.4: Occupation of the respondents



Source: Created by the Author based on Research

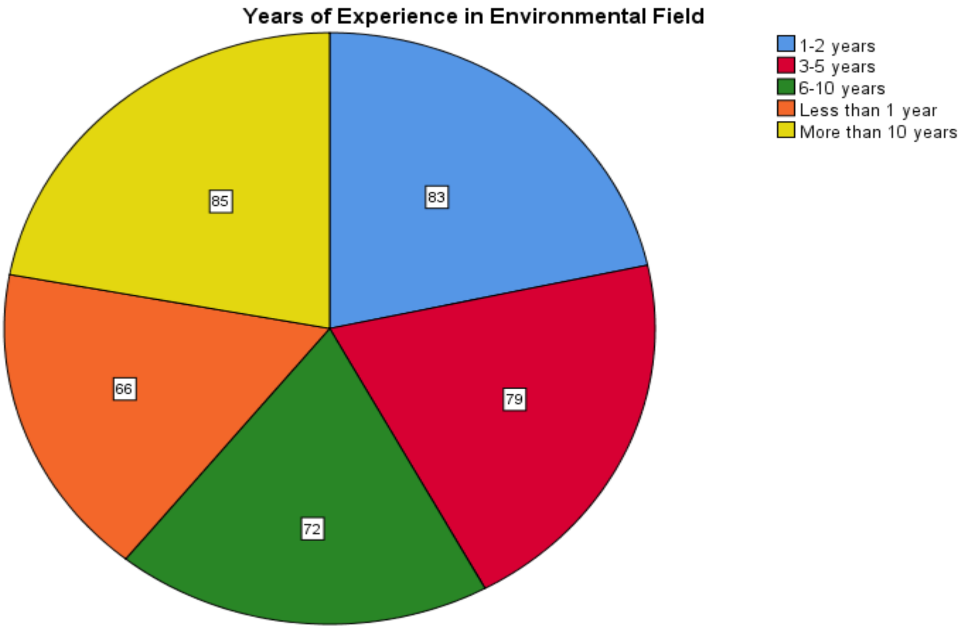
The above table 4.4 and pie chart (figure 4.4) define the occupation of the respondents. It is observed from table 4.4 that out of 385 respondents, 14.8% of the respondents are engineers, 20.8% of the respondents are government officials, 21.8% of the respondents are scientists, 20.5% of the respondents are students, and the remaining 22.1% of the respondents belongs to others. It is understood that the majority of the respondents belongs to others (22.1%).

Table 4.5: Years of Experience in Environmental Field of the respondents

Years of Experience in Environmental Field					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1-2 years	83	21.6	21.6	21.6
	3-5 years	79	20.5	20.5	42.1
	6-10 years	72	18.7	18.7	60.8
	Less than 1 year	66	17.1	17.1	77.9
	More than 10 years	85	22.1	22.1	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.5: Years of Experience in Environmental Field of the respondents



Source: Created by the Author based on Research

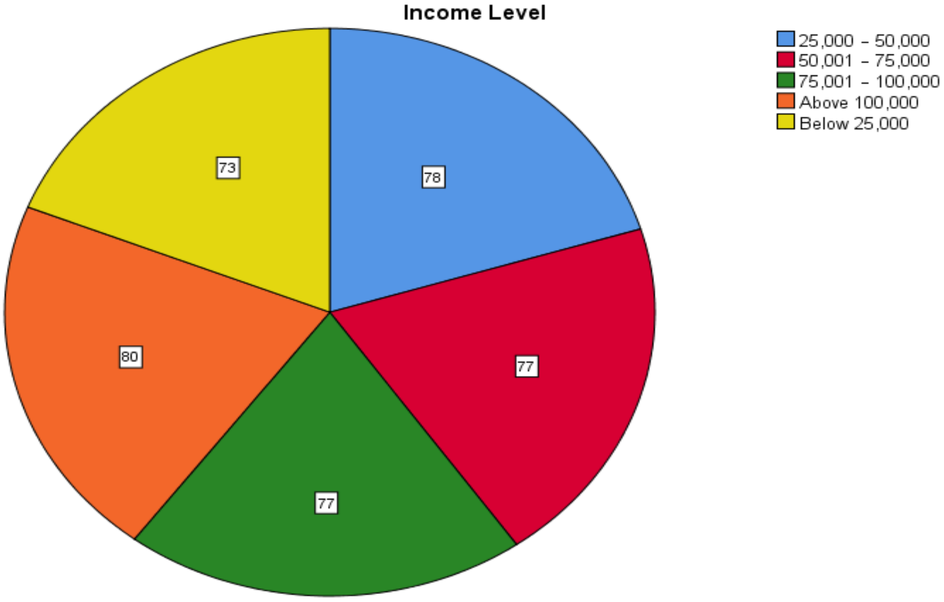
The above table 4.5 and pie chart (figure 4.5) define the years of experience in environmental field of the respondents. It is observed from table 4.5 that out of 385 respondents, 17.1% of the respondents have an experience of less than 1 year, 21.6% of the respondents have an experience of 1 – 2 years, 20.5% of the respondents have an experience of 3 – 5 years, 18.7% of the respondents have an experience of 6 – 10 years, and the remaining 22.1% of the respondents have an experience of more than 10 years. It is understood that the majority of the respondents have an experience of more than 10 years (22.1%).

Table 4.6: Income level of the respondents

Income Level					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	25,000 – 50,000	78	20.3	20.3	20.3
	50,001 – 75,000	77	20.0	20.0	40.3
	75,001 – 100,000	77	20.0	20.0	60.3
	Above 100,000	80	20.8	20.8	81.0
	Below 25,000	73	19.0	19.0	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.6: Income level of the respondents



Source: Created by the Author based on Research

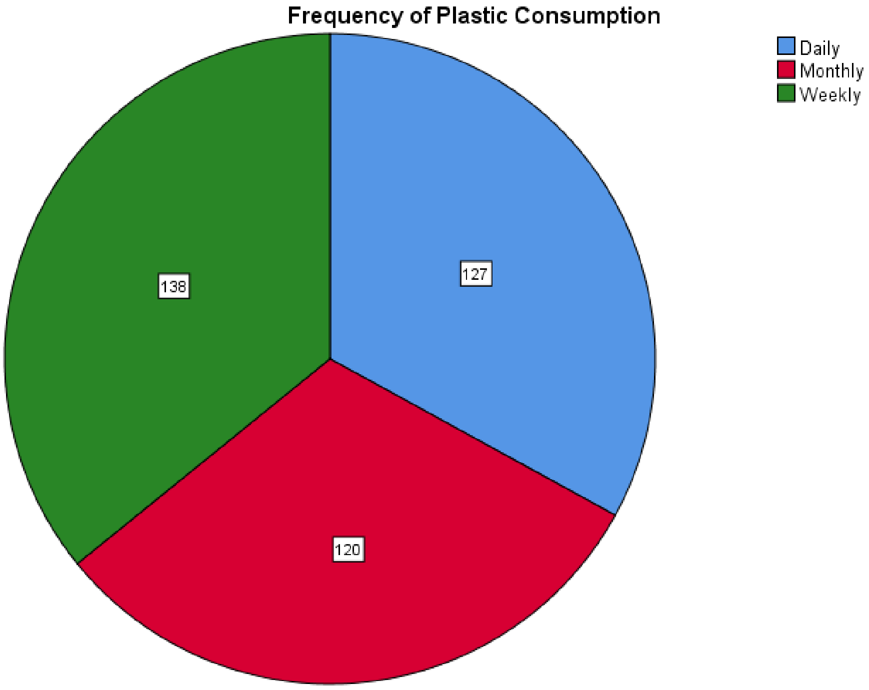
The above table 4.6 and pie chart (figure 4.6) define the income level of the respondents. It is observed from table 4.6 that out of 385 respondents, 19.0% of the respondents have an income level of below 25,000, 20.3% of the respondents have an income level of 25,000 – 50,000, 20.0% of the respondents have an income level of 50,001 – 75,000, 20.0% of the respondents have an income level of 75,001 – 1,00,000, and the remaining 20.8% of the respondents have an income level of above 1,00,000. It is understood that the majority of the respondents have an income level of above 1,00,000 (20.8%).

Table 4.7: Frequency of Plastic Consumption of the respondents

Frequency of Plastic Consumption					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Daily	127	33.0	33.0	33.0
	Monthly	120	31.2	31.2	64.2
	Weekly	138	35.8	35.8	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.7: Frequency of Plastic Consumption of the respondents



Source: Created by the Author

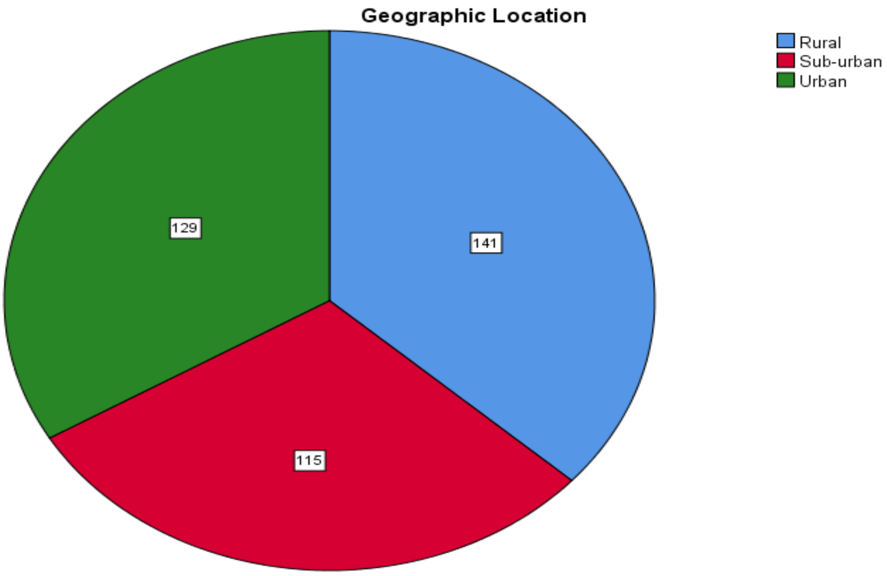
The above table 4.7 and pie chart (figure 4.7) define the frequency of plastic consumption of the respondents. It is observed from table 4.7 that out of 385 respondents, 33.0% of the respondents have frequency of plastic consumption as daily, 35.8% of the respondents have frequency of plastic consumption as weekly, and the remaining 31.2% of the respondents have frequency of plastic consumption as monthly. It is understood that the majority of the respondents have frequency of plastic consumption as weekly (35.8%).

Table 4.8: Geographical location of the respondents

Geographic Location					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Rural	141	36.6	36.6	36.6
	Sub-urban	115	29.9	29.9	66.5
	Urban	129	33.5	33.5	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.8: Geographical location of the respondents



Source: Created by the Author based on Research

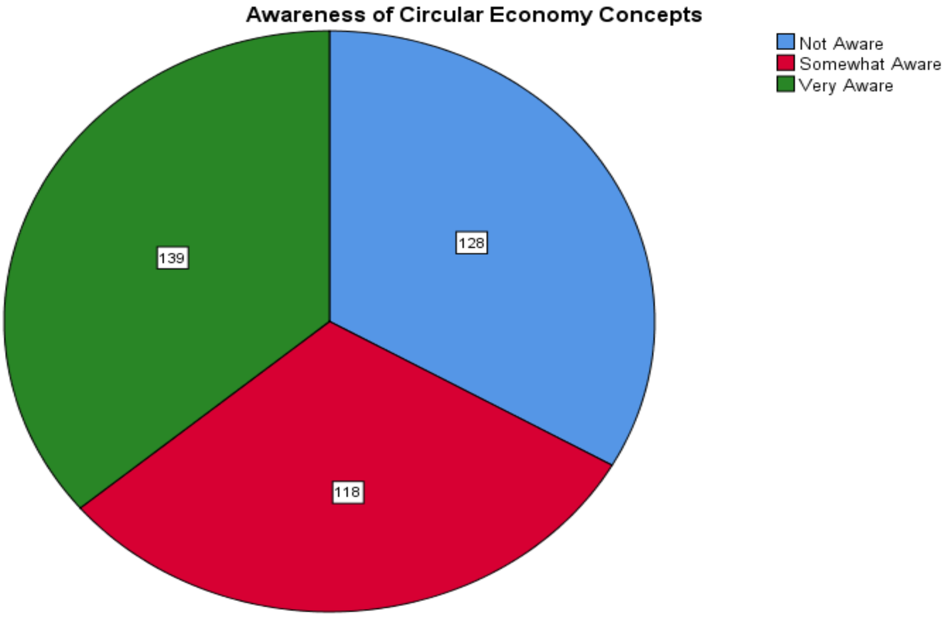
The above table 4.8 and pie chart (figure 4.8) define the geographical location of the respondents. It is observed from table 4.8 that out of 385 respondents, 36.6% of the respondents belongs from rural area, 29.9% of the respondents belongs from sub-urban area, and the remaining 33.5% of the respondents belongs from urban area. It is understood that the majority of the respondents belongs from rural area (36.6%).

Table 4.9: Awareness of Circular Economy Concepts of the respondents

Awareness of Circular Economy Concepts					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not Aware	128	33.2	33.2	33.2
	Somewhat Aware	118	30.6	30.6	63.9
	Very Aware	139	36.1	36.1	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.9: Awareness of Circular Economy Concepts of the respondents



Source: Created by the Author based on Research

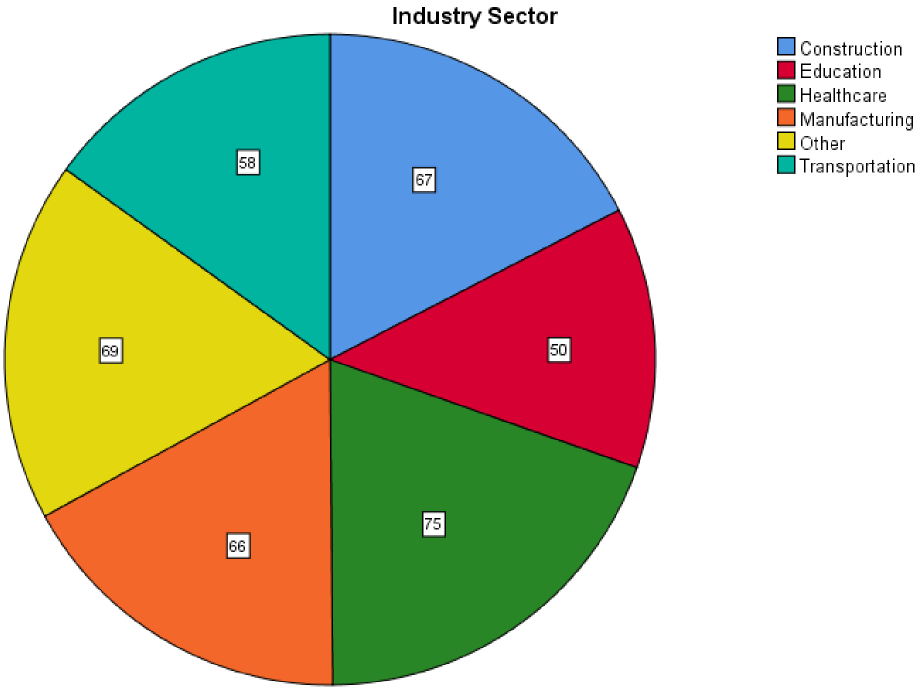
The above table 4.9 and pie chart (figure 4.9) define the awareness of circular economy concepts of the respondents. It is observed from table 4.9 that out of 385 respondents, 33.2% of the respondents are not aware, 30.6% of the respondents are somewhat aware, and the remaining 36.1% of the respondents are very aware. It is understood that the majority of the respondents are very aware (36.1%).

Table 4.10: Industry sector of the respondents

Industry Sector					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Construction	67	17.4	17.4	17.4
	Education	50	13.0	13.0	30.4
	Healthcare	75	19.5	19.5	49.9
	Manufacturing	66	17.1	17.1	67.0
	Other	69	17.9	17.9	84.9
	Transportation	58	15.1	15.1	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.10: Industry sector of the respondents



Source: Created by the Author based on Research

The above table 4.10 and pie chart (figure 4.10) define the industry sector of the respondents. It is observed from table 4.10 that out of 385 respondents, 17.4% of the respondents belongs from construction sector, 13.0% of the respondents belongs from education sector, 19.5% of the respondents belongs from healthcare sector, 17.1% of the respondents belongs from manufacturing sector, 15.1% of the respondents belongs from transportation sector, and the remaining 17.9% of the respondents belongs from others sector. It is understood that the majority of the respondents belongs from healthcare sector (19.5%).

4.2 Results Based on Objectives/Hypothesis

Obj-1. To identify the impact of challenges, such as technological limitations, regulatory barriers, and market constraints, faced by industries in effectively managing polymeric waste within the circular economy framework.

H1: There is a significant impact of challenges, such as technological limitations, regulatory barriers, and market constraints, faced by industries in effectively managing polymeric waste within the circular economy framework.

H01: There is no significant impact of challenges, such as technological limitations, regulatory barriers, and market constraints, faced by industries in effectively managing polymeric waste within the circular economy framework.

Table 4.11: Model Summary Table

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.102[a]	.010	.008	6.52465
a. Predictors: (Constant), Challenges faced by industries				

Source: Created by the Author based on Research

Table 4.11 defines the model summary, indicating a significant degree of connection. The R-value for the simple correlation is 0.102, which reflects how much of the overall variance in the dependent variable, Innovative polymeric waste management systems, the independent variable can be used to explain the results.

Table 4.12: ANOVA Table

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	171.272	1	171.272	4.023	.046[b]
	Residual	16304.691	383	42.571		
	Total	16475.964	384			
a. Dependent Variable: Innovative polymeric waste management systems						
b. Predictors: (Constant), Challenges faced by industries						

Source: Created by the Author based on Research

The above table is the ANOVA table 4.12, which reports how well the regression equation fits the data (i.e., predicts the dependent variable). This table indicates that the regression model predicts the dependent variable significantly well. This indicates the statistical significance of the regression model 0.046, which is less than 0.05, and indicates that, overall, the regression model statistically significantly predicts the outcome variable (i.e., it is a good fit for the data).

Table 4.13: Coefficients Table

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	37.695	1.641		22.977	.000
	Challenges faced by industries	-.095	.048	-.102	-2.006	.046
a. Dependent Variable: Innovative polymeric waste management systems						

Source: Created by the Author based on Research

The Coefficients table 4.13 provides us with the necessary information to predict the effect of the "Innovative polymeric waste management systems", as well as determine whether the "Challenges faced by industries" is statistically significant to the model.

Obj-2. To assess the environmental, economic, and social factors influencing the adoption of innovative polymeric waste management systems.

H2: There is a significant impact of environmental, economic, and social factors on the adoption of innovative polymeric waste management systems.

H02: There is no significant impact of environmental, economic, and social factors on the adoption of innovative polymeric waste management systems.

Table 4.14: Model Summary Table

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.116[a]	.013	.011	6.51456
a. Predictors: (Constant), Environmental, economic, and social factors				

Source: Created by the Author based on Research

Table 4.14 defines the model summary, indicating a significant degree of connection. The R-value for the simple correlation is 0.116, which reflects how much of the overall variance in the dependent variable, Innovative polymeric waste management systems, the independent variable can be used to explain the results.

Table 4.15: ANOVA Table

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	221.641	1	221.641	5.223	.023[b]
	Residual	16254.323	383	42.439		
	Total	16475.964	384			
a. Dependent Variable: Innovative polymeric waste management systems						
b. Predictors: (Constant), Environmental, economic, and social factors						

Source: Created by the Author based on Research

The above table is the ANOVA table 4.15, which reports how well the regression equation fits the data (i.e., predicts the dependent variable). This table indicates that the regression model predicts the dependent variable significantly well. This indicates the statistical significance of the regression model 0.023, which is less than 0.05, and indicates that, overall, the regression model statistically significantly predicts the outcome variable (i.e., it is a good fit for the data).

Table 4.16: Coefficients Table

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	30.443	1.794		16.965	.000
	Environmental, economic, and social factors	.117	.051	.116	2.285	.023
a. Dependent Variable: Innovative polymeric waste management systems						

Source: Created by the Author based on Research

The Coefficients table 4.16 provides us with the necessary information to predict the effect of the "Innovative polymeric waste management systems", as well as determine whether the "Environmental, economic, and social factors" is statistically significant to the model.

Obj-3. To Examine consumer attitudes, behaviors, and awareness regarding polymeric waste and circular economy initiatives and their influence on adoption rates of innovative waste management solutions.

H3: Consumer perceptions and attitudes regarding polymeric waste and circular economy initiatives significantly influence the adoption rates of innovative waste management solutions.

H03: Consumer perceptions and attitudes regarding polymeric waste and circular economy initiatives do not influence adoption rates of innovative waste management solutions.

Table 4.17: Model Summary Table

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.103[a]	.011	.008	6.52381
a. Predictors: (Constant), Consumer perceptions and attitudes				

Source: Created by the Author based on Research

Table 4.17 defines the model summary, indicating a significant degree of connection. The R-value for the simple correlation is 0.103, which reflects how much of the overall variance in the dependent variable, Innovative polymeric waste management systems, the independent variable can be used to explain the results.

Table 4.18: ANOVA Table

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	175.454	1	175.454	4.122	.043[b]
	Residual	16300.510	383	42.560		
	Total	16475.964	384			
a. Dependent Variable: Innovative polymeric waste management systems						
b. Predictors: (Constant), Consumer perceptions and attitudes						

Source: Created by the Author based on Research

The above table is the ANOVA table 4.18, which reports how well the regression equation fits the data (i.e., predicts the dependent variable). This table indicates that the regression model predicts the dependent variable significantly well. This indicates the statistical significance of the regression model 0.043, which is less than 0.05, and indicates that, overall, the regression model statistically significantly predicts the outcome variable (i.e., it is a good fit for the data).

Table 4.19: Coefficients Table

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	37.553	1.553		24.183	.000
	Consumer perceptions and attitudes	-.089	.044	-.103	-2.030	.043
a. Dependent Variable: Innovative polymeric waste management systems						

Source: Created by the Author based on Research

The Coefficients table 4.19 provides us with the necessary information to predict the effect of the "Innovative polymeric waste management systems", as well as determine whether the "Consumer perceptions and attitudes" is statistically significant to the model.

