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PLASTIC WASTE MANAGEMENT IN PAKISTAN: CHALLENGES AND PROSPECTS FOR TRANSITIONING TOWARDS A CIRCULAR ECONOMY

Dr. Abdul Qadir

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By:

Dr. Abdul Qadir[1]

Abstract:

This research paper investigates the concept of the circular economy (CE) and its application in the plastic value chain. The study emphasizes the importance of effective stakeholder communication and the adoption of circular principles to prolong product lifespan, enhance resource efficiency, and minimize waste generation. While plastic waste poses significant challenges to achieving circularity, the implementation of CE practices offers promising solutions to enhance sustainability, ensure raw material availability, and drive economic progress. The research examines the substantial contribution of plastic waste to global municipal solid waste, shedding light on the low rates of recycling and recovery. This finding underscores the pressing need for waste diversion and material reusability improvements. Additionally, the study explores the correlation between waste generation, income levels, and consumption patterns across countries, recognizing their influence on waste management outcomes. The paper highlights the global economy's heavy reliance on fossil fuel production for plastic manufacturing and draws attention to the non-degradability of plastics, presenting an urgent environmental concern. However, it also underscores the recyclability of plastics as a significant opportunity to integrate circular practices. To expand the circular economy, the paper proposes differentiating between open and closed-loop recycling, as well as exploring upcycling and down cycling approaches. Drawing on successful circular practices in Japan and Germany, such as chemical recycling and energy recovery, the research showcases advanced techniques that contribute to achieving circularity. In contrast, the study reveals prevailing linear economy practices in Pakistan's plastic industry, calling for the implementation of circular economy practices to address future challenges effectively. Identifying gaps in household participation, awareness, and infrastructure, the research emphasizes the importance of improved product design, efficient waste separation methods, and sustainable procurement to overcome contamination and quality issues. Additionally, the paper underscores the significance of ensuring a steady waste supply and creating appropriate markets to establish economic viability within the circular economy framework. Furthermore, the study suggests that non-governmental organizations (NGOs) can play a crucial role as communication partners, providing vital information on the availability and applications of secondary plastics. The research also highlights the role of Smart City developments, exemplified by innovative projects like the construction of Plastic Roads using post-

[1] College of Earth and Environmental Sciences University of the Punjab

consumer plastic waste. These initiatives demonstrate the potential of incorporating circular practices in urban development towards a more sustainable future. The paper emphasizes the alignment of Sustainable Development Goal-12 (SDG-12) with Pakistan's national agenda and the opportunities it presents for plastic recycling and reuse. It advocates for the implementation of policies and initiatives that support SDG-12 targets, fostering a circular economy and effectively managing plastic waste. Successful implementation of the circular economy in the plastic value chain requires improved stakeholder communication, policy changes, and the adoption of regional solutions with small-scale recycling units. Moreover, the paper underscores the critical role of educating and motivating consumers to support local products as an integral part of driving the circular economy forward.

Keywords: Circular economy, plastic value chain, waste management, sustainable development

LIST OF ABREVIATIONS:

PET	Polyethylene terephthalate
LDPE	Low density polyethylene
HDPE	high density polyethylene
PP	Polypropylene
PS	Polystyrene

I. Introduction

In modern times, plastics are used in a wide range of industries, including electronic equipment, packaging, healthcare, construction, automotive and agriculture (Plastics Europe, 2016). Throughout the past several decades, the manufacturing of plastics has increased exponentially, and by 2035, output is expected to have doubled (Ellen MacArthur Foundation, 2016). But this sudden rise in manufacturing of plastic has created a serious ecological problem. Around eight million metric tons of plastic reach the oceans each year, posing a serious danger to environment and aquatic life (World Economic Forum, 2020). Long-term plastic waste accumulation threatens human health and causes environment to deteriorate (Jambeck et al., 2015; World Bank, 2018).

There is increasing awareness of the necessity to move past a linear economy into a circular one for plastics in order to tackle the harmful ecological effects of plastic waste. A circular economy seeks to reduce waste production while fostering material regeneration through recycling, reuse and composting (European Commission, 2014). Reduced contamination of the environment, resource conservation, and promoted sustainable economic development are only a few advantages of moving towards a plastic circular economy (Nike, Google, and H&M, as quoted in WWF, 2021). It necessitates an all-encompassing strategy that includes value chain transparency, strong policy systems, and appropriate handling of plastic waste at the completion of its useful life.