4.3 Response sheet of the respondents

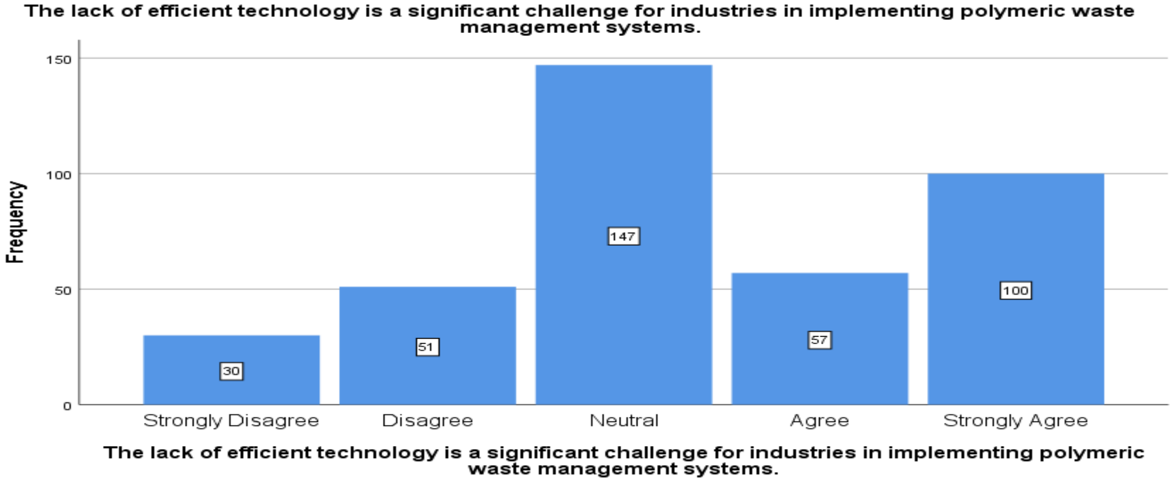
➢ Challenges faced by industries

Table 4.20: Response regarding the lack of efficient technology

The lack of efficient technology is a significant challenge for industries in implementing polymeric waste management systems.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	30	7.8	7.8	7.8
	Disagree	51	13.2	13.2	21.0
	Neutral	147	38.2	38.2	59.2
	Agree	57	14.8	14.8	74.0
	Strongly Agree	100	26.0	26.0	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.11: Response regarding the lack of efficient technology



Source: Created by the Author based on Research

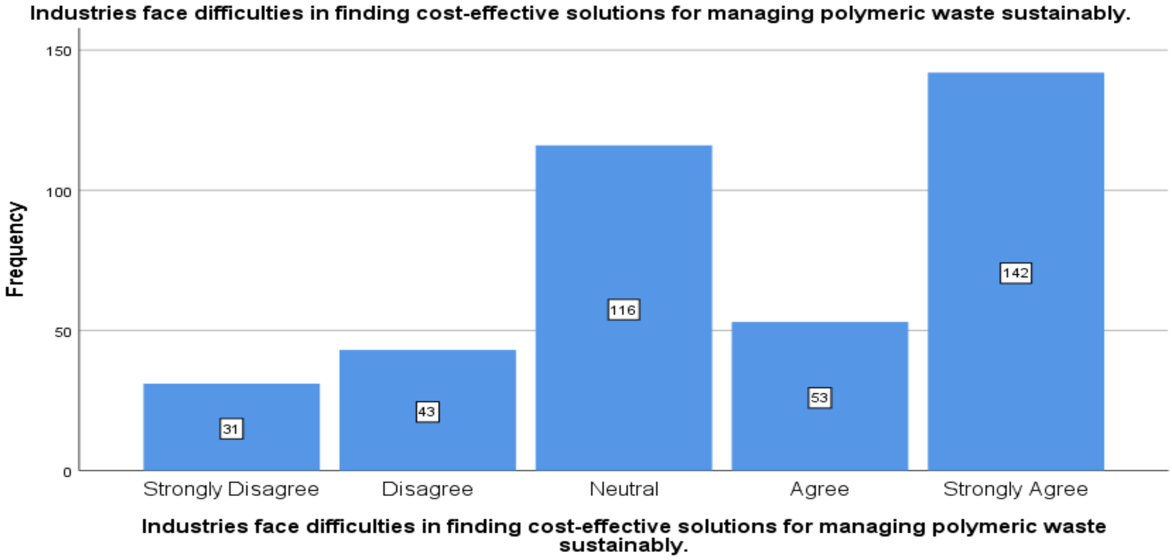
Table 4.20 and figure 4.11 show the response regarding the statement, “The lack of efficient technology is a significant challenge for industries in implementing polymeric waste management systems”. According to table 4.20 and figure 4.11 (Bar chart), out of 385 respondents, 7.8% of the respondents strongly disagreed with the statement, 13.2% of the respondents disagreed with the statement, 38.2% of the respondents were neutral about the statement, 14.8% of the respondents agreed with the statement, and 26.0% of the respondents strongly agreed with the statement.

Table 4.21: Response regarding difficulties in industries

Industries face difficulties in finding cost-effective solutions for managing polymeric waste sustainably.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	31	8.1	8.1	8.1
	Disagree	43	11.2	11.2	19.2
	Neutral	116	30.1	30.1	49.4
	Agree	53	13.8	13.8	63.1
	Strongly Agree	142	36.9	36.9	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.12: Response regarding difficulties in industries



Source: Created by the Author based on Research

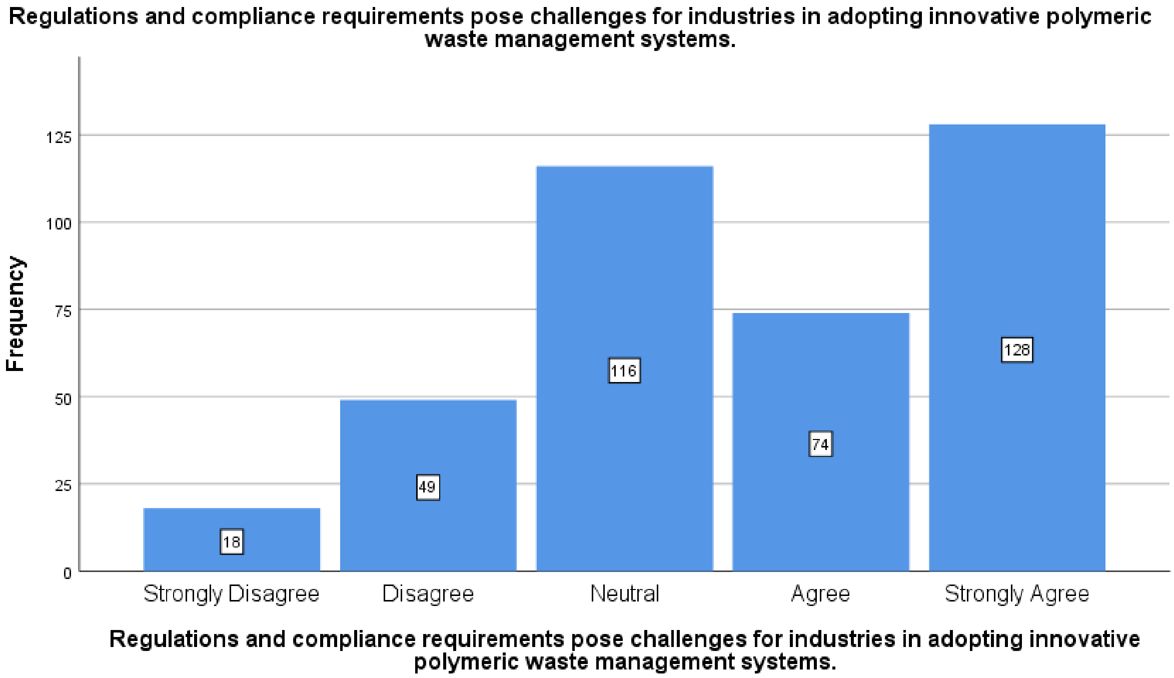
Table 4.21 and figure 4.12 show the response regarding the statement, "Industries face difficulties in finding cost-effective solutions for managing polymeric waste sustainably". According to table 4.21 and figure 4.12 (Bar chart), out of 385 respondents, 8.1% of the respondents strongly disagreed with the statement, 11.2% of the respondents disagreed with the statement, 30.1% of the respondents were neutral about the statement, 13.8% of the respondents agreed with the statement, and 36.9% of the respondents strongly agreed with the statement.

Table 4.22: Response regarding regulations and compliance requirements

Regulations and compliance requirements pose challenges for industries in adopting innovative polymeric waste management systems.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	18	4.7	4.7	4.7
	Disagree	49	12.7	12.7	17.4
	Neutral	116	30.1	30.1	47.5
	Agree	74	19.2	19.2	66.8
	Strongly Agree	128	33.2	33.2	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.13: Response regarding regulations and compliance requirements



Source: Created by the Author based on Research

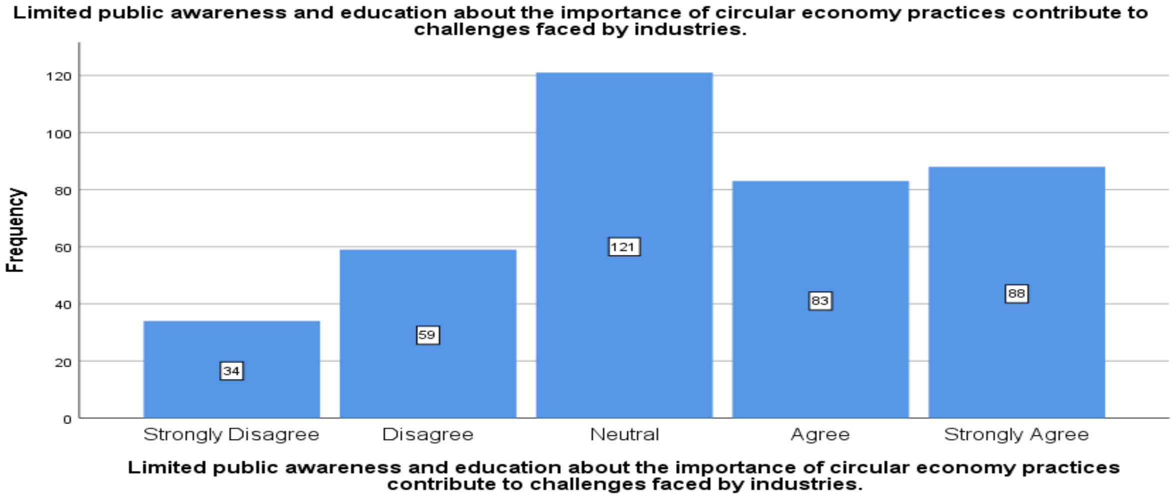
Table 4.22 and figure 4.13 show the response regarding the statement, "Regulations and compliance requirements pose challenges for industries in adopting innovative polymeric waste management systems". According to table 4.22 and figure 4.13 (Bar chart), out of 385 respondents, 4.7% of the respondents strongly disagreed with the statement, 12.7% of the respondents disagreed with the statement, 30.1% of the respondents were neutral about the statement, 19.2% of the respondents agreed with the statement, and 33.2% of the respondents strongly agreed with the statement.

Table 4.23: Response regarding limited public awareness and education

Limited public awareness and education about the importance of circular economy practices contribute to challenges faced by industries.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	34	8.8	8.8	8.8
	Disagree	59	15.3	15.3	24.2
	Neutral	121	31.4	31.4	55.6
	Agree	83	21.6	21.6	77.1
	Strongly Agree	88	22.9	22.9	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.14: Response regarding limited public awareness and education



Source: Created by the Author based on Research

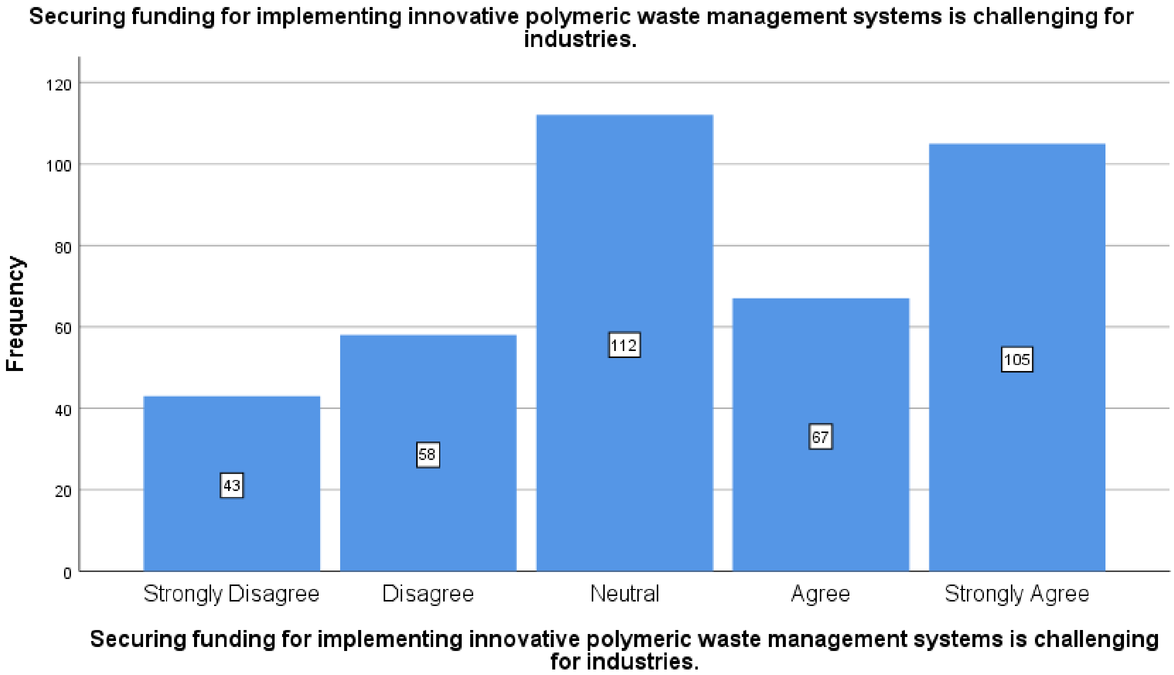
Table 4.23 and figure 4.14 show the response regarding the statement, “Limited public awareness and education about the importance of circular economy practices contribute to challenges faced by industries”. According to table 4.23 and figure 4.14 (Bar chart), out of 385 respondents, 8.8% of the respondents strongly disagreed with the statement, 15.3% of the respondents disagreed with the statement, 31.4% of the respondents were neutral about the statement, 21.6% of the respondents agreed with the statement, and 22.9% of the respondents strongly agreed with the statement.

Table 4.24: Response regarding securing funding

Securing funding for implementing innovative polymeric waste management systems is challenging for industries.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	43	11.2	11.2	11.2
	Disagree	58	15.1	15.1	26.2
	Neutral	112	29.1	29.1	55.3
	Agree	67	17.4	17.4	72.7
	Strongly Agree	105	27.3	27.3	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.15: Response regarding securing funding



Source: Created by the Author based on Research

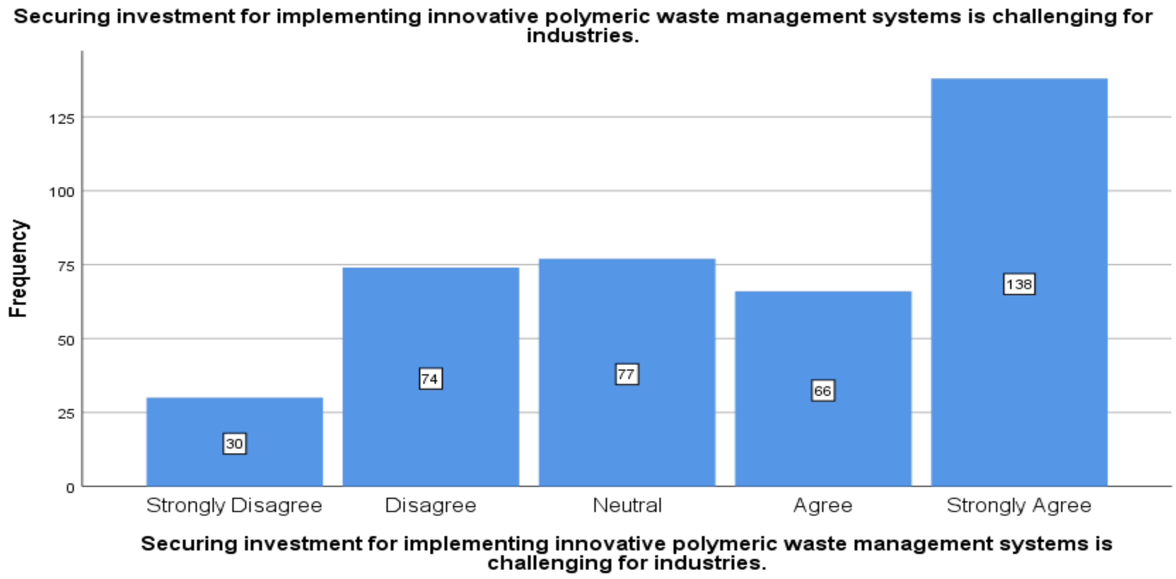
Table 4.24 and figure 4.15 show the response regarding the statement, “Securing funding for implementing innovative polymeric waste management systems is challenging for industries”. According to table 4.24 and figure 4.15 (Bar chart), out of 385 respondents, 11.2% of the respondents strongly disagreed with the statement, 15.1% of the respondents disagreed with the statement, 29.1% of the respondents were neutral about the statement, 17.4% of the respondents agreed with the statement, and 27.3% of the respondents strongly agreed with the statement.

Table 4.25: Response regarding securing investment

Securing investment for implementing innovative polymeric waste management systems is challenging for industries.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	30	7.8	7.8	7.8
	Disagree	74	19.2	19.2	27.0
	Neutral	77	20.0	20.0	47.0
	Agree	66	17.1	17.1	64.2
	Strongly Agree	138	35.8	35.8	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.16: Response regarding securing investment



Source: Created by the Author based on Research

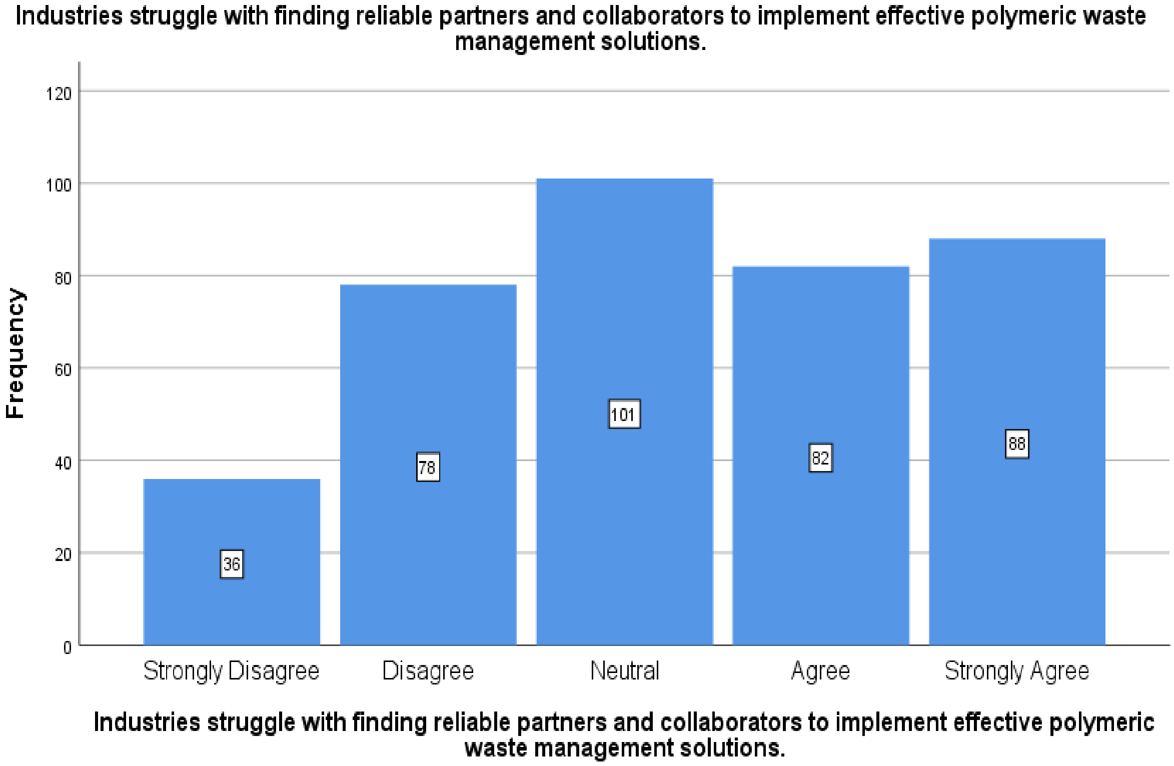
Table 4.25 and figure 4.16 show the response regarding the statement, "Securing investment for implementing innovative polymeric waste management systems is challenging for industries”. According to table 4.25 and figure 4.16 (Bar chart), out of 385 respondents, 7.8% of the respondents strongly disagreed with the statement, 19.2% of the respondents disagreed with the statement, 20.0% of the respondents were neutral about the statement, 17.1% of the respondents agreed with the statement, and 35.8% of the respondents strongly agreed with the statement.