With a focus on developing a circular economy, the goal of this review article is to explore the difficulties and future prospects of managing plastic waste in Pakistan. This

study intends to add to the knowledge about successful methods for decreasing plastic waste and achieving circularity by assessing the state of present practices for managing plastic waste, looking into alternative solutions, and examining the economic, social, and impact on the environment. Decision makers, academia, and managers can use the review paper's results to develop approaches and measures to deal with Pakistan's plastic waste problems and to support worldwide efforts to establish a green and circular economy. In the parts that follow, there is a general overview of the history and importance of managing plastic waste, talk about how urgent it is to take action to reduce plastic pollution, and emphasis on the SDGs that are pertinent to this topic. After that the idea of circularity and why it is crucial for controlling plastic waste is explored. Advantages, disadvantages, and trade-offs of boosting recycling of plastic waste in Pakistan has been discussed. Finally, there is the review of Pakistan's existing waste management procedures and talk about Pakistan's global commitment to combating plastic waste.

II. Literature Review

Plastic Waste Management in Pakistan

The amount of plastic waste being produced in Pakistan is alarmingly high, endangering both the environment and human health. The potential harm to the ecosystem and human health is highlighted by the lengthy time it takes for plastic to degrade, which is projected to be at least 450 years (Arim, 2019). Plastic waste escapes into the oceans as a result of inadequate plastic waste management techniques, such as landfilling and insufficient waste segregation, harming aquatic organisms and ecosystems (Kilvert, 2019). About 78,000 tons of plastic contaminants are thought to be present in the "great Pacific garbage patch" alone (Kilvert, 2019). It is vital to look at the data and studies that are currently accessible to acquire understanding of the state of plastic waste production and disposal in Pakistan. Details on per capita GDP, plastic waste generation, and recycling rates for plastic waste is available from Envirotech Online (2020) for a few selected countries. This information can help with analyses and an improved awareness of Pakistan's plastic waste situation.

To build efficient and long-lasting practices, Pakistan's plastic waste management must overcome a number of obstacles. Pakistan faces challenges with its collection and recycling infrastructure, which is insufficient for handling plastic waste. The country's capacity to manage plastic waste effectively is constrained by a lack of recycling facilities. The inadequate handling of plastic waste in Pakistan is a result of improper waste segregation systems and unproductive disposal techniques. Due to these difficulties, waste management procedures and practices need to be improved (Australian Bureau of Statistics, 2020; Khan et al., 2020). The general the public's lack of involvement and awareness in managing plastic waste presents considerable difficulties. It is essential to promote participation in sustainable practices and increase knowledge of the negative effects plastic waste has on the environment (Khan et al., 2020; Tong et al., 2021).

Despite these difficulties, Pakistan has implemented a number of measures and legislation to address the issue of managing plastic waste. The nation is committed to the Basel Convention and Stockholm Convention, as well as other international accords and conventions that place an emphasis on minimizing, handling, and dumping of plastic waste, particularly multilayer plastics, in an environmentally responsible manner.

Pakistan regularly participates in South Asian activities at the regional level that are geared towards capacity development, knowledge exchange, and joint efforts to combat plastic pollution. To tackle plastic pollution on a national level, laws and policies have been put in place, such as prohibitions on specific plastic bags (United Nations, 2021).

Pakistan has become part of the World Economic Forum-led Global Plastic Action Partnership (GPAP) to fight plastic pollution. Pakistan hopes to create a national action plan through the National Plastic Action Partnership (NPAP) to lessen plastic pollution, match creative ideas with funding options, and solve the major plastic waste burden in the country (World Economic Forum, 2022). In Pakistan, the pollution caused by plastic waste is also being addressed using a comprehensive and systemic strategy. This entails working with a variety of parties, implementing alternative materials, changing supply chains, affecting consumer behavior, and advocating policy changes (UNDP, 2021). In addition, Pakistan has shown its dedication to sustainable practices by putting into action experimental programs, such the plastic bag ban in Islamabad, in cooperation with international agencies notably the World Bank (World Bank, 2019). Pakistan can significantly advance plastic waste handling and help create a cleaner, more environmentally friendly atmosphere by tackling the issues and putting in place sensible measures and legislation.