Table 4.26: Response regarding struggle of industries

Industries struggle with finding reliable partners and collaborators to implement effective polymeric waste management solutions.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	36	9.4	9.4	9.4
	Disagree	78	20.3	20.3	29.6
	Neutral	101	26.2	26.2	55.8
	Agree	82	21.3	21.3	77.1
	Strongly Agree	88	22.9	22.9	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.17: Response regarding struggle of industries



Source: Created by the Author based on Research

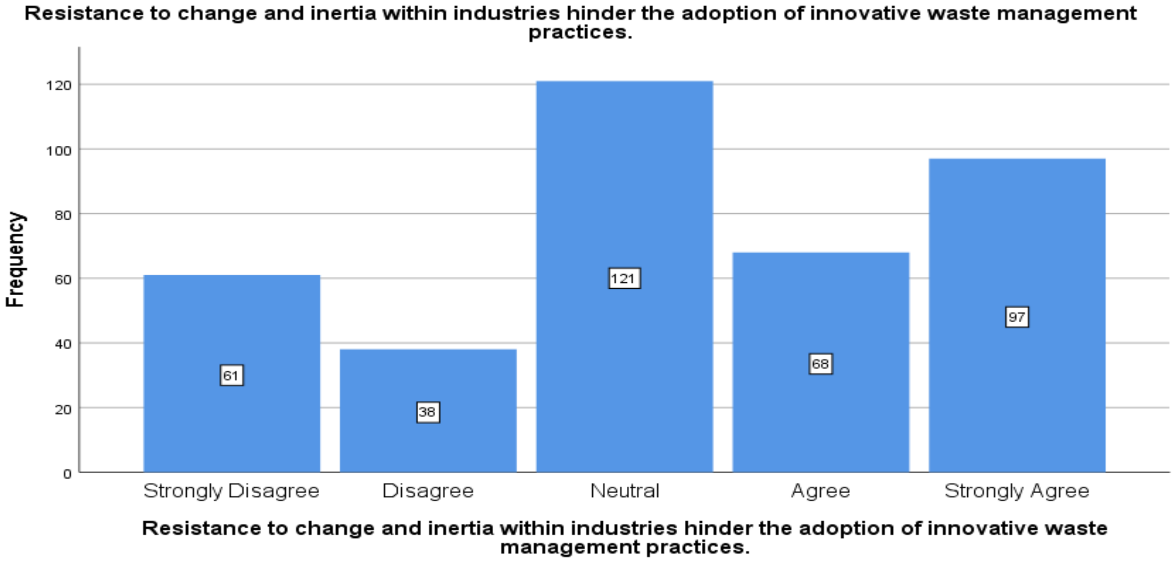
Table 4.26 and figure 4.17 show the response regarding the statement, “Industries struggle with finding reliable partners and collaborators to implement effective polymeric waste management solutions”. According to table 4.26 and figure 4.17 (Bar chart), out of 385 respondents, 9.4% of the respondents strongly disagreed with the statement, 20.3% of the respondents disagreed with the statement, 26.2% of the respondents were neutral about the statement, 21.3% of the respondents agreed with the statement, and 22.9% of the respondents strongly agreed with the statement.

Table 4.27: Response regarding resistance to change

Resistance to change and inertia within industries hinder the adoption of innovative waste management practices.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	61	15.8	15.8	15.8
	Disagree	38	9.9	9.9	25.7
	Neutral	121	31.4	31.4	57.1
	Agree	68	17.7	17.7	74.8
	Strongly Agree	97	25.2	25.2	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.18: Response regarding resistance to change



Source: Created by the Author based on Research

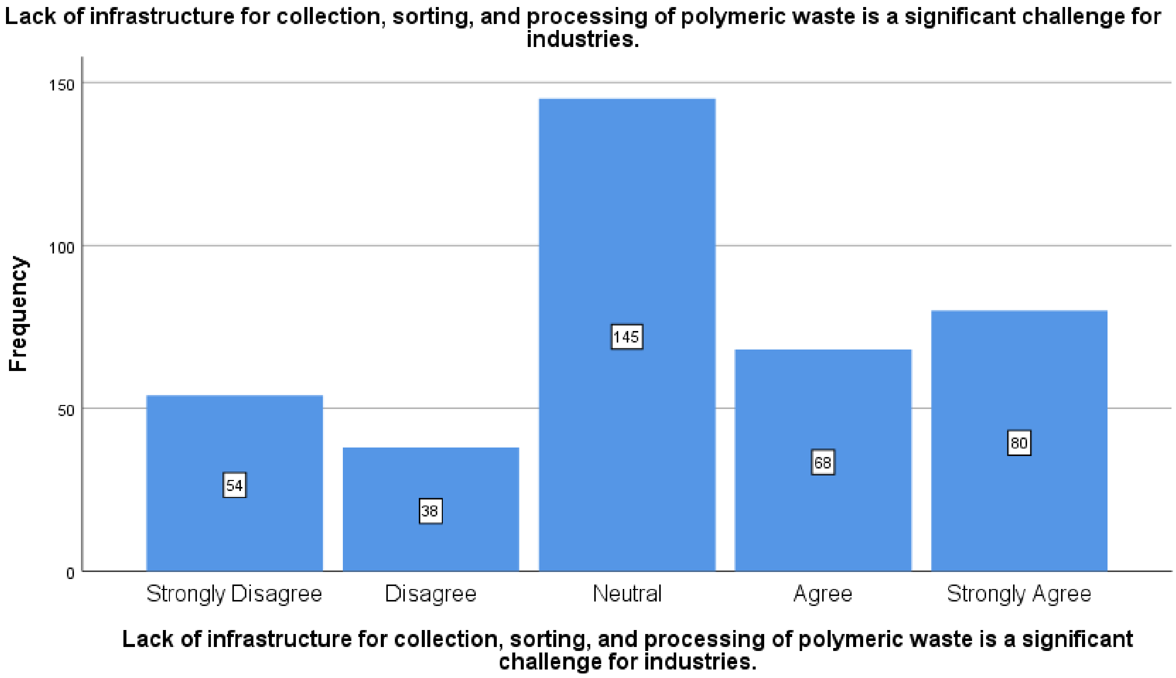
Table 4.27 and figure 4.18 show the response regarding the statement, “Resistance to change and inertia within industries hinder the adoption of innovative waste management practices”. According to table 4.27 and figure 4.18 (Bar chart), out of 385 respondents, 15.8% of the respondents strongly disagreed with the statement, 9.9% of the respondents disagreed with the statement, 31.4% of the respondents were neutral about the statement, 17.7% of the respondents agreed with the statement, and 25.2% of the respondents strongly agreed with the statement.

Table 4.28: Response regarding lack of infrastructure

Lack of infrastructure for collection, sorting, and processing of polymeric waste is a significant challenge for industries.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	54	14.0	14.0	14.0
	Disagree	38	9.9	9.9	23.9
	Neutral	145	37.7	37.7	61.6
	Agree	68	17.7	17.7	79.2
	Strongly Agree	80	20.8	20.8	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.19: Response regarding lack of infrastructure



Source: Created by the Author based on Research

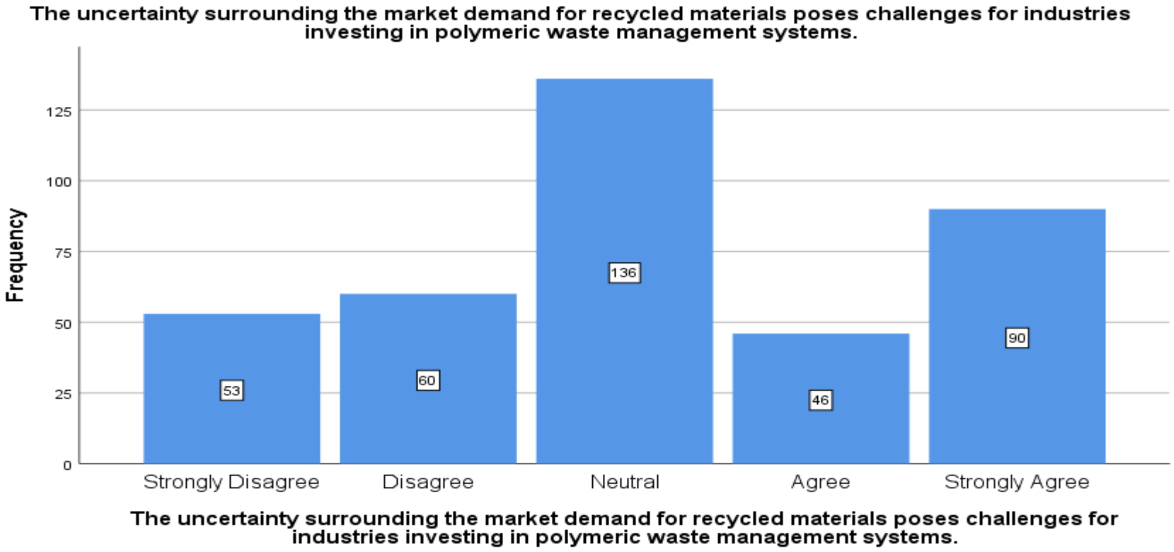
Table 4.28 and figure 4.19 show the response regarding the statement, “Lack of infrastructure for collection, sorting, and processing of polymeric waste is a significant challenge for industries”. According to table 4.28 and figure 4.19 (Bar chart), out of 385 respondents, 14.0% of the respondents strongly disagreed with the statement, 9.9% of the respondents disagreed with the statement, 37.7% of the respondents were neutral about the statement, 17.7% of the respondents agreed with the statement, and 20.8% of the respondents strongly agreed with the statement.

Table 4.29: Response regarding the uncertainty surrounding the market demand

The uncertainty surrounding the market demand for recycled materials poses challenges for industries investing in polymeric waste management systems.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	53	13.8	13.8	13.8
	Disagree	60	15.6	15.6	29.4
	Neutral	136	35.3	35.3	64.7
	Agree	46	11.9	11.9	76.6
	Strongly Agree	90	23.4	23.4	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.20: Response regarding the uncertainty surrounding the market demand



Source: Created by the Author based on Research

Table 4.29 and figure 4.20 show the response regarding the statement, “The uncertainty surrounding the market demand for recycled materials poses challenges for industries investing in polymeric waste management systems”. According to table 4.29 and figure 4.20 (Bar chart), out of 385 respondents, 13.8% of the respondents strongly disagreed with the statement, 15.6% of the respondents disagreed with the statement, 35.3% of the respondents were neutral about the statement, 11.9% of the respondents agreed with the statement, and 23.4% of the respondents strongly agreed with the statement.

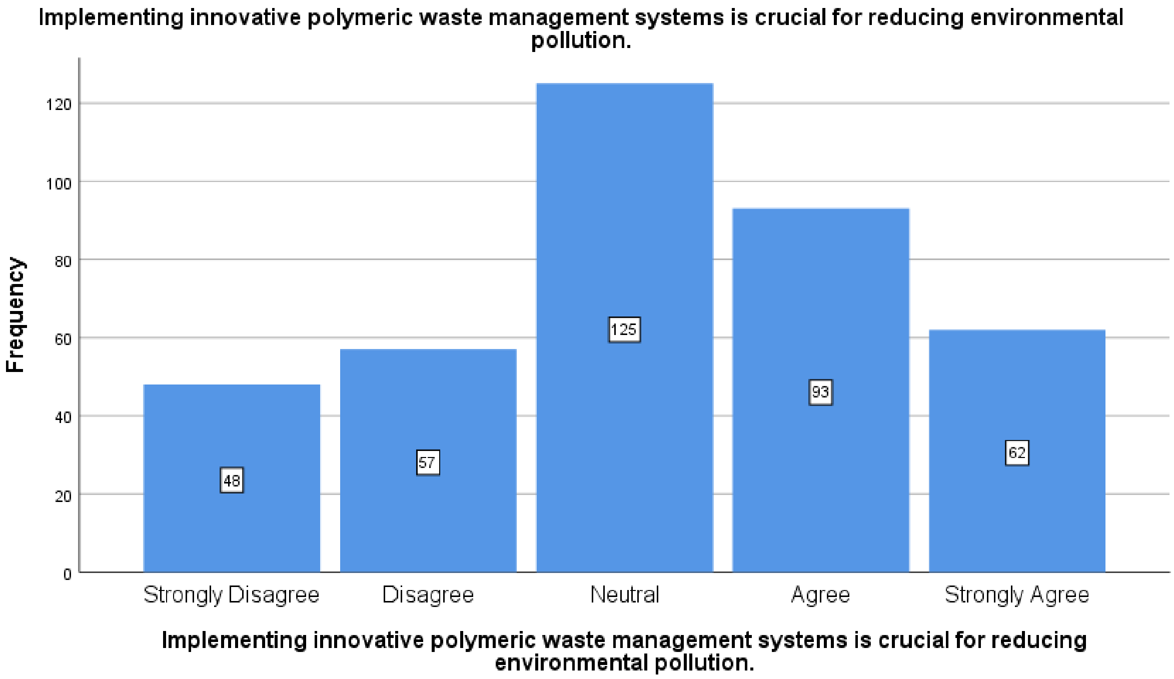
- **Environmental, economic, and social factors**

Table 4.30: Response regarding implementing innovative polymeric waste management systems

Implementing innovative polymeric waste management systems is crucial for reducing environmental pollution.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	48	12.5	12.5	12.5
	Disagree	57	14.8	14.8	27.3
	Neutral	125	32.5	32.5	59.7
	Agree	93	24.2	24.2	83.9
	Strongly Agree	62	16.1	16.1	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.21: Response regarding implementing innovative polymeric waste management systems



Source: Created by the Author based on Research

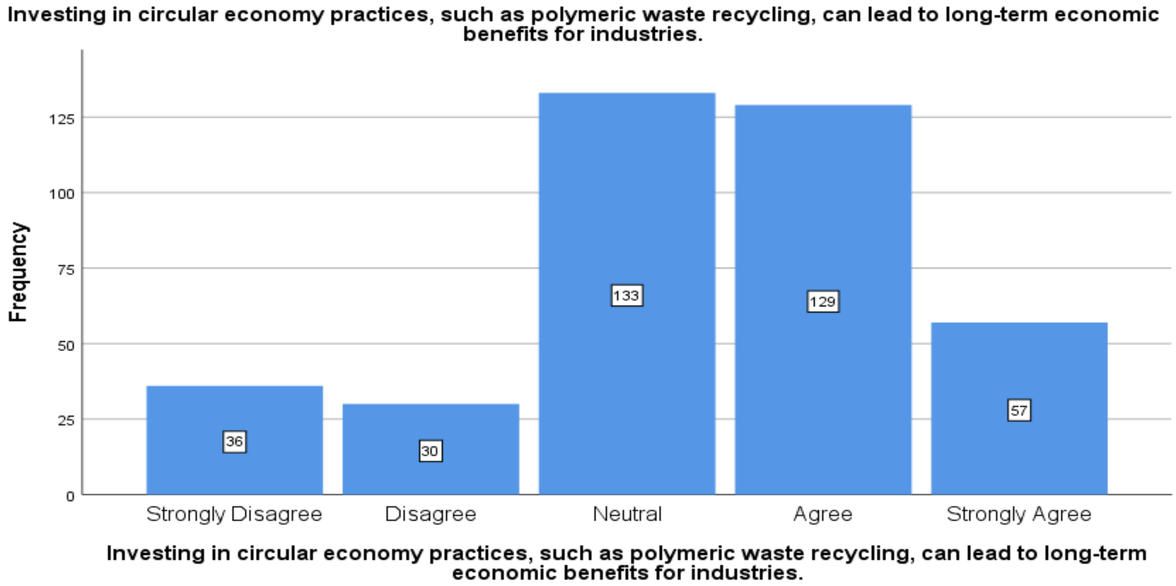
Table 4.30 and figure 4.21 show the response regarding the statement, “The uncertainty surrounding the market demand for recycled materials poses challenges for industries investing in polymeric waste management systems”. According to table 4.30 and figure 4.21 (Bar chart), out of 385 respondents, 12.5% of the respondents strongly disagreed with the statement, 14.8% of the respondents disagreed with the statement, 32.5% of the respondents were neutral about the statement, 24.2% of the respondents agreed with the statement, and 16.1% of the respondents strongly agreed with the statement.

Table 4.31: Response regarding investing in circular economy practices

Investing in circular economy practices, such as polymeric waste recycling, can lead to long-term economic benefits for industries.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	36	9.4	9.4	9.4
	Disagree	30	7.8	7.8	17.1
	Neutral	133	34.5	34.5	51.7
	Agree	129	33.5	33.5	85.2
	Strongly Agree	57	14.8	14.8	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.22: Response regarding investing in circular economy practices



Source: Created by the Author based on Research

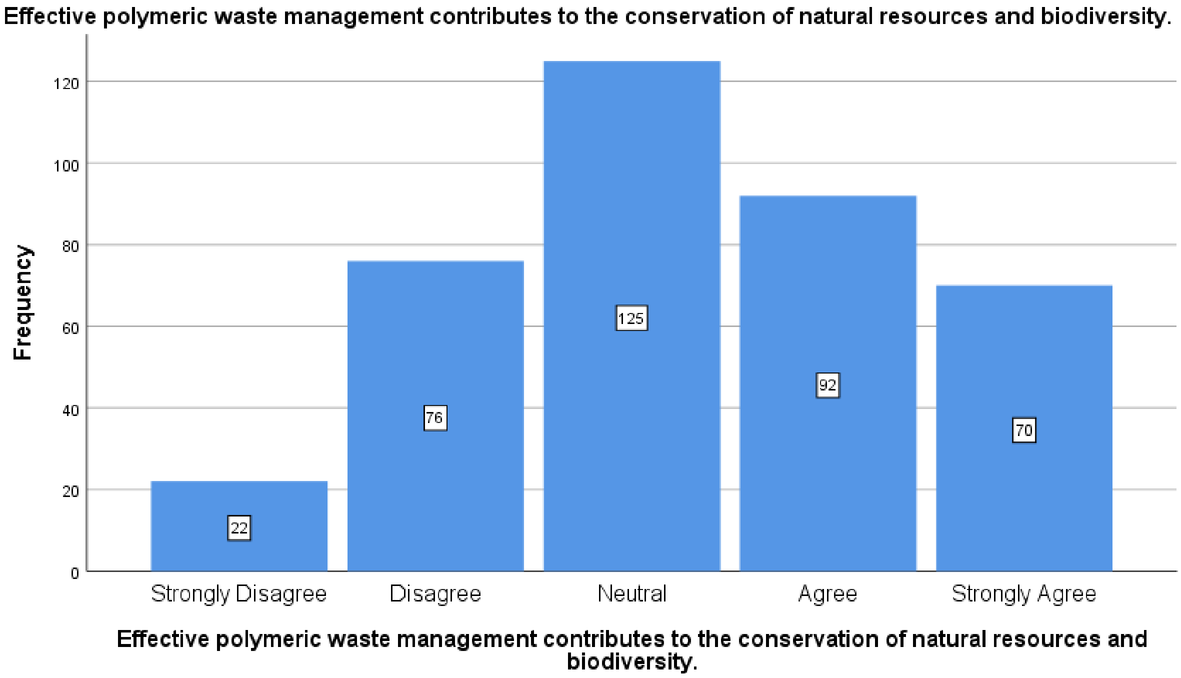
Table 4.31 and figure 4.22 show the response regarding the statement, “Investing in circular economy practices, such as polymeric waste recycling, can lead to long-term economic benefits for industries". According to table 4.31 and figure 4.22 (Bar chart), out of 385 respondents, 9.4% of the respondents strongly disagreed with the statement, 7.8% of the respondents disagreed with the statement, 34.5% of the respondents were neutral about the statement, 33.5% of the respondents agreed with the statement, and 14.8% of the respondents strongly agreed with the statement.

Table 4.32: Response regarding effective polymeric waste management

Effective polymeric waste management contributes to the conservation of natural resources and biodiversity.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	22	5.7	5.7	5.7
	Disagree	76	19.7	19.7	25.5
	Neutral	125	32.5	32.5	57.9
	Agree	92	23.9	23.9	81.8
	Strongly Agree	70	18.2	18.2	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.23: Response regarding effective polymeric waste management



Source: Created by the Author based on Research

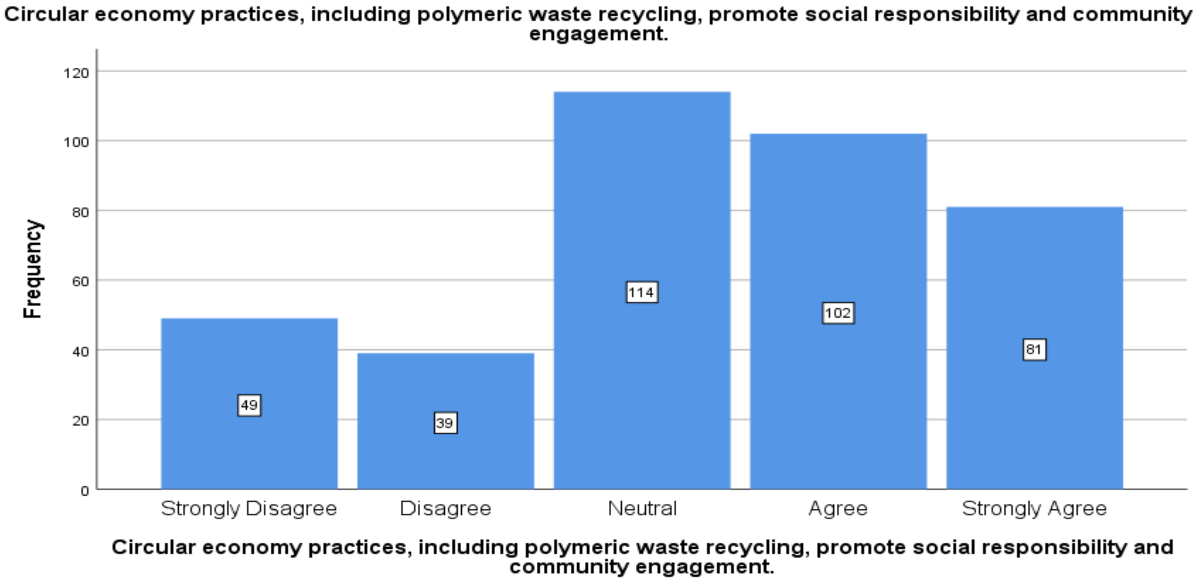
Table 4.32 and figure 4.23 show the response regarding the statement, “Effective polymeric waste management contributes to the conservation of natural resources and biodiversity”. According to table 4.32 and figure 4.23 (Bar chart), out of 385 respondents, 5.7% of the respondents strongly disagreed with the statement, 19.7% of the respondents disagreed with the statement, 32.5% of the respondents were neutral about the statement, 23.9% of the respondents agreed with the statement, and 18.2% of the respondents strongly agreed with the statement.

Table 4.33: Response regarding Circular Economy Practices

Circular economy practices, including polymeric waste recycling, promote social responsibility and community engagement.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	49	12.7	12.7	12.7
	Disagree	39	10.1	10.1	22.9
	Neutral	114	29.6	29.6	52.5
	Agree	102	26.5	26.5	79.0
	Strongly Agree	81	21.0	21.0	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.24: Response regarding circular economy practices



Source: Created by the Author based on Research

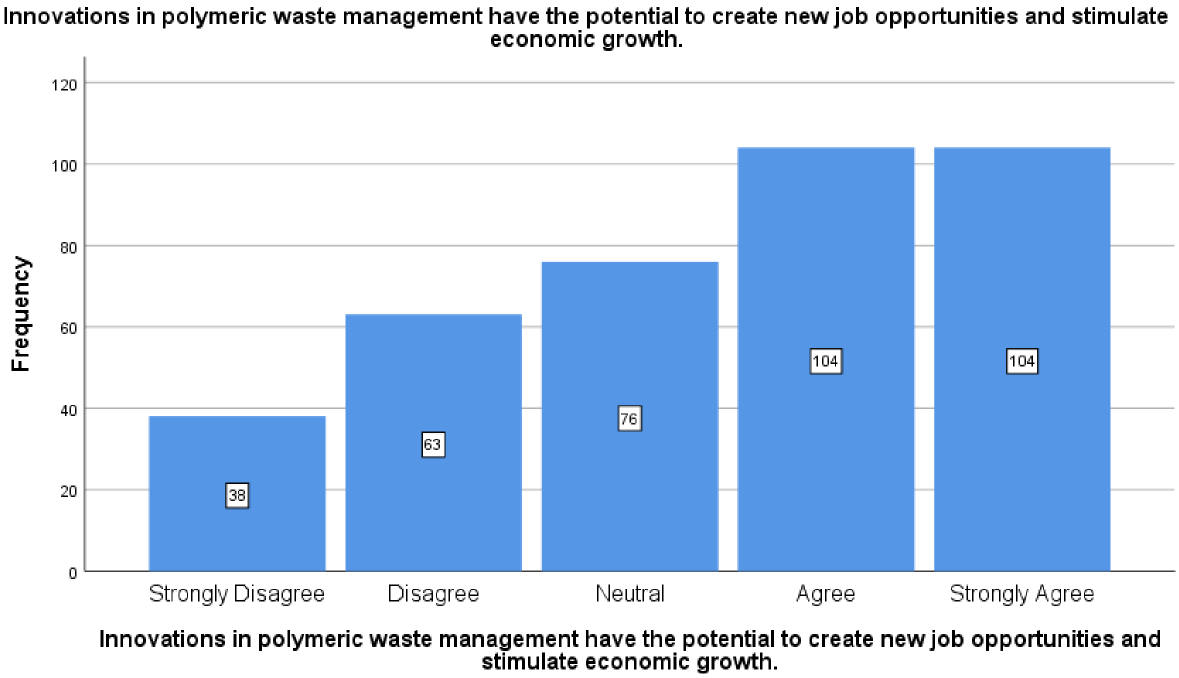
Table 4.33 and figure 4.24 show the response regarding the statement, “Circular economy practices, including polymeric waste recycling, promote social responsibility and community engagement". According to table 4.33 and figure 4.24 (Bar chart), out of 385 respondents, 12.7% of the respondents strongly disagreed with the statement, 10.1% of the respondents disagreed with the statement, 29.6% of the respondents were neutral about the statement, 26.5% of the respondents agreed with the statement, and 21.0% of the respondents strongly agreed with the statement.

Table 4.34: Response regarding innovations in polymeric waste management

Innovations in polymeric waste management have the potential to create new job opportunities and stimulate economic growth.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	38	9.9	9.9	9.9
	Disagree	63	16.4	16.4	26.2
	Neutral	76	19.7	19.7	46.0
	Agree	104	27.0	27.0	73.0
	Strongly Agree	104	27.0	27.0	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.25: Response regarding innovations in polymeric waste management



Source: Created by the Author based on Research

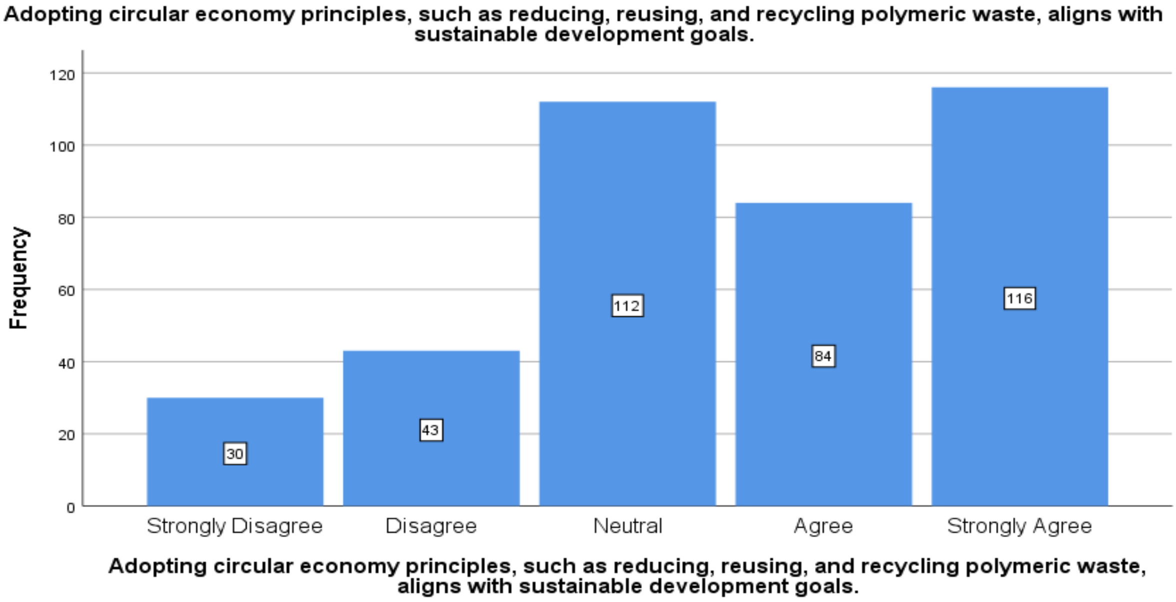
Table 4.34 and figure 4.25 show the response regarding the statement, "Innovations in polymeric waste management have the potential to create new job opportunities and stimulate economic growth". According to table 4.34 and figure 4.25 (Bar chart), out of 385 respondents, 9.9% of the respondents strongly disagreed with the statement, 16.4% of the respondents disagreed with the statement, 19.7% of the respondents were neutral about the statement, 27.0% of the respondents agreed with the statement, and 27.0% of the respondents strongly agreed with the statement.

Table 4.35: Response regarding adopting circular economy principles

Adopting circular economy principles, such as reducing, reusing, and recycling polymeric waste, aligns with sustainable development goals.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	30	7.8	7.8	7.8
	Disagree	43	11.2	11.2	19.0
	Neutral	112	29.1	29.1	48.1
	Agree	84	21.8	21.8	69.9
	Strongly Agree	116	30.1	30.1	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.26: Response regarding adopting circular economy principles



Source: Created by the Author based on Research

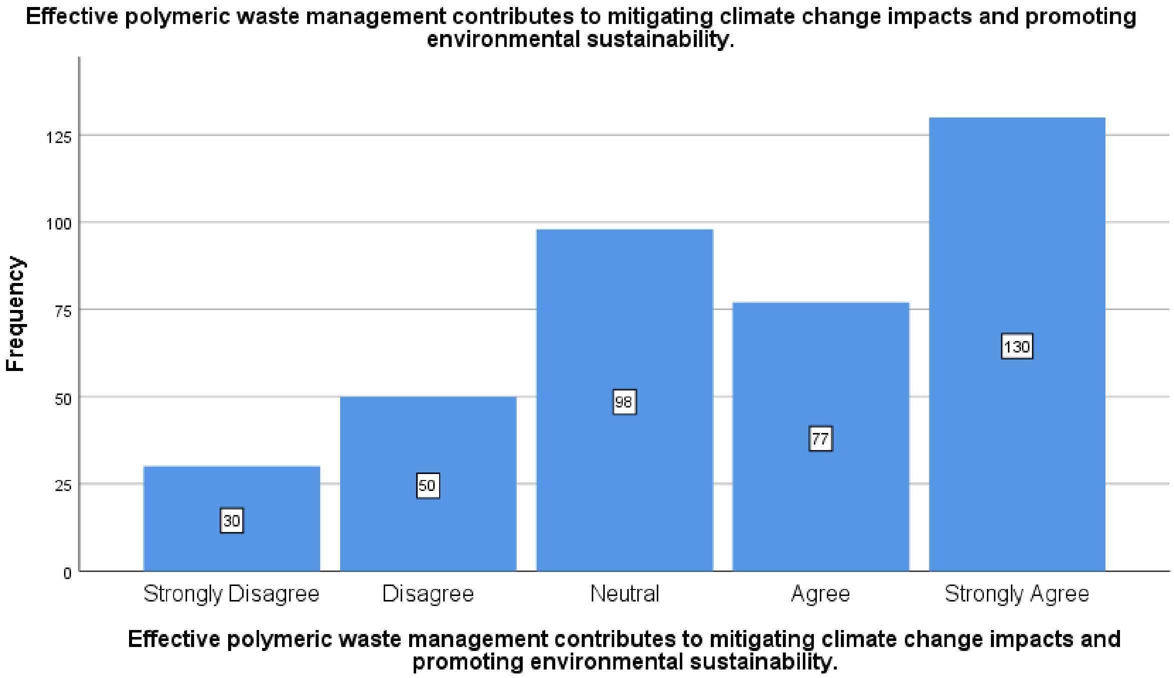
Table 4.35 and figure 4.26 show the response regarding the statement, “Adopting circular economy principles, such as reducing, reusing, and recycling polymeric waste, aligns with sustainable development goals”. According to table 4.35 and figure 4.26 (Bar chart), out of 385 respondents, 7.8% of the respondents strongly disagreed with the statement, 11.2% of the respondents disagreed with the statement, 29.1% of the respondents were neutral about the statement, 21.8% of the respondents agreed with the statement, and 30.1% of the respondents strongly agreed with the statement.

Table 4.36: Response regarding contribution to mitigating climate change

Effective polymeric waste management contributes to mitigating climate change impacts and promoting environmental sustainability.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	30	7.8	7.8	7.8
	Disagree	50	13.0	13.0	20.8
	Neutral	98	25.5	25.5	46.2
	Agree	77	20.0	20.0	66.2
	Strongly Agree	130	33.8	33.8	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.27: Response regarding contribution to mitigating climate change



Source: Created by the Author based on Research

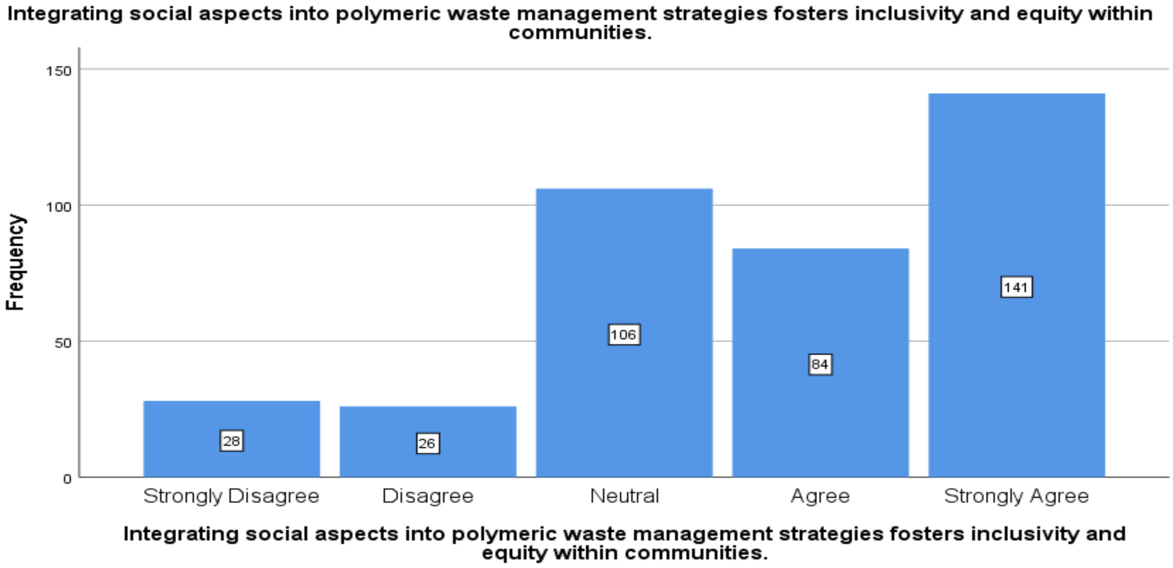
Table 4.36 and figure 4.27 show the response regarding the statement, "Effective polymeric waste management contributes to mitigating climate change impacts and promoting environmental sustainability". According to table 4.36 and figure 4.27 (Bar chart), out of 385 respondents, 7.8% of the respondents strongly disagreed with the statement, 13.0% of the respondents disagreed with the statement, 25.5% of the respondents were neutral about the statement, 20.0% of the respondents agreed with the statement, and 33.8% of the respondents strongly agreed with the statement.

Table 4.37: Response regarding integrating social aspects

Integrating social aspects into polymeric waste management strategies fosters inclusivity and equity within communities.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	28	7.3	7.3	7.3
	Disagree	26	6.8	6.8	14.0
	Neutral	106	27.5	27.5	41.6
	Agree	84	21.8	21.8	63.4
	Strongly Agree	141	36.6	36.6	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.28: Response regarding integrating social aspects



Source: Created by the Author based on Research

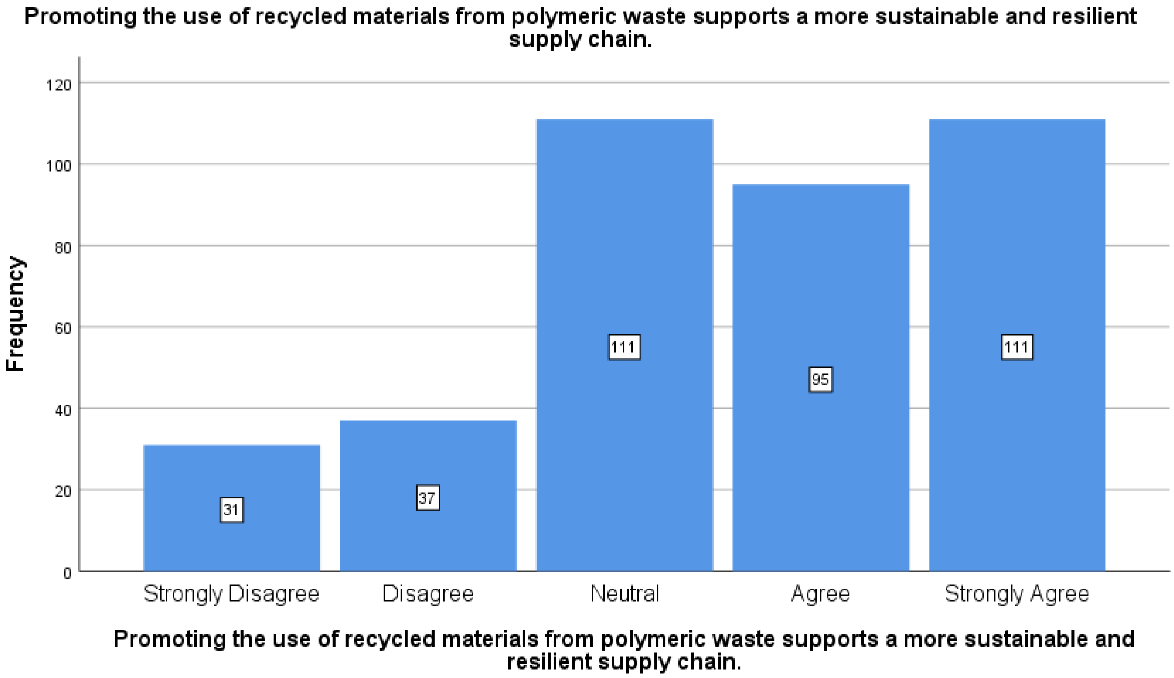
Table 4.37 and figure 4.28 show the response regarding the statement, “Integrating social aspects into polymeric waste management strategies fosters inclusivity and equity within communities”. According to table 4.37 and figure 4.28 (Bar chart), out of 385 respondents, 7.3% of the respondents strongly disagreed with the statement, 6.8% of the respondents disagreed with the statement, 27.5% of the respondents were neutral about the statement, 21.8% of the respondents agreed with the statement, and 36.6% of the respondents strongly agreed with the statement.

Table 4.38: Response regarding promoting the use of recycled materials

Promoting the use of recycled materials from polymeric waste supports a more sustainable and resilient supply chain.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	31	8.1	8.1	8.1
	Disagree	37	9.6	9.6	17.7
	Neutral	111	28.8	28.8	46.5
	Agree	95	24.7	24.7	71.2
	Strongly Agree	111	28.8	28.8	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.29: Response regarding promoting the use of recycled materials



Source: Created by the Author based on Research

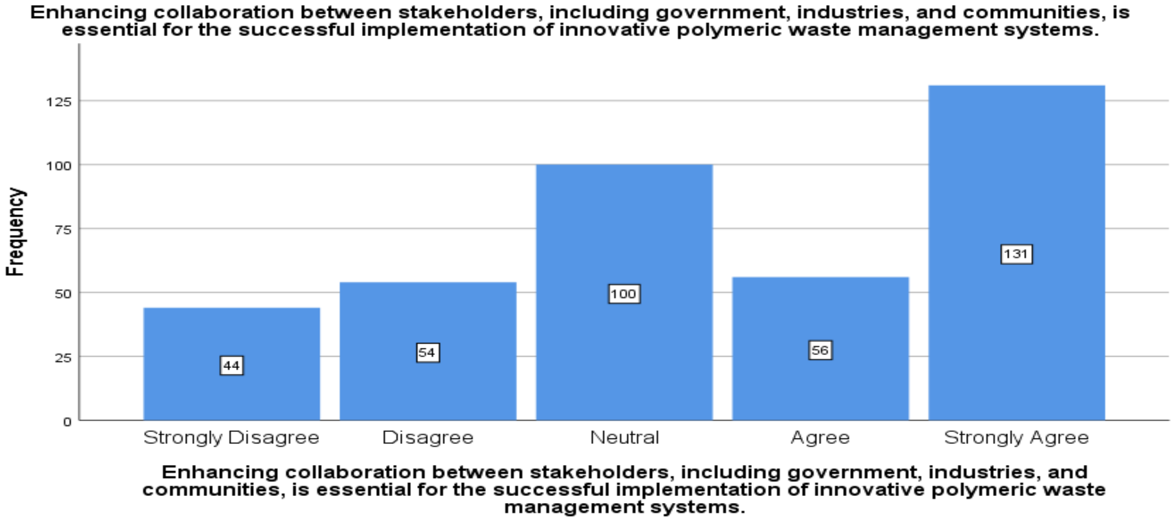
Table 4.38 and figure 4.29 show the response regarding the statement, "Promoting the use of recycled materials from polymeric waste supports a more sustainable and resilient supply chain". According to table 4.38 and figure 4.29 (Bar chart), out of 385 respondents, 8.1% of the respondents strongly disagreed with the statement, 9.6% of the respondents disagreed with the statement, 28.8% of the respondents were neutral about the statement, 24.7% of the respondents agreed with the statement, and 28.8% of the respondents strongly agreed with the statement.

Table 4.39: Response regarding enhancing collaboration

Enhancing collaboration between stakeholders, including government, industries, and communities, is essential for the successful implementation of innovative polymeric waste management systems.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	44	11.4	11.4	11.4
	Disagree	54	14.0	14.0	25.5
	Neutral	100	26.0	26.0	51.4
	Agree	56	14.5	14.5	66.0
	Strongly Agree	131	34.0	34.0	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.30: Response regarding enhancing collaboration



Source: Created by the Author based on Research

Table 4.39 and figure 4.30 show the response regarding the statement, "Enhancing collaboration between stakeholders, including government, industries, and communities, is essential for the successful implementation of innovative polymeric waste management systems". According to table 4.39 and figure 4.30 (Bar chart), out of 385 respondents, 11.4% of the respondents strongly disagreed with the statement, 14.0% of the respondents disagreed with the statement, 26.0% of the respondents were neutral about the statement, 14.5% of the respondents agreed with the statement, and 34.0% of the respondents strongly agreed with the statement.

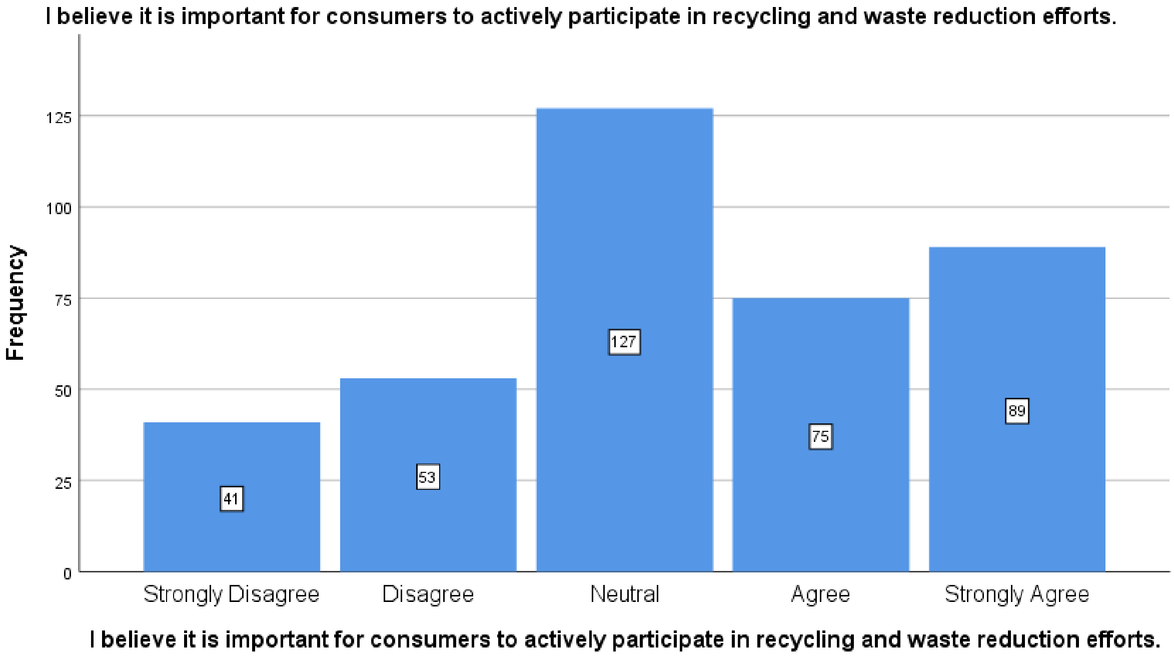
- **Consumer perceptions and attitudes**

Table 4.40: Response regarding consumers actively participation

I believe it is important for consumers to actively participate in recycling and waste reduction efforts.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	41	10.6	10.6	10.6
	Disagree	53	13.8	13.8	24.4
	Neutral	127	33.0	33.0	57.4
	Agree	75	19.5	19.5	76.9
	Strongly Agree	89	23.1	23.1	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.31: Response regarding consumers actively participation



Source: Created by the Author based on Research

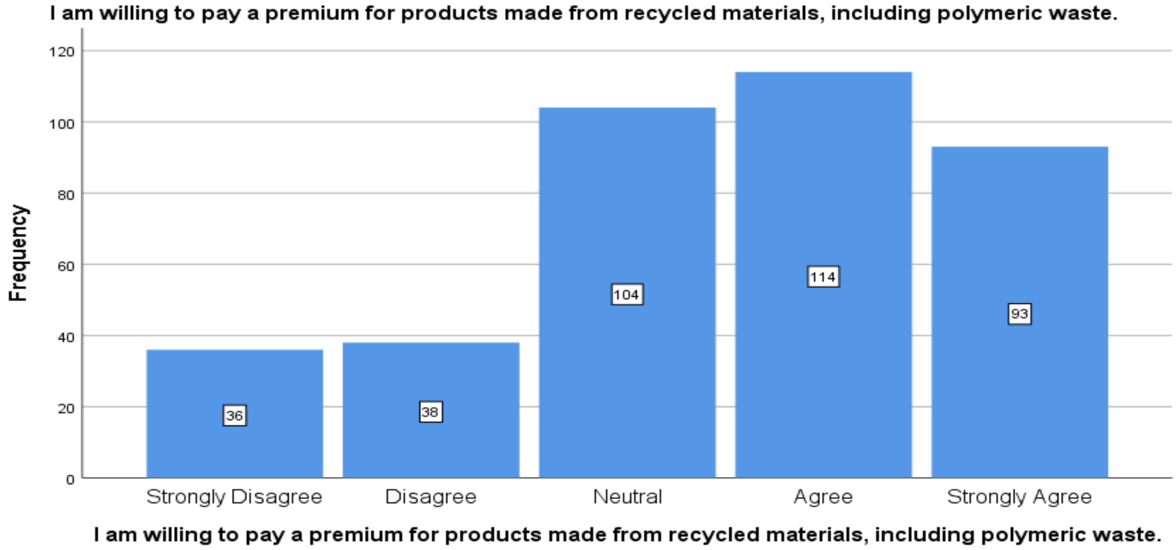
Table 4.40 and figure 4.31 show the response regarding the statement, "I believe it is important for consumers to actively participate in recycling and waste reduction efforts". According to table 4.40 and figure 4.31 (Bar chart), out of 385 respondents, 10.6% of the respondents strongly disagreed with the statement, 13.8% of the respondents disagreed with the statement, 33.0% of the respondents were neutral about the statement, 19.5% of the respondents agreed with the statement, and 23.1% of the respondents strongly agreed with the statement.

Table 4.41: Response regarding payment of premium

I am willing to pay a premium for products made from recycled materials, including polymeric waste.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	36	9.4	9.4	9.4
	Disagree	38	9.9	9.9	19.2
	Neutral	104	27.0	27.0	46.2
	Agree	114	29.6	29.6	75.8
	Strongly Agree	93	24.2	24.2	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.32: Response regarding payment of premium



Source: Created by the Author based on Research

Table 4.41 and figure 4.32 show the response regarding the statement, “I am willing to pay a premium for products made from recycled materials, including polymeric waste”.

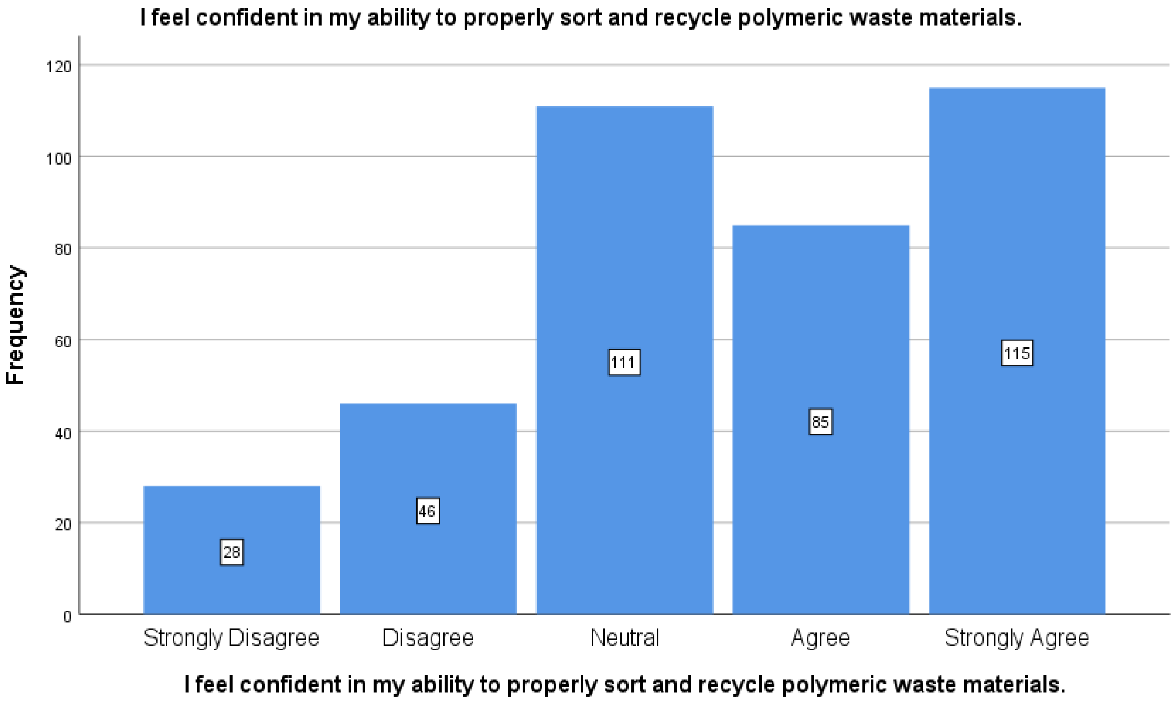
According to table 4.41 and figure 4.32 (Bar chart), out of 385 respondents, 9.4% of the respondents strongly disagreed with the statement, 9.9% of the respondents disagreed with the statement, 27.0% of the respondents were neutral about the statement, 29.6% of the respondents agreed with the statement, and 24.2% of the respondents strongly agreed with the statement.

Table 4.42: Response regarding properly sort and recycle

I feel confident in my ability to properly sort and recycle polymeric waste materials.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	28	7.3	7.3	7.3
	Disagree	46	11.9	11.9	19.2
	Neutral	111	28.8	28.8	48.1
	Agree	85	22.1	22.1	70.1
	Strongly Agree	115	29.9	29.9	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.33: Response regarding properly sort and recycle



Source: Created by the Author based on Research

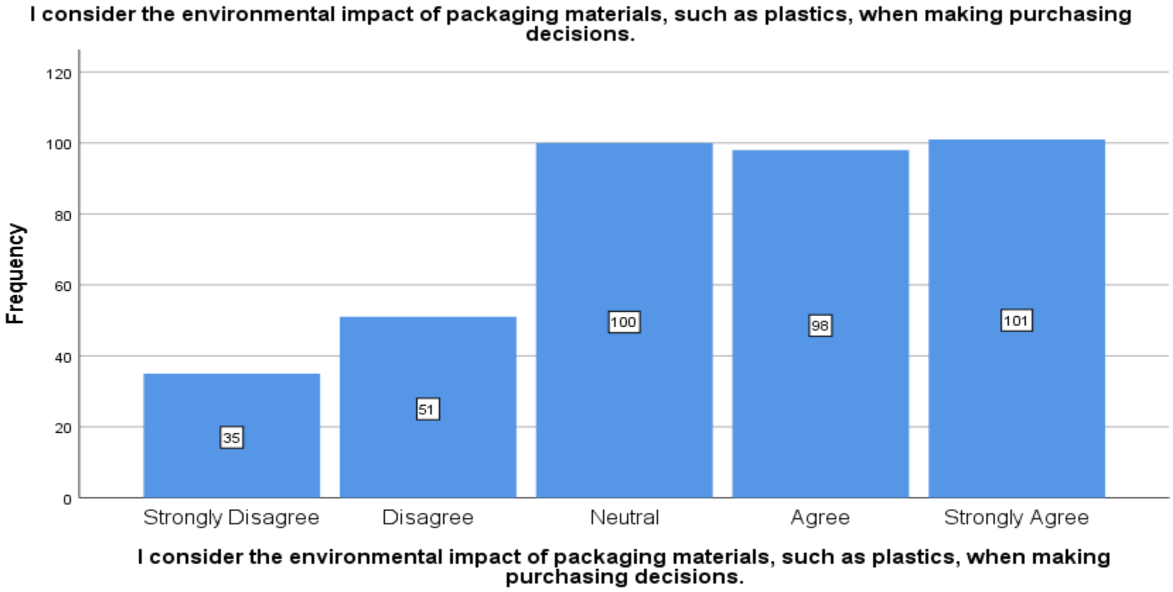
Table 4.42 and figure 4.33 show the response regarding the statement, “I feel confident in my ability to properly sort and recycle polymeric waste materials”. According to table 4.42 and figure 4.33 (Bar chart), out of 385 respondents, 7.3% of the respondents strongly disagreed with the statement, 11.9% of the respondents disagreed with the statement, 28.8% of the respondents were neutral about the statement, 22.1% of the respondents agreed with the statement, and 29.9% of the respondents strongly agreed with the statement.

Table 4.43: Response regarding environmental impact of packaging materials

I consider the environmental impact of packaging materials, such as plastics, when making purchasing decisions.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	35	9.1	9.1	9.1
	Disagree	51	13.2	13.2	22.3
	Neutral	100	26.0	26.0	48.3
	Agree	98	25.5	25.5	73.8
	Strongly Agree	101	26.2	26.2	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.34: Response regarding environmental impact of packaging materials



Source: Created by the Author based on Research

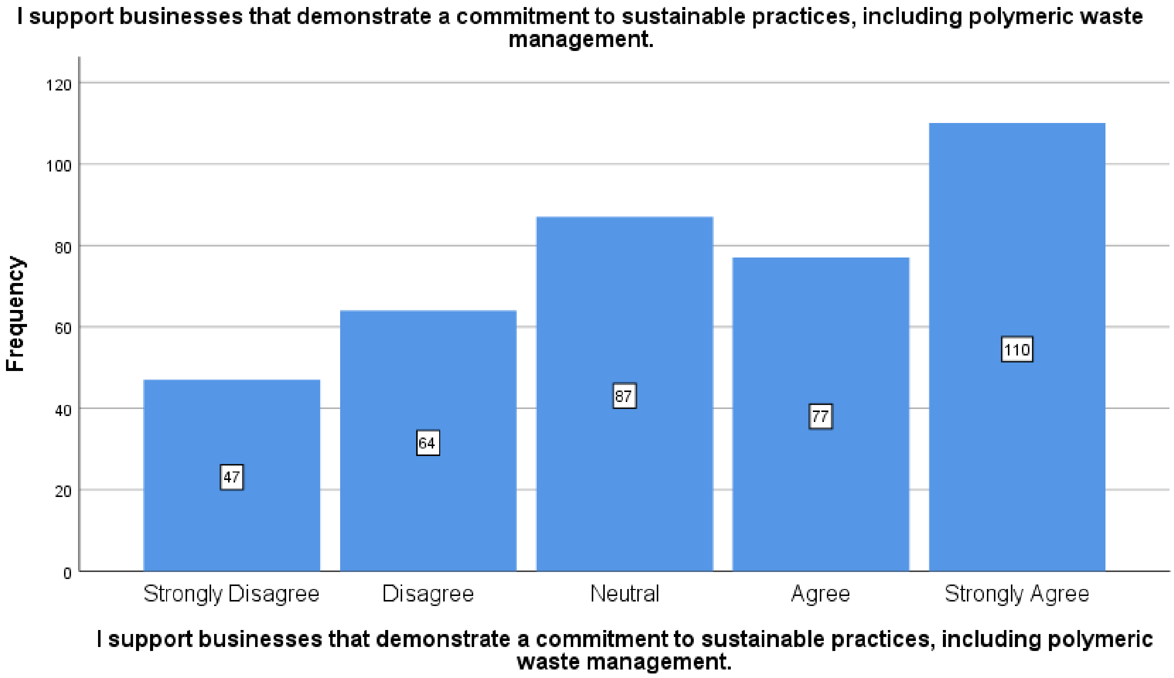
Table 4.43 and figure 4.34 show the response regarding the statement, “I consider the environmental impact of packaging materials, such as plastics, when making purchasing decisions”. According to table 4.43 and figure 4.34 (Bar chart), out of 385 respondents, 9.1% of the respondents strongly disagreed with the statement, 13.2% of the respondents disagreed with the statement, 26.0% of the respondents were neutral about the statement, 25.5% of the respondents agreed with the statement, and 26.2% of the respondents strongly agreed with the statement.

Table 4.44: Response regarding commitment to sustainable practices

I support businesses that demonstrate a commitment to sustainable practices, including polymeric waste management.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	47	12.2	12.2	12.2
	Disagree	64	16.6	16.6	28.8
	Neutral	87	22.6	22.6	51.4
	Agree	77	20.0	20.0	71.4
	Strongly Agree	110	28.6	28.6	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.35: Response regarding commitment to sustainable practices



Source: Created by the Author based on Research

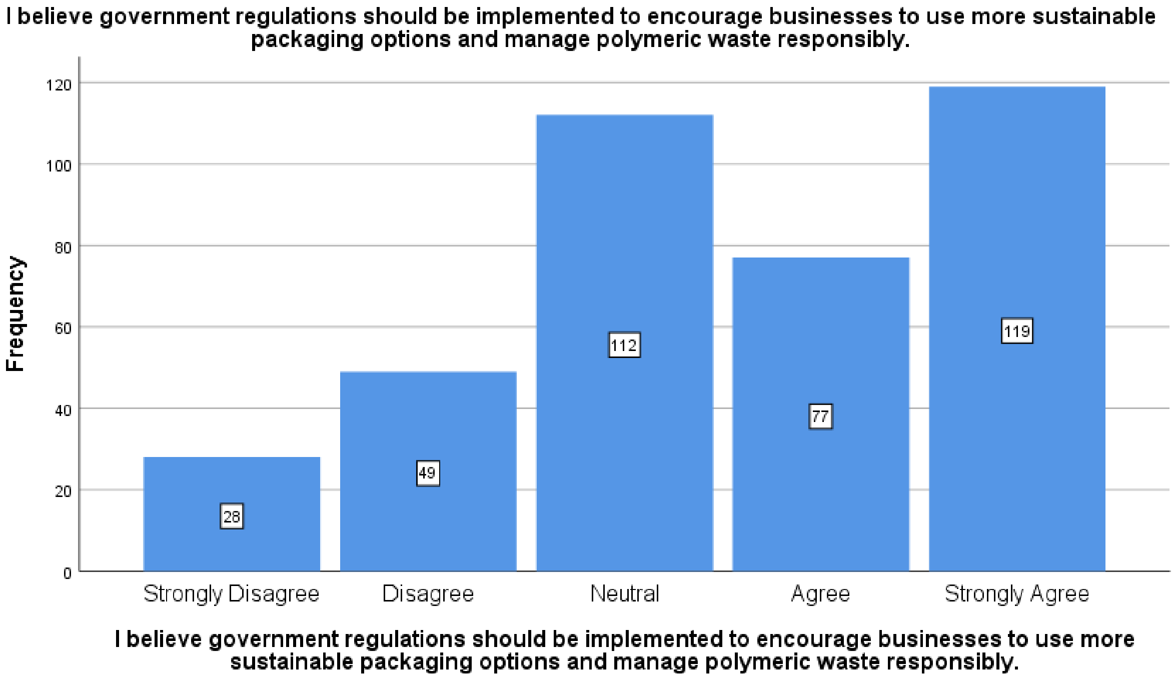
Table 4.44 and figure 4.35 show the response regarding the statement, "I support businesses that demonstrate a commitment to sustainable practices, including polymeric waste management". According to table 4.44 and figure 4.35 (Bar chart), out of 385 respondents, 12.2% of the respondents strongly disagreed with the statement, 16.6% of the respondents disagreed with the statement, 22.6% of the respondents were neutral about the statement, 20.0% of the respondents agreed with the statement, and 28.6% of the respondents strongly agreed with the statement.

Table 4.45: Response regarding implementation of government regulations

I believe government regulations should be implemented to encourage businesses to use more sustainable packaging options and manage polymeric waste responsibly.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	28	7.3	7.3	7.3
	Disagree	49	12.7	12.7	20.0
	Neutral	112	29.1	29.1	49.1
	Agree	77	20.0	20.0	69.1
	Strongly Agree	119	30.9	30.9	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.36: Response regarding implementation of government regulations



Source: Created by the Author based on Research

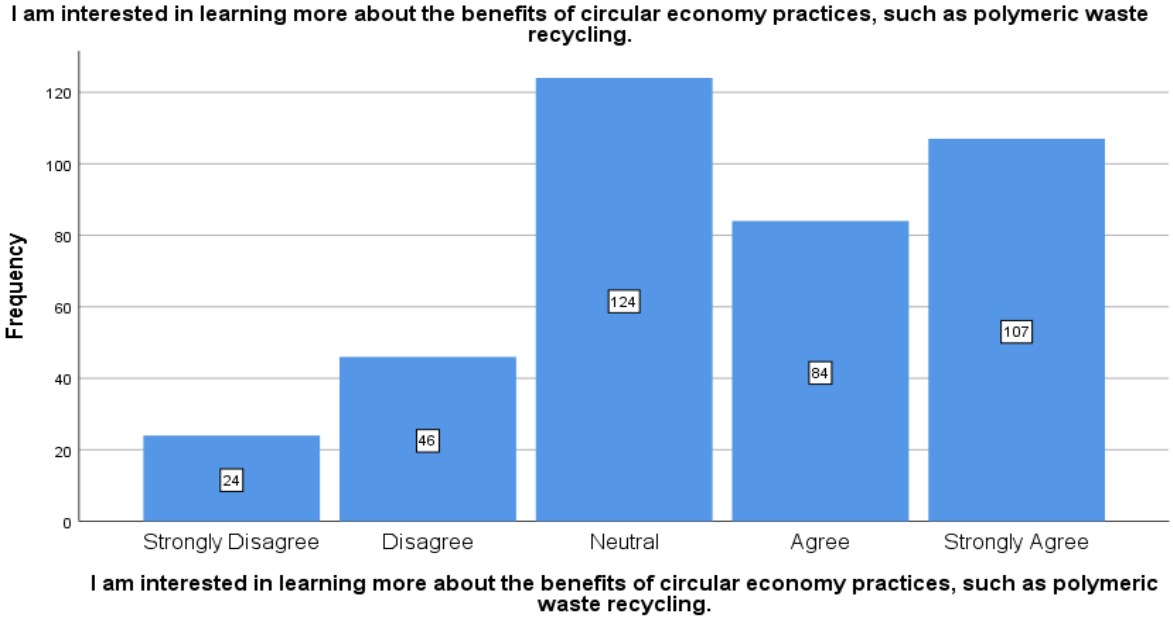
Table 4.45 and figure 4.36 show the response regarding the statement, “I believe government regulations should be implemented to encourage businesses to use more sustainable packaging options and manage polymeric waste responsibly”. According to table 4.45 and figure 4.36 (Bar chart), out of 385 respondents, 7.3% of the respondents strongly disagreed with the statement, 12.7% of the respondents disagreed with the statement, 29.1% of the respondents were neutral about the statement, 20.0% of the respondents agreed with the statement, and 30.9% of the respondents strongly agreed with the statement.

Table 4.46: Response regarding benefits of circular economy practices

I am interested in learning more about the benefits of circular economy practices, such as polymeric waste recycling.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	24	6.2	6.2	6.2
	Disagree	46	11.9	11.9	18.2
	Neutral	124	32.2	32.2	50.4
	Agree	84	21.8	21.8	72.2
	Strongly Agree	107	27.8	27.8	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.37: Response regarding benefits of circular economy practices



Source: Created by the Author based on Research

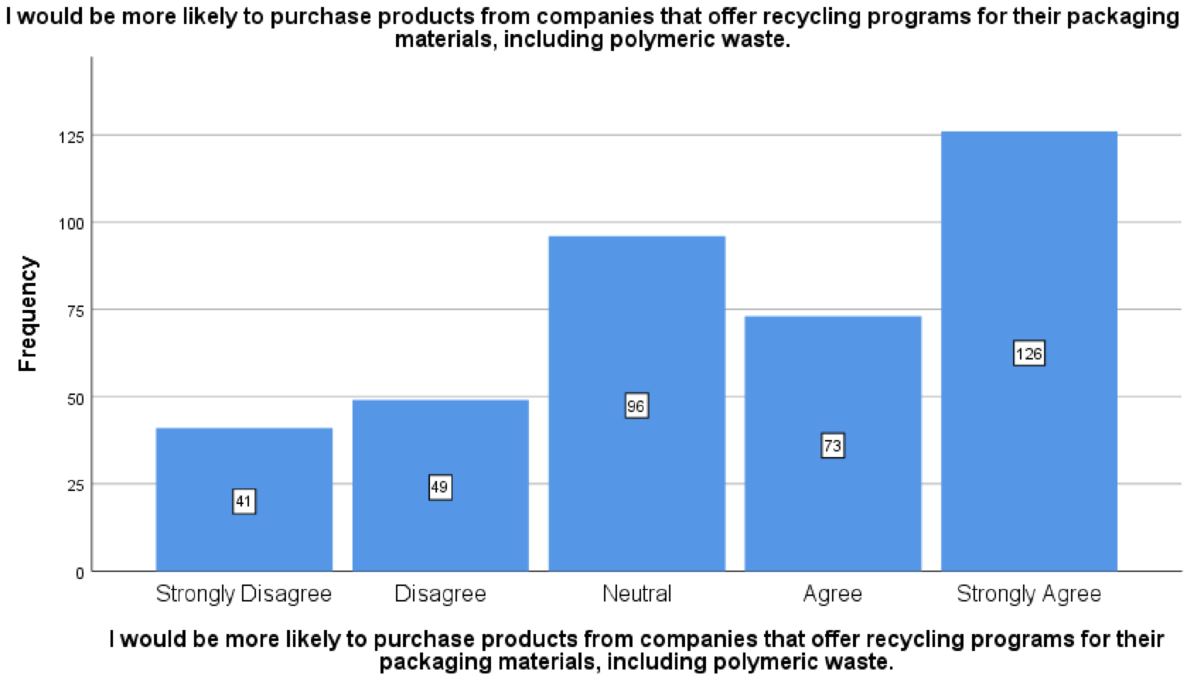
Table 4.46 and figure 4.37 show the response regarding the statement, “I am interested in learning more about the benefits of circular economy practices, such as polymeric waste recycling”. According to table 4.46 and figure 4.37 (Bar chart), out of 385 respondents, 6.2% of the respondents strongly disagreed with the statement, 11.9% of the respondents disagreed with the statement, 32.2% of the respondents were neutral about the statement, 21.8% of the respondents agreed with the statement, and 27.8% of the respondents strongly agreed with the statement.

Table 4.47: Response regarding purchasing of products from companies

I would be more likely to purchase products from companies that offer recycling programs for their packaging materials, including polymeric waste.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	41	10.6	10.6	10.6
	Disagree	49	12.7	12.7	23.4
	Neutral	96	24.9	24.9	48.3
	Agree	73	19.0	19.0	67.3
	Strongly Agree	126	32.7	32.7	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.38: Response regarding purchasing of products from companies



Source: Created by the Author based on Research

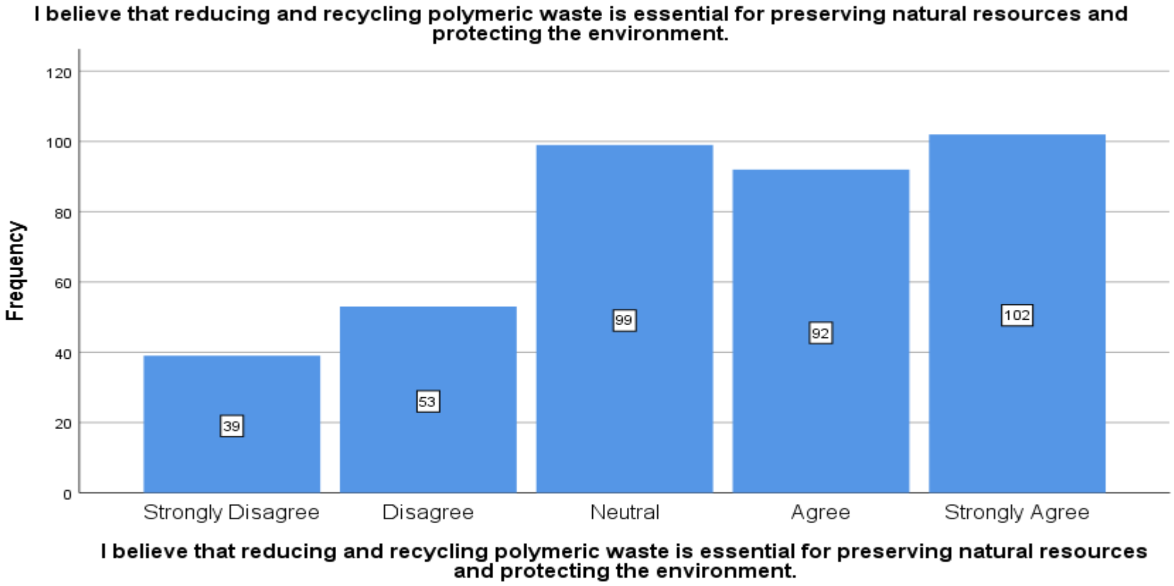
Table 4.47 and figure 4.38 show the response regarding the statement, "I would be more likely to purchase products from companies that offer recycling programs for their packaging materials, including polymeric waste". According to table 4.47 and figure 4.38 (Bar chart), out of 385 respondents, 10.6% of the respondents strongly disagreed with the statement, 12.7% of the respondents disagreed with the statement, 24.9% of the respondents were neutral about the statement, 19.0% of the respondents agreed with the statement, and 32.7% of the respondents strongly agreed with the statement.

Table 4.48: Response regarding reducing and recycling polymeric waste

I believe that reducing and recycling polymeric waste is essential for preserving natural resources and protecting the environment.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	39	10.1	10.1	10.1
	Disagree	53	13.8	13.8	23.9
	Neutral	99	25.7	25.7	49.6
	Agree	92	23.9	23.9	73.5
	Strongly Agree	102	26.5	26.5	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.39: Response regarding reducing and recycling polymeric waste



Source: Created by the Author based on Research

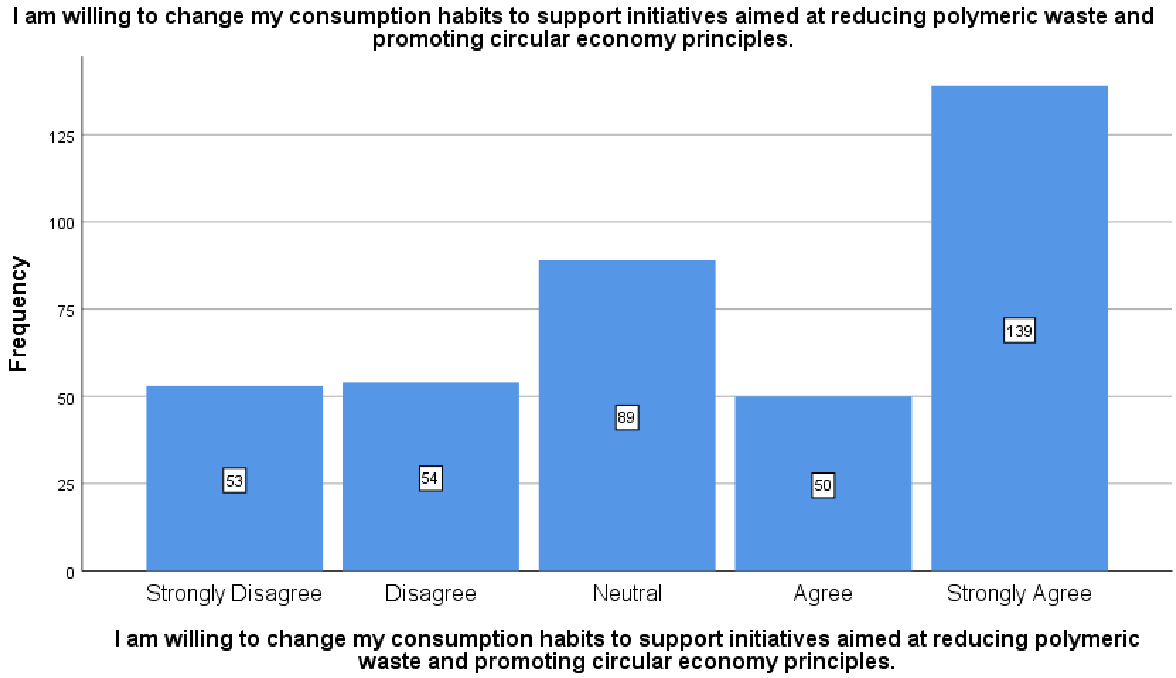
Table 4.48 and figure 4.39 show the response regarding the statement, “I believe that reducing and recycling polymeric waste is essential for preserving natural resources and protecting the environment". According to table 4.48 and figure 4.39 (Bar chart), out of 385 respondents, 10.1% of the respondents strongly disagreed with the statement, 13.8% of the respondents disagreed with the statement, 25.7% of the respondents were neutral about the statement, 23.9% of the respondents agreed with the statement, and 26.5% of the respondents strongly agreed with the statement.

Table 4.49: Response regarding change of consumption habits

I am willing to change my consumption habits to support initiatives aimed at reducing polymeric waste and promoting circular economy principles.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	53	13.8	13.8	13.8
	Disagree	54	14.0	14.0	27.8
	Neutral	89	23.1	23.1	50.9
	Agree	50	13.0	13.0	63.9
	Strongly Agree	139	36.1	36.1	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.40: Response regarding change of consumption habits



Source: Created by the Author based on Research

Table 4.49 and figure 4.40 show the response regarding the statement, “I am willing to change my consumption habits to support initiatives aimed at reducing polymeric waste and promoting circular economy principles”. According to table 4.49 and figure 4.40 (Bar chart), out of 385 respondents, 13.8% of the respondents strongly disagreed with the statement, 14.0% of the respondents disagreed with the statement, 23.1% of the respondents were neutral about the statement, 13.0% of the respondents agreed with the statement, and 36.1% of the respondents strongly agreed with the statement.

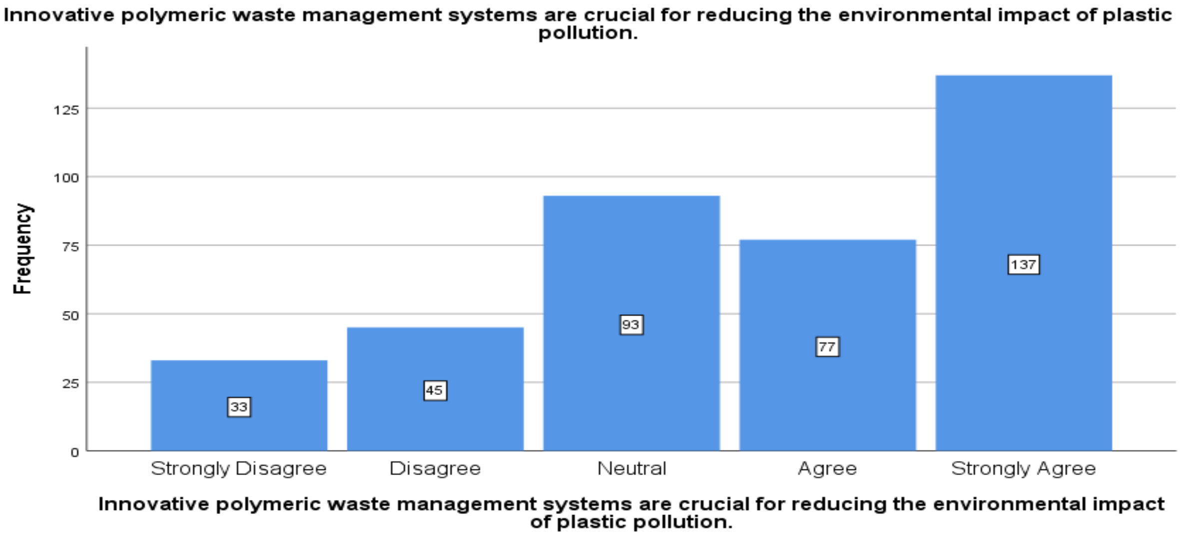
- **Innovative polymeric waste management systems**

Table 4.50: Response regarding innovative polymeric waste management systems

Innovative polymeric waste management systems are crucial for reducing the environmental impact of plastic pollution.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	33	8.6	8.6	8.6
	Disagree	45	11.7	11.7	20.3
	Neutral	93	24.2	24.2	44.4
	Agree	77	20.0	20.0	64.4
	Strongly Agree	137	35.6	35.6	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.41: Response regarding innovative polymeric waste management systems



Source: Created by the Author based on Research

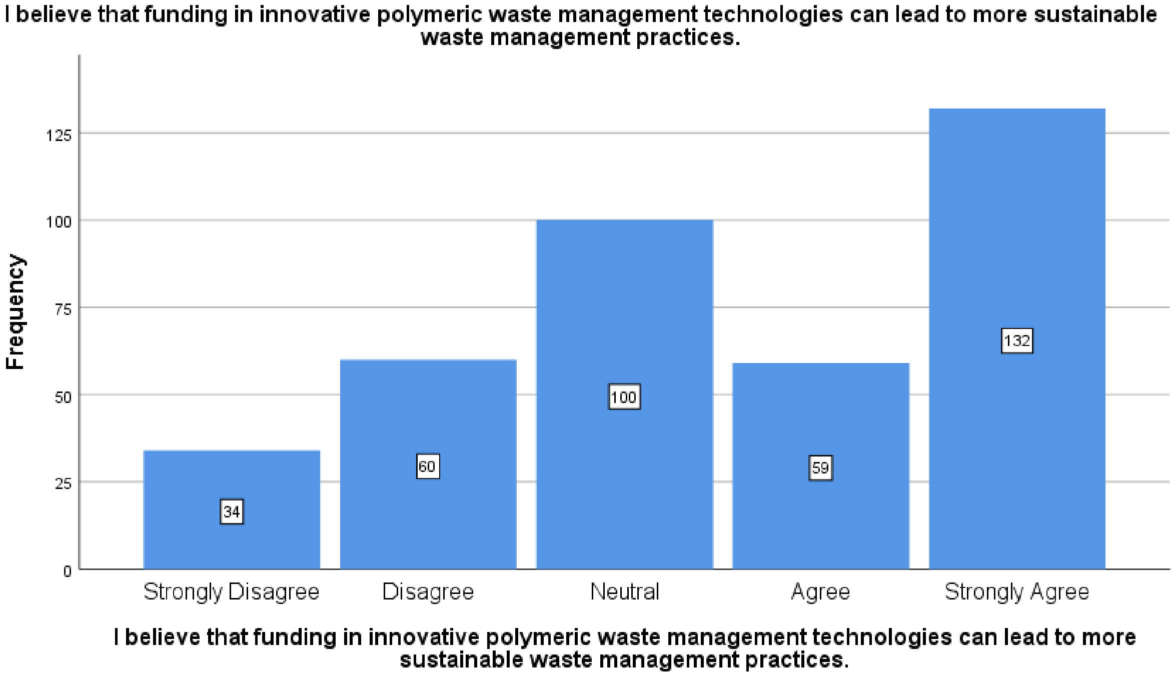
Table 4.50 and figure 4.41 show the response regarding the statement, “Innovative polymeric waste management systems are crucial for reducing the environmental impact of plastic pollution”. According to table 4.50 and figure 4.41 (Bar chart), out of 385 respondents, 8.6% of the respondents strongly disagreed with the statement, 11.7% of the respondents disagreed with the statement, 24.2% of the respondents were neutral about the statement, 20.0% of the respondents agreed with the statement, and 35.6% of the respondents strongly agreed with the statement.

Table 4.51: Response regarding funding in innovative polymeric waste management systems

I believe that funding in innovative polymeric waste management technologies can lead to more sustainable waste management practices.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	34	8.8	8.8	8.8
	Disagree	60	15.6	15.6	24.4
	Neutral	100	26.0	26.0	50.4
	Agree	59	15.3	15.3	65.7
	Strongly Agree	132	34.3	34.3	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.42: Response regarding funding in innovative polymeric waste management systems



Source: Created by the Author based on Research

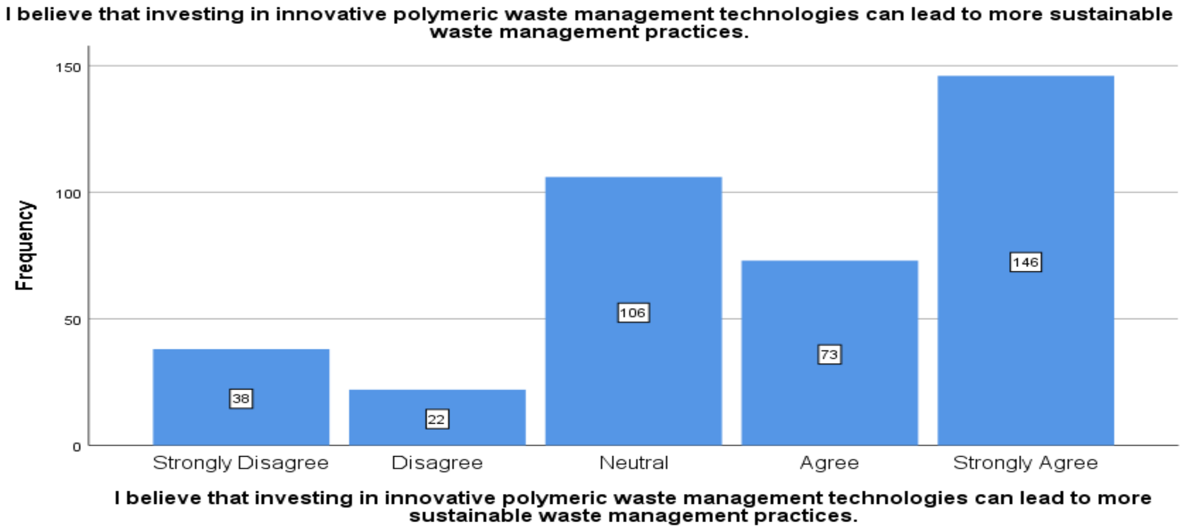
Table 4.51 and figure 4.42 show the response regarding the statement, "I believe that funding in innovative polymeric waste management technologies can lead to more sustainable waste management practices". According to table 4.51 and figure 4.42 (Bar chart), out of 385 respondents, 8.8% of the respondents strongly disagreed with the statement, 15.6% of the respondents disagreed with the statement, 26.0% of the respondents were neutral about the statement, 15.3% of the respondents agreed with the statement, and 34.3% of the respondents strongly agreed with the statement.

Table 4.52: Response regarding investing in innovative polymeric waste management systems

I believe that investing in innovative polymeric waste management technologies can lead to more sustainable waste management practices.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	38	9.9	9.9	9.9
	Disagree	22	5.7	5.7	15.6
	Neutral	106	27.5	27.5	43.1
	Agree	73	19.0	19.0	62.1
	Strongly Agree	146	37.9	37.9	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.43: Response regarding investing in innovative polymeric waste management systems



Source: Created by the Author based on Research

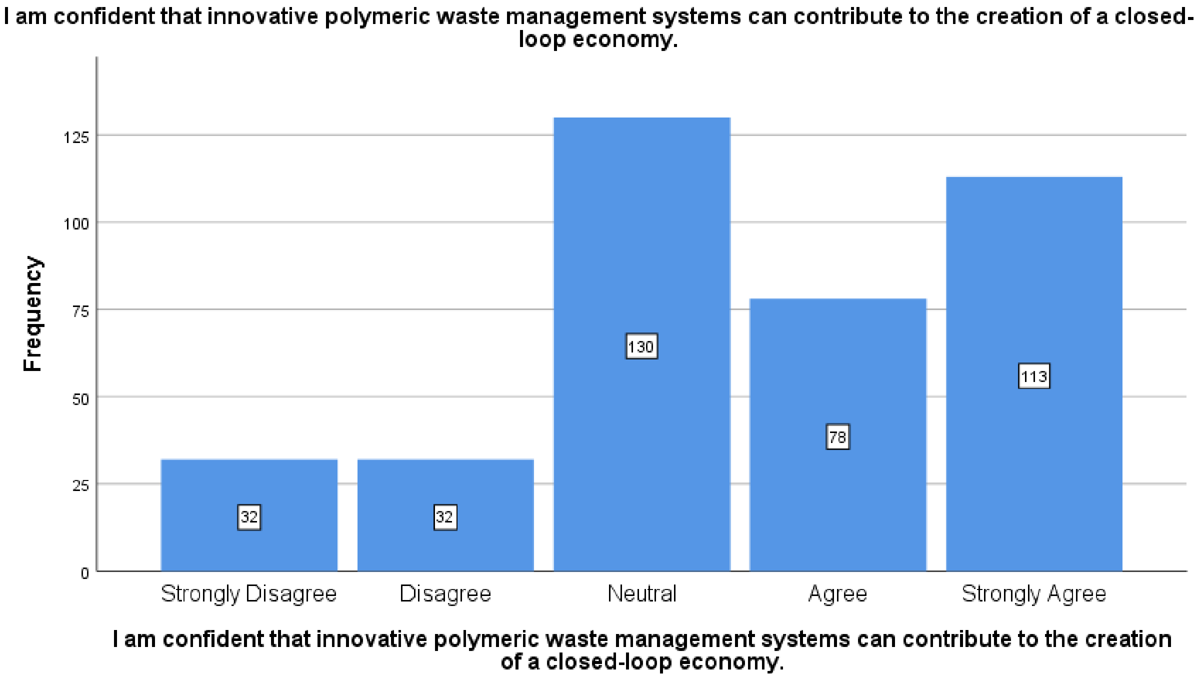
Table 4.52 and figure 4.43 show the response regarding the statement, “I believe that investing in innovative polymeric waste management technologies can lead to more sustainable waste management practices”. According to table 4.52 and figure 4.43 (Bar chart), out of 385 respondents, 9.9% of the respondents strongly disagreed with the statement, 5.7% of the respondents disagreed with the statement, 27.5% of the respondents were neutral about the statement, 19.0% of the respondents agreed with the statement, and 37.9% of the respondents strongly agreed with the statement.

Table 4.53: Response regarding contribution to the creation of a closed-loop economy

I am confident that innovative polymeric waste management systems can contribute to the creation of a closed-loop economy.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	32	8.3	8.3	8.3
	Disagree	32	8.3	8.3	16.6
	Neutral	130	33.8	33.8	50.4
	Agree	78	20.3	20.3	70.6
	Strongly Agree	113	29.4	29.4	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.44: Response regarding contribution to the creation of a closed-loop economy



Source: Created by the Author based on Research

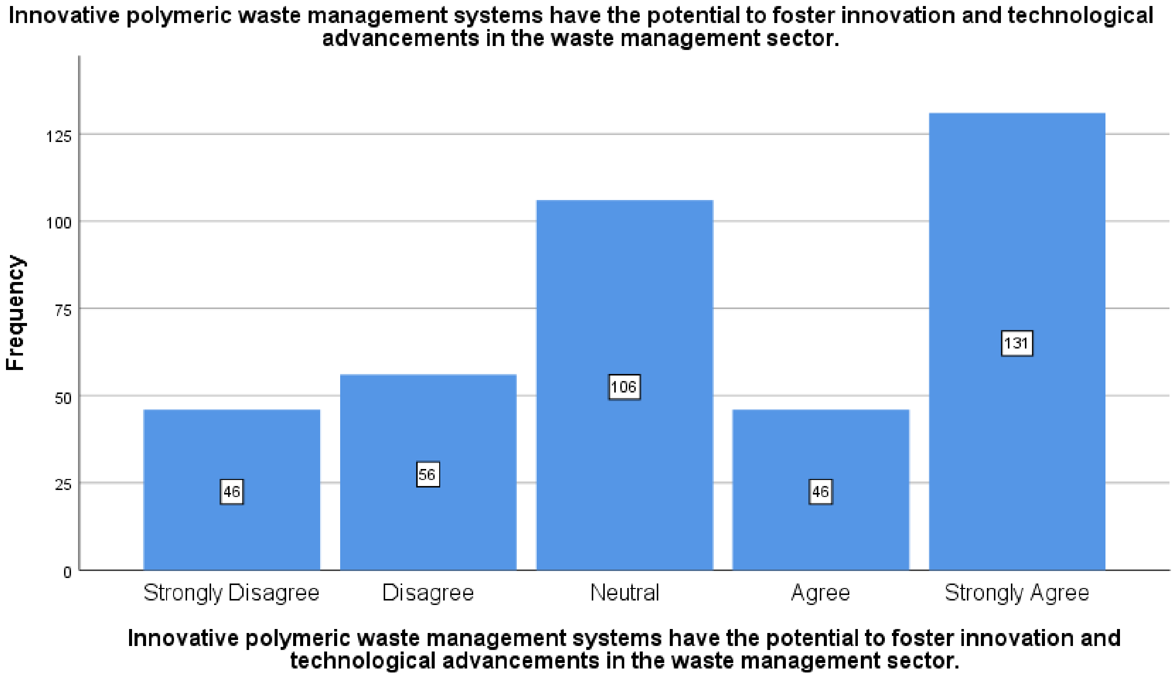
Table 4.53 and figure 4.44 show the response regarding the statement, "I am confident that innovative polymeric waste management systems can contribute to the creation of a closed-loop economy". According to table 4.53 and figure 4.44 (Bar chart), out of 385 respondents, 8.3% of the respondents strongly disagreed with the statement, 8.3% of the respondents disagreed with the statement, 33.8% of the respondents were neutral about the statement, 20.3% of the respondents agreed with the statement, and 29.4% of the respondents strongly agreed with the statement.

Table 4.54: Response regarding potential to foster innovation and technological advancements

Innovative polymeric waste management systems have the potential to foster innovation and technological advancements in the waste management sector.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	46	11.9	11.9	11.9
	Disagree	56	14.5	14.5	26.5
	Neutral	106	27.5	27.5	54.0
	Agree	46	11.9	11.9	66.0
	Strongly Agree	131	34.0	34.0	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.45: Response regarding potential to foster innovation and technological advancements



Source: Created by the Author based on Research

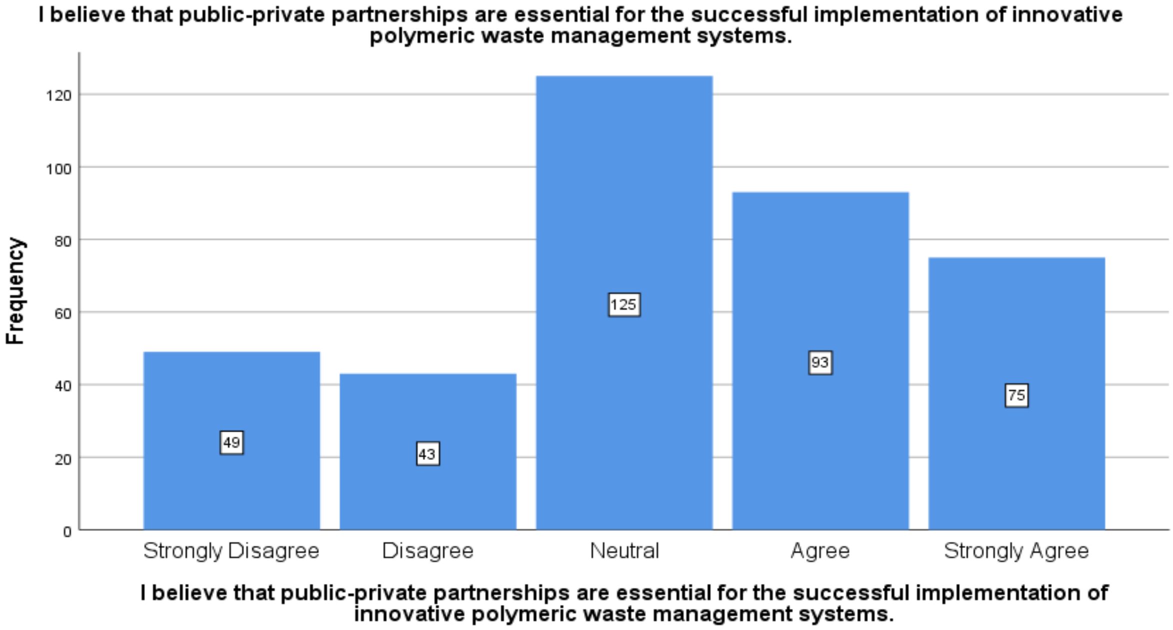
Table 4.54 and figure 4.45 show the response regarding the statement, "Innovative polymeric waste management systems have the potential to foster innovation and technological advancements in the waste management sector". According to table 4.54 and figure 4.45 (Bar chart), out of 385 respondents, 11.9% of the respondents strongly disagreed with the statement, 14.5% of the respondents disagreed with the statement, 27.5% of the respondents were neutral about the statement, 11.9% of the respondents agreed with the statement, and 34.0% of the respondents strongly agreed with the statement.

Table 4.55: Response regarding public-private partnerships

I believe that public-private partnerships are essential for the successful implementation of innovative polymeric waste management systems.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	49	12.7	12.7	12.7
	Disagree	43	11.2	11.2	23.9
	Neutral	125	32.5	32.5	56.4
	Agree	93	24.2	24.2	80.5
	Strongly Agree	75	19.5	19.5	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.46: Response regarding public-private partnerships



Source: Created by the Author based on Research

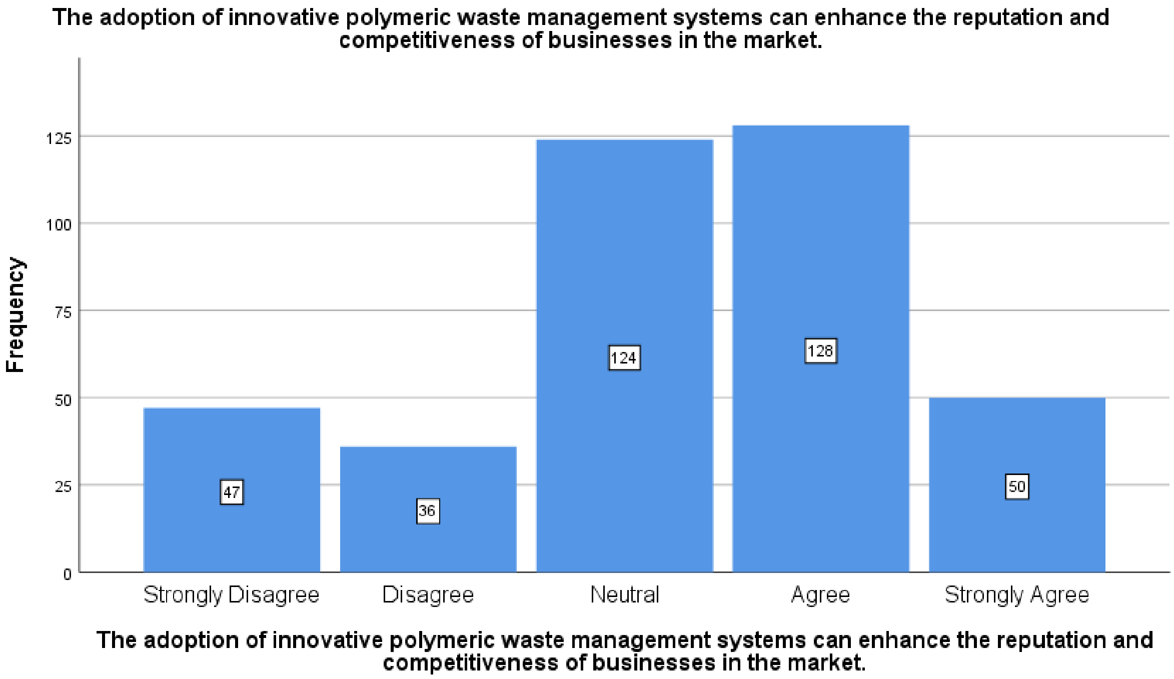
Table 4.55 and figure 4.46 show the response regarding the statement, “I believe that public-private partnerships are essential for the successful implementation of innovative polymeric waste management systems”. According to table 4.55 and figure 4.46 (Bar chart), out of 385 respondents, 12.7% of the respondents strongly disagreed with the statement, 11.2% of the respondents disagreed with the statement, 32.5% of the respondents were neutral about the statement, 24.2% of the respondents agreed with the statement, and 19.5% of the respondents strongly agreed with the statement.

Table 4.56: Response regarding the adoption of innovative polymeric waste management systems

The adoption of innovative polymeric waste management systems can enhance the reputation and competitiveness of businesses in the market.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	47	12.2	12.2	12.2
	Disagree	36	9.4	9.4	21.6
	Neutral	124	32.2	32.2	53.8
	Agree	128	33.2	33.2	87.0
	Strongly Agree	50	13.0	13.0	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.47: Response regarding the adoption of innovative polymeric waste management systems



Source: Created by the Author based on Research

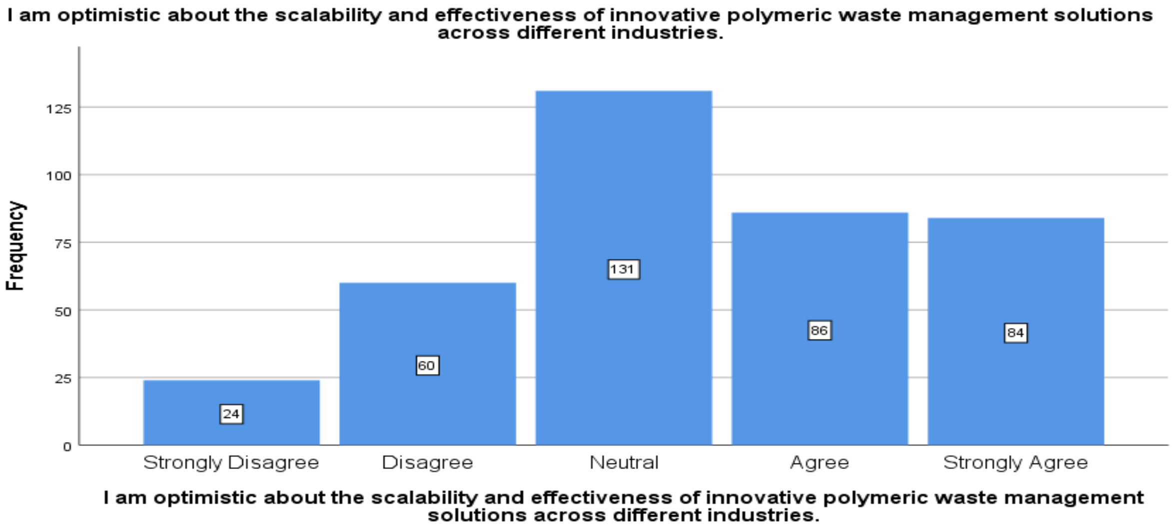
Table 4.56 and figure 4.47 show the response regarding the statement, "The adoption of innovative polymeric waste management systems can enhance the reputation and competitiveness of businesses in the market". According to table 4.56 and figure 4.47 (Bar chart), out of 385 respondents, 12.2% of the respondents strongly disagreed with the statement, 9.4% of the respondents disagreed with the statement, 32.2% of the respondents were neutral about the statement, 33.2% of the respondents agreed with the statement, and 13.0% of the respondents strongly agreed with the statement.

Table 4.57: Response regarding scalability and effectiveness of innovative polymeric waste management systems

I am optimistic about the scalability and effectiveness of innovative polymeric waste management solutions across different industries.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	24	6.2	6.2	6.2
	Disagree	60	15.6	15.6	21.8
	Neutral	131	34.0	34.0	55.8
	Agree	86	22.3	22.3	78.2
	Strongly Agree	84	21.8	21.8	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.48: Response regarding scalability and effectiveness of innovative polymeric waste management systems



Source: Created by the Author based on Research

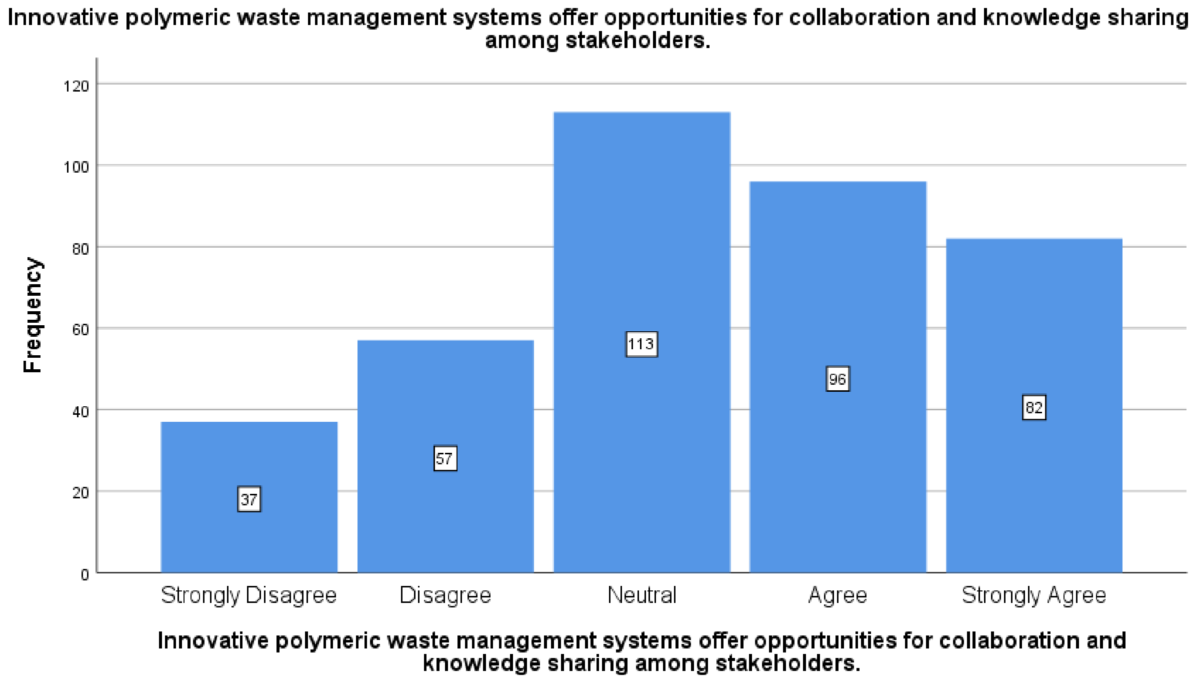
Table 4.57 and figure 4.48 show the response regarding the statement, “I am optimistic about the scalability and effectiveness of innovative polymeric waste management solutions across different industries”. According to table 4.57 and figure 4.48 (Bar chart), out of 385 respondents, 6.2% of the respondents strongly disagreed with the statement, 15.6% of the respondents disagreed with the statement, 34.0% of the respondents were neutral about the statement, 22.3% of the respondents agreed with the statement, and 21.8% of the respondents strongly agreed with the statement.

Table 4.58: Response regarding opportunities for collaboration and knowledge sharing among stakeholders

Innovative polymeric waste management systems offer opportunities for collaboration and knowledge sharing among stakeholders.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	37	9.6	9.6	9.6
	Disagree	57	14.8	14.8	24.4
	Neutral	113	29.4	29.4	53.8
	Agree	96	24.9	24.9	78.7
	Strongly Agree	82	21.3	21.3	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.49: Response regarding opportunities for collaboration and knowledge sharing among stakeholders



Source: Created by the Author based on Research

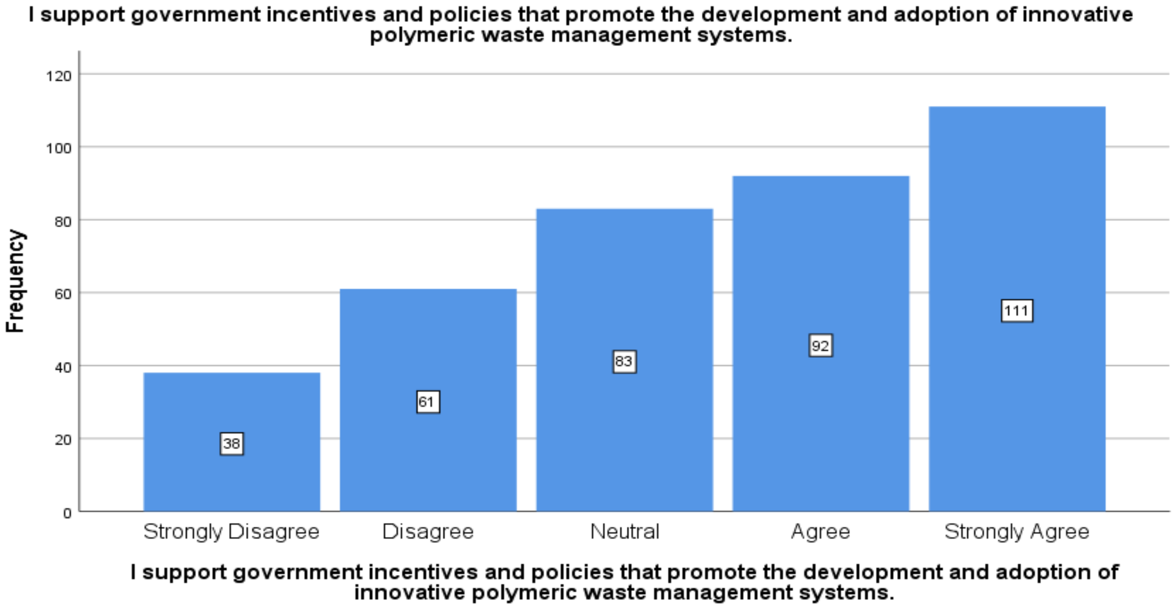
Table 4.58 and figure 4.49 show the response regarding the statement, “Innovative polymeric waste management systems offer opportunities for collaboration and knowledge sharing among stakeholders”. According to table 4.58 and figure 4.49 (Bar chart), out of 385 respondents, 9.6% of the respondents strongly disagreed with the statement, 14.8% of the respondents disagreed with the statement, 29.4% of the respondents were neutral about the statement, 24.9% of the respondents agreed with the statement, and 21.3% of the respondents strongly agreed with the statement.

Table 4.59: Response regarding government incentives and policies

I support government incentives and policies that promote the development and adoption of innovative polymeric waste management systems.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	38	9.9	9.9	9.9
	Disagree	61	15.8	15.8	25.7
	Neutral	83	21.6	21.6	47.3
	Agree	92	23.9	23.9	71.2
	Strongly Agree	111	28.8	28.8	100.0
	Total	385	100.0	100.0	

Source: Created by the Author based on Research

Figure 4.50: Response regarding government incentives and policies



Source: Created by the Author based on Research

Table 4.59 and figure 4.50 show the response regarding the statement, "I support government incentives and policies that promote the development and adoption of innovative polymeric waste management systems". According to table 4.59 and figure 4.50 (Bar chart), out of 385 respondents, 9.9% of the respondents strongly disagreed with the statement, 15.8% of the respondents disagreed with the statement, 21.6% of the respondents were neutral about the statement, 23.9% of the respondents agreed with the statement, and 28.8% of the respondents strongly agreed with the statement.

CHAPTER V:

DISCUSSION

5.1 Overview

The research outcomes from the preceding chapters provide an in-depth understanding of the management of waste and its temporal variability in response to different occurrences. Furthermore, it evaluates and contrasts the findings of interviews and surveys across different age groups. The chapter provides a comprehensive examination of the results, including an assessment of the study's limitations and suggestions for further research. The research highlights a significant change in how waste management is perceived, emphasizing the growing importance of polymeric waste control techniques. There are many discussions on the possibility of change, the influence of social surroundings, and the transformative effects of different waste management practices in this study topic.

Waste refers to any material that has to be discarded since it is an unavoidable byproduct of industrial or home activities and has no economic value. Comprehending the characteristics of waste its inherent nature, environmental impact, proper disposal methods, and other relevant factors is an essential and fundamental component. Wastes exist in numerous forms, including liquid, gaseous, and solid phases, and are generated by a range of human manufacturing activities. Plastic trash is a distinct kind of solid waste. Plastics have a significantly prolonged degradation period when compared to other forms of garbage. Due to the affordability of plastics, people often abuse them, resulting in injury. However, several regions, mostly industrialized countries, have embraced the concept of implementing fees for the use of plastics. As a result, individuals now have to pay for plastic bags while buying in malls. Due to their extensive use, plastic is a very distinctive category of materials that generate significant attention in the worldwide economy. The rapid growth of the worldwide population and industrial development has led to a significant increase in the generation and disposal of plastic garbage. The combination of anthropogenic and biodegradable factors, such as industrial expansion, social development, climate, and operational sectors, leads to the generation of substantial quantities of both non-biodegradable and biodegradable waste. To facilitate the proper disposal of old plastic garbage by the general people, many environmental safety laws, regulations, and protocols have been implemented by government municipalities, social groups, and local authorities. Several waste management solutions, such as landfills, recycling, burning, and bioremediation, are backed by scientific concepts. Implementing these protocols guarantees a hygienic setting and efficient management of plastic waste.

In recent decades, the development of population, growing urbanization, growing industrialization, and the widespread use of plastics in many sectors have together led to a steady rise in the production of plastic from other countries. Plastics are versatile substances that are widely used in several industries such as building, electronics, packaging, and automobiles. As a result, the growing need for plastics has led to a significant growth in manufacturing capacity worldwide. However, there are concerns about the environmental consequences of the fast growth of plastic manufacturing, particularly addressing the depletion of resources, emissions of greenhouse gases, and pollution caused by plastic. The inadequate handling and improper disposal of plastic trash have led to significant degradation of the environment, including the contamination of marine ecosystems, disruption of ecological balance, and threats to human health and welfare. The focus on promoting sustainable practices across the whole plastic value chain, including reducing plastic use, improving the handling and recycling of waste infrastructure, and transitioning to circular economy models, has gained increased attention in response to these challenges. Efforts to reduce the negative impact of plastic manufacture and use on the natural world and human well-being are being led by governments, companies, civil society organizations, and international initiatives. The objective of these endeavors is to promote sustainability and tackle the issue of plastic pollution. The proliferation of plastic has surged in many families worldwide, prompting several governments, such as China, to impose a ban on the material to mitigate the volume of plastics in circulation. This is due to the well-established evidence that polymers are very effective contaminants in both urban environments and marine ecosystems.

5.2 Discussion on Result

5.2.1 Discussion Based on Demographic Characteristics

- Upon observation, it is noted that out of the 385 respondents chosen for the research, 201 are men, accounting for 52.2% of the whole sample, while 184 are females, making up 47.8% of the overall sample.
- The average age of the participants out of the 385 people who were chosen for the research, 16.4% are under 18 years old, 18.4% are between 18 and 24 years old, 13.8% are between 25 and 34 years old, 18.7% are between 35 and 44 years old, 17.9% are between 45 and 54 years old, and remaining 14.8% are above 54 years old. The age group of 35-44 years has the largest proportion (18.7%) among the sample responses.

- The educational background of the participants. Table 4.3 shows that among the 385 respondents, 27.8% possess bachelor's degrees, 21.3% hold master's degrees, 24.7% hold doctorates, and the other 26.2% hold other degrees. The data indicates that the largest proportion of respondents possess a bachelor's degree (27.8%).
- The respondents' occupation. that of the 385 respondents, 14.8% are engineers, 20.8% are government employees, 21.8% are scientists, 20.5% are students, and the other 22.1% belong to other categories. The data indicates that the largest portion of the respondents, namely 22.1%, belongs to the category labeled as "others".
- The respondents' years of expertise in the environmental sector. Table 4.5 shows that out of the 385 respondents, 17.1% have less than 1 year of experience, 21.6% have 1-2 years of experience, 20.5% have 3-5 years of experience, 18.7% have 6-10 years of experience, and remaining 22.1% have more than 10 years of experience. The data indicates that 22.1% of the respondents had more than 10 years of experience.
- The respondents' income level that out of 385 participants, 19.0% have an income level below 25,000, 20.3% have an income level between 25,000 and 50,000, 20.0% have an income level between 50,001 and 75,000, 20.0% have an income level between 75,001 and 1,00,000, and the rest, or 20.8% have an income level above 1,00,000. The data indicates that 20.8% of the respondents had an income level of over 1,00,000.
- The respondents' plastic usage frequency. Table 4.7 shows that of the 385 respondents, 33.0% use plastic daily, 35.8% consume plastic every week, and the other 31.2% consume plastic monthly. The data indicates that most of the respondents consume plastic every week, with a frequency of 35.8%.
- The geographic coordinates of the participants are that of the 385 respondents, 36.6% come from rural areas, 29.9% come from suburban areas, and the balance of 33.5% come from urban areas. The data indicates that 36.6% of the respondents are from rural areas.
- The level of understanding that the respondents have about the principles of circular economy. Table 4.9 shows that of the 385 respondents, 33.2% have no awareness, 30.6% have some awareness, and the rest, 36.1% have a high level of awareness. The data indicates that a significant proportion of the respondents (36.1%) possess a high level of awareness.
- The respondents' industry sector out of the 385 respondents, 17.4% are from the construction sector, 13.0% are from the education sector, 19.5% are from the healthcare sector, 17.1% are from the manufacturing sector, 15.1% are from the transport sector,

and the other 17.9% are from other sectors. The data indicates that the largest proportion of respondents, namely 19.5%, are affiliated with the healthcare industry.

5.2.2 Discussion based on Objectives/Hypothesis

- The model summary demonstrates a substantial level of correlation. The R-value for a straightforward correlation is 0.102, indicating the extent to which the independent variable can account for the variation in the dependent variable, novel polymeric waste management solutions.
- The ANOVA provides a measure of the degree to which the regression equation accurately fits the data and predicts the dependent variable. This table demonstrates that the model of regression accurately predicts the variable that is dependent with a high degree of significance. The regression model has a statistical significance of 0.046, which is below the threshold of 0.05. This suggests that the model is a good match for the data and can accurately predict the outcome variable.
- The model summary demonstrates a substantial level of correlation. The simple correlation has an R-value of 0.116, indicating the extent to which the independent variable can explain the outcomes of the dependent variable, advanced polymeric waste management techniques, in terms of the total variance.
- The regression equation accurately predicts the variable that is dependent based on the data. The model of regression accurately predicts the variable that is dependent with a high level of significance. The regression model has a statistical significance of 0.023, which is below the threshold of 0.05. This suggests that the model is a good match for the data and can reliably predict the outcome variable.
- The model summary suggests a substantial level of correlation. The R-value for a simple correlation is 0.103, indicating the extent to which the independent variable may account for the variability in the dependent variable, namely novel polymeric waste management technologies.
- The ANOVA provides a measure of how well the model of regression predicts the dependent variable. This table demonstrates that the model of regression accurately predicts the variable that is dependent with a high level of significance.
- The regression model has a statistical significance of 0.043, which is below the threshold of 0.05. This implies that the regression model is a good match for the data and can predict the outcome variable with statistical significance.

CHAPTER VI:

CONCLUSION

6.1 Overview

An overview and final analysis of the extensive investigation on the topic of inference in the chapter "Polymeric waste management systems that are innovative and enhance the circular economy." The study focused on elucidating the impact of Waste Management Systems, particularly those that promote a circular economy, on the conventional notions of entrepreneurship and leadership. The research presumably investigated several complex topics about the subject, including the management of waste, Waste Management Systems, obstacles to polymeric waste management, and the efficacy of the Circular Economy.

The study titled "Innovative Polymeric Waste Management Systems to Enhance Circular Economy" investigates the interdependent connection between waste management and circular economy concepts, with a particular emphasis on polymeric waste. The study presents fundamental principles and difficulties in waste management while pushing for inventive approaches to encourage circularity. The chapter explores the methods of managing polymeric waste by analyzing several factors such as technical breakthroughs, regulatory frameworks, economic conditions, and buyer habits using an interdisciplinary approach. The integration of knowledge from many sources such as literature, study methods, and statistical data provides a thorough and detailed understanding of the intricacies within this field. In conclusion, the research highlights the need to adopt circularity as a means to reduce environmental harm, stimulate economic development, and improve social welfare. It also offers valuable insights and suggestions to facilitate significant changes in waste management methods.

6.2 Summary of the Chapters

Chapter 1 Introduction

The Chapter provided an overview of the management of polymeric waste, including the sources of polymer waste and the systems used for polymeric waste management. These features highlight the effectiveness of the Circular Economy. The chapter focused on innovative technologies for combating plastic waste as well as management strategies for waste made of plastic. The chapter also discussed the evaluated statement of the problem of the study, which calls for an analysis of the main elements influencing the worldwide manufacturing of plastics. The first section of the chapter establishes the background and circumstances for the subsequent chapters.

Chapter 2 Literature Review

The chapter included a comprehensive synopsis of previous academic publications that were significant to the subject matter of the research. An overview of the broader field of study was provided at the outset, emphasizing the importance of the chosen research subject. The evaluations were organized thematically and included several important topics, such as the difficulties encountered by industry in efficiently handling polymeric waste. The literature review analyzed consumer attitudes, actions, and awareness about the management of polymeric waste within the context of a circular economy. The concluding part of the chapter sets the theme for the ongoing inquiry by highlighting deficiencies in the existing collection of literature and offering a summary of the chapter.

Chapter 3 Research Methodology

The chapter served as a comprehensive framework for conducting the study, providing a systematic approach to doing research. A preliminary overview was presented at the outset, including fundamental information about the chosen methodology. The operational concepts, such as "polymeric waste," "circular economy," "polymeric waste management," and "sustainability," were precisely defined to establish a shared comprehension. The chapter proceeded to illustrate the significance of the investigation by offering a systematic approach to the research and providing a thorough explanation of its objectives and underlying assumptions. A conceptual structure was introduced, emphasizing the interrelated components being examined. The research methodology provided a comprehensive description of the methods and strategies used in data collecting and analysis. The chapter emphasizes the importance of maintaining methodological integrity by describing and using the random sample approach as a crucial measure. The chapter acknowledged the limits and defined the scope of the study to provide a comprehensive and truthful examination of the key factors that influence the techniques to manage waste.

Chapter 4 Analysis and Interpretation

The chapter provided a clear explanation of the main factors that affect these dynamics, to prepare for a comprehensive analysis. Detailed participant characterization is facilitated by demographic profiling, which further provides essential background and contextual information. To ensure the validity and accuracy of the gathered data, the chapter utilizes rigorous testing processes for assessing dependability. This step is crucial for determining the reliability and coherence of the study's findings. Moreover, indexing strategies are used to enhance both the accuracy and speed of the assessment process by simplifying it. The findings derived from the proposed hypotheses were meticulously reported and provided perceptive insights into the research's limitations. Upon conducting a meticulous examination of the responses provided by the participants, a full comprehension of their viewpoints was acquired. The chapter analyzed the intricate details of the complex. To provide a thorough understanding of the key factors that influence company success, a meticulous approach was used to analyze and interpret data.

Chapter 5 Discussion

The Chapter provided a comprehensive review of the subject matter. Furthermore, it does a comparative analysis of the survey and interview findings across different generations. The chapter provides a comprehensive examination of the results, including an assessment of the study's limitations and suggestions for further research. There are several topics on polymeric waste and its treatment in this research field. The chapter provides a structure for critically assessing the study's results and presents many viewpoints on the intricate handling of polymeric waste to improve the circular economy. By doing an analysis and engaging in a conversation centered on the proposed hypothesis and research goals. This presents novel prospects for investigation and advancement in this noteworthy field of study.

6.3 Findings Based on the Demographic Profile of the Respondents

- **Respondents were categorized by gender**

The survey had a total of 385 respondents. Among them, 201 were men, accounting for 52.2% of the sample, while 184 were females, making up 47.8% of the sample.

- **Respondents were categorized by age**

The study included 385 respondents, with the following distribution across age groups: 16.4% were under 18 years old, 18.4% were between 18 and 24 years old, 13.8% were between 25 and 34 years old, 18.7% were between 35 and 44 years old, 17.9% were between 45 and 54 years old, and the others 14.8% were above 54 years old. The age group of 35-44 years had the largest proportion (18.7%) of the sample responses.

- **The education level of the respondents**

The study found that among the 385 respondents, 27.8% had bachelor's degrees, 21.3% held master's degrees, 24.7% held doctorates, and the other 26.2% held various types of degrees. The data indicates that 27.8% of the respondents possess a bachelor's degree.

- **Respondents were categorized by occupation**

The respondents' profession or job It was noted that among the 385 respondents, 14.8% were engineers, 20.8% were government officials, 21.8% were scientists, 20.5% were students, and the rest of the 22.1% belonged to other categories. The data indicates that 22.1% of the people who responded belong to the category labeled as "others".

- **Respondents were categorized by Years of Experience in Environmental Field**

The respondents' years of expertise in the environmental sector. Out of the 385 respondents, 17.1% have less than 1 year of experience, 21.6% have 1-2 years of experience, 20.5% have 3-5 years of experience, 18.7% have 6-10 years of experience, and the other 22.1% have more than 10 years of experience. The data indicates that 22.1% of the respondents had more than 10 years of experience.

- **Respondents were categorized by Income Level**

The respondents' income level It was observed that out of the 385 respondents, 19.0% had an income level below 25,000, 20.3% had an income level between 25,000 and 50,000, 20.0% had an income level between 50,001 and 75,000, 20.0% had an income level between 75,001 and 1,00,000, and the rest 20.8% had an income level above 1,00,000. The data indicates that 20.8% of the respondents had an income level of over 1,00,000.

- **Respondents were categorized by Frequency of Plastic Consumption**

The frequency with which the respondents consume plastic. Table 4.7 shows that among the 385 respondents, 33.0% consume plastic daily, 35.8% consume plastic weekly, and the other 31.2% consume plastic monthly. The data indicates that most of the respondents consume plastic every week, with a frequency of 35.8%.

- **Respondents were categorized by Geographical location**

The survey found that of the 385 respondents, 36.6% were from rural regions, 29.9% were from suburban regions, and the other 33.5% were from urban areas. The data indicates that 36.6% of the respondents come from rural regions.

- **Awareness of Circular Economy Concepts of the respondents**

The understanding of circular economy principles the survey participants noted that of the 385 respondents, 33.2% were found to be unaware, 30.6% had some level of awareness, and the balance 36.1% were very aware. The data indicates that a significant proportion of the respondents (36.1%) possess a high level of awareness.

- **Industry sector of the respondents**

The industry sector of those who participated was analyzed and it was found that out of the total 385 respondents, 17.4% were from the construction sector, 13.0% were from the education sector, 19.5% were from the healthcare sector, 17.1% were from the manufacturing sector, 15.1% were from the transportation industry, and the remaining 17.9% were from other sectors. The data indicates that 19.5% of the respondents are from the healthcare industry.

6.4 Findings Based on Objectives/Hypothesis

Obj-1. To identify the impact of challenges, such as technological limitations, regulatory barriers, and market constraints, faced by industries in effectively managing polymeric waste within the circular economy framework.

H1: There is a significant impact of challenges, such as technological limitations, regulatory barriers, and market constraints, faced by industries in effectively managing polymeric waste within the circular economy framework.

H01: There is no significant impact of challenges, such as technological limitations, regulatory barriers, and market constraints, faced by industries in effectively managing polymeric waste within the circular economy framework.

The model summary demonstrates a substantial level of correlation. The R-value for the basic correlation is 0.102, indicating the extent to which the independent variable can account for the variation in the variable that is dependent. Innovative polymeric waste management solutions.

The ANOVA provides a measure of the goodness of fit of the regression equation to the data, specifically in terms of its ability to predict the dependent variable. This table demonstrates that the model of regression accurately predicts the variable that is dependent with a high level of significance. The regression model has a statistical significance of 0.046, which is below the threshold of 0.05. This suggests that the regression model is a good match for the data and can accurately predict the outcome variable.

The coefficients provide essential data for predicting the impact of "Innovative polymeric waste management systems" and determining the statistical significance of the "Challenges faced by industries" in the model.

Obj-2. To assess the environmental, economic, and social factors influencing the adoption of innovative polymeric waste management systems.

H2: There is a significant impact of environmental, economic, and social factors on the adoption of innovative polymeric waste management systems.

H02: There is no significant impact of environmental, economic, and social factors on the adoption of innovative polymeric waste management systems.

The model summary demonstrates a substantial level of correlation. The R-value for the straightforward correlation is 0.116, indicating the extent to which the independent variable can account for the variation in the variable that is dependent. Innovative polymeric waste management solutions.

The regression equation accurately models the data, allowing for the prediction of the dependent variable. The table demonstrated that the model of regression accurately predicts a dependent variable with a high level of significance. The regression model has a statistical significance of 0.023, which is below the threshold of 0.05. This shows that the model is a good match for the data and can accurately predict the outcome variable.

The coefficients provide essential data for forecasting the impact of "Innovative polymeric waste management systems" and assessing the statistical significance of the "Environmental, economic, and social factors" in the model.

Obj-3. To Examine consumer attitudes, behaviors, and awareness regarding polymeric waste and circular economy initiatives and their influence on adoption rates of innovative waste management solutions.

H3: Consumer perceptions and attitudes regarding polymeric waste and circular economy initiatives significantly influence the adoption rates of innovative waste management solutions.

H03: Consumer perceptions and attitudes regarding polymeric waste and circular economy initiatives do not influence adoption rates of innovative waste management solutions.

The model summary demonstrates a substantial level of correlation. The r value for a simple correlation was 0.103, indicating the extent to which the independent variable can account for the variability in the variable that is dependent, Innovative polymeric waste management solutions.

The regression equation accurately models the data, allowing for the prediction of the dependent variable. This table demonstrates that the model of regression accurately predicts the variable that is dependent with a high level of significance. The regression model has a statistical significance of 0.043, which is below the threshold of 0.05. This suggests that the regression model is a good match for the data and can predict the outcome variable with statistical significance.

The Coefficients contain the essential data for predicting the impact of "Innovative polymeric waste management systems" and determining the statistical significance of "Consumer perceptions and attitudes" in the model.

6.5 Implications of the Study

The study that examined novel polymeric waste management technologies to improve the circular economy might have significant ramifications in several fields. From an ecological standpoint, such studies might emphasize the crucial significance of sophisticated waste management technology in reducing plastic pollution and conserving natural resources. The research aims to encourage the adoption of circular economy methods in the plastics sector. This may lead to a transition towards closed-loop structures and circular principles of design, resulting in a decrease in waste creation and an improvement in resource efficiency. Furthermore, the discoveries might contribute to the formulation of policies by offering valuable knowledge on successful approaches to controlling plastic waste and encouraging environmentally friendly activities. In addition, the research may foster technical innovation by discovering new techniques and materials for recycling, reusing, or upcycling polymeric waste. This, in turn, will promote progress in environmentally friendly production and product development. Moreover, the study's consequences have a broader reach in terms of economic prospects, as it has the potential to reveal untapped market segments and customer inclinations towards environmentally sustainable goods and services. In essence, the research has the potential to contribute to a future that is more environmentally friendly and able to withstand challenges by taking into account the economic, social, and environmental aspects of managing polymeric waste.

6.6 Limitations of the Study

- Respondents may have a bias in their perspectives, which is unavoidable.
- The research will have a restricted scope, including just 385 participants.
- The research seems to be cross-sectional since it collects data at a certain moment in time. This constraint hinders the capacity to determine a cause-and-effect relationship between variables and fails to include potential changes in components over some time.
- The accuracy of the findings may be influenced by the reliability of the measuring methods used to evaluate elements such as technology restrictions, regulatory hurdles, market restraints, economic, environmental, and social issues, as well as customer views and actions.

6.7 Suggestions and Recommendations

- **Research and Development Investment**

Promote more investment in research and development (R&D) to advance the creation of cutting-edge polymeric waste management technologies. This may include providing financial assistance via financing programs, grants, and collaborations among government agencies, educational institutions, and industry players to facilitate the creation and commercialization of innovative technologies and processes.

- **Collaborative Partnerships**

Establish cooperative alliances among business, academia, administration, and NGOs (non-governmental organizations) to use combined knowledge, resources, and networks in promoting advancements in polymeric disposal solutions. Collaboration may enhance the exchange of information, transfer of technology, and development of capabilities to expedite the advancement toward an economy that is circular for plastics.

- **Policy Support**

Promote governmental frameworks and laws that encourage the use of creative polymeric systems for waste management and circular economy activities. These measures may include incentives for environmentally friendly design, programs that hold producers accountable for their products throughout their lifecycle, and laws that encourage the use of reused components in production.

- **Education and Awareness**

Advocate for educational and awareness campaigns aimed at enhancing public comprehension of the significance of managing polymeric waste and the advantages of the circular economy. This may include instructional campaigns, seminars, and outreach activities aimed at consumers, companies, and legislators to enhance awareness and promote behavioral modification.

- **Technology Transfer and Capacity Building**

Promote the transfer of technology and the development of skills to assist in promoting the use and implementation of advanced polymeric waste management techniques, with a specific focus on developing nations and underprivileged areas. This may include offering technical support, educational initiatives, and financial resources to facilitate the acceptance of technology and the development of infrastructure.

- **Market Development**

Encourage the demand for recycled resources and goods in the market by providing incentives to firms to integrate recycled materials into their supply networks and production processes. One such approach is to use market-driven mechanisms, like tax reductions, subsidies, or preferred procurement laws, to incentivize the adoption of reused resources and foster the adoption of circular economy activities.

- **Monitoring and Evaluation**

Implement strong monitoring and evaluation systems to effectively evaluate the progress made in accomplishing circular economy objectives and desired results. This may include the creation of indicators, measurements, and benchmarks to assess the efficiency and influence of polymeric waste management strategies over some time and then modify tactics as needed.

6.8 Conclusion

Overall, the topic of advanced polymeric systems for waste management and their crucial contribution to promoting the principles of a circular economy. The study highlights the complex obstacles and possibilities in dealing with plastic waste management by thoroughly examining literature, using a rigorous research approach, and conducting detailed analysis of demographic characteristics and statistical data. The results illuminate the substantial influence of technology limitations, regulatory obstacles, consumer habits, and economic conditions on the implementation of environmentally friendly waste management techniques within the circular economic framework. Although the study has limitations, such as a small sample size and a cross-sectional design, it provides useful insights into how environmental preservation, economic feasibility, and societal acceptability influence the direction of polymeric waste management.

The findings of this research have far-reaching effects in several areas, including environmental conservation, policy development, technology advancement, and corporate planning. The study aims to stimulate substantial progress towards a more environmentally friendly future by promoting more investment in research, fostering collaborative collaborations, establishing supporting policy frameworks, enhancing education, and facilitating market growth.

Moreover, the research proposes suggestions that seek to promote resilience, resource effectiveness, and circularity in the practices of managing plastic trash. By working together and taking deliberate actions, stakeholders may use the capabilities of cutting-edge technology, encourage sustainable consumption habits, and provide a favorable setting for the shift towards the circular economy for plastic. In essence, our study aims to motivate practical observations and facilitate concrete advancements toward a future that is both sustainable and robust for future generations.

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