Circular Economy Concept and Its Relevance to Plastic Waste

The circular economy seeks to imitate the nature's loop closing property in artificial systems. Planning out waste and pollution, preserving resources and goods, and renewing natural systems are all part of it. Developing circularity in plastics requires resolving a number of concerns, including the durability of recycled materials and their acceptability in new products, in the context of the circular economy. In order to reduce the production of waste and advance sustainable resource utilization, a circular economy's guiding principles include recycling, recovering, reusing and reducing resources and products (Kalmykova et al., 2018). Closed loop cycle of circular economy is shown in [Figure 1].



Figure-1: Circular Economy Diagram

Using a circular economy strategy to address the problems with plastic waste has many advantages. Old materials or goods can be used as secondary raw materials by following circular economy practices, increasing resource availability and lowering environmental consequences. It encourages the transition from a linear system of manufacturing and utilization to one that is more resource- and sustainably-efficient (Kalmykova et al., 2018). By promoting recycling and processing of plastic waste, a circular economy strategy lessens the demand for virgin resources. This saves natural resources and lessens energy use and GHG emissions linked to the manufacture of plastic. Additionally, it assists in reducing the negative effects of plastic waste on the surroundings, like pollution and landfilling (Ayeleru et al., 2020).

The circular economy approach also emphasizes the importance of designing products for recyclability and implementing effective waste management systems. By improving waste segregation and recycling infrastructure, plastic waste can be properly managed, and valuable materials can be recovered. This reduces the reliance on landfilling and encourages the creation of a closed-loop system (Ayeleru et al., 2020).

For the management of plastic waste, multiple countries have adopted circular economy practices, offering helpful case studies and examples. The Chinese government's ban on the importation of foreign plastic waste, especially PET bottles, has had a substantial negative impact on the environment. This restriction has brought to light how crucial it is for policymakers to take into account emerging technology and their effects. It highlights the requirement for an infrastructure for recycling that is both affordable and coordinated on a global scale (Ren et al., 2020). European nations have established recycling goals for plastics with the goal of raising recycling rates from 22.5% to 55% by the year 2025.

To promote recycling among homes, various strategies and incentive programs have been put in place, including virtual reward vouchers. These initiatives have improved recycling engagement and behaviour (Gibovic & Bikfalvi, 2021). Studies have emphasized the value of mechanical recycling as a method for recycling plastics that is practicable from an industrial standpoint. For the creation of a Circular Economy Framework for plastics products, cooperation between scientists, standardization committees, and the industry is essential. The necessity for worldwide recycling regulations, regional variances in waste handling systems, and the worldwide flow of plastic wastes must all be addressed (Shamsuyeva & Endres, 2021).

The likelihood for mechanical recycling and recovery of energy in cement manufacturing facilities to lessen the effects of global warming is highlighted by the evaluation of several different waste treatment options for particular kinds of plastics, such as PS, PET, LDPE, HDPE and PP and PS. Recycling chemicals into monomers or products with added value has the potential to lessen their negative effects on the environment (Meys et al., 2020). Those case studies and examples show the viability and efficacy of putting into practice circular economy practices for managing plastic trash, showing the potential for increased recycling efforts, a smaller ecological footprint, and better utilization of resources.

Opportunities and Prospects for Achieving a Circular Economy in Pakistan

The general public is concerned about the ongoing global issue of plastic waste being dumped into the environment. For the purpose of managing plastic waste sustainably and circularly, chemical recycling is viewed as a viable method. It enables the repurposing of plastic waste to produce useful materials like bisphenol A and cutting-edge carbonate-containing diols, that can be polymerized to create distinctive aliphatic polycarbonates. These materials have the potential to be used as durable polymer electrolytes in solid-state batteries, advancing the creation of more eco-friendly energy storage options (Saito et al., 2020). Processes for chemical recycling and upcycling have shown promise for reclaiming value from used plastics. Plastic waste can be converted into useful resources by depolymerizing it into monomers, breaking it down into liquid fuels and waxes, or turning it into fine chemical feedstocks and hydrogen. These methods provide solutions to develop a circular economy for plastics that is sustainable while reducing waste and preserving resources (Chen et al., 2021). [Figure 2] shows the concept of implementing a circular economy in the value-chain of plastics.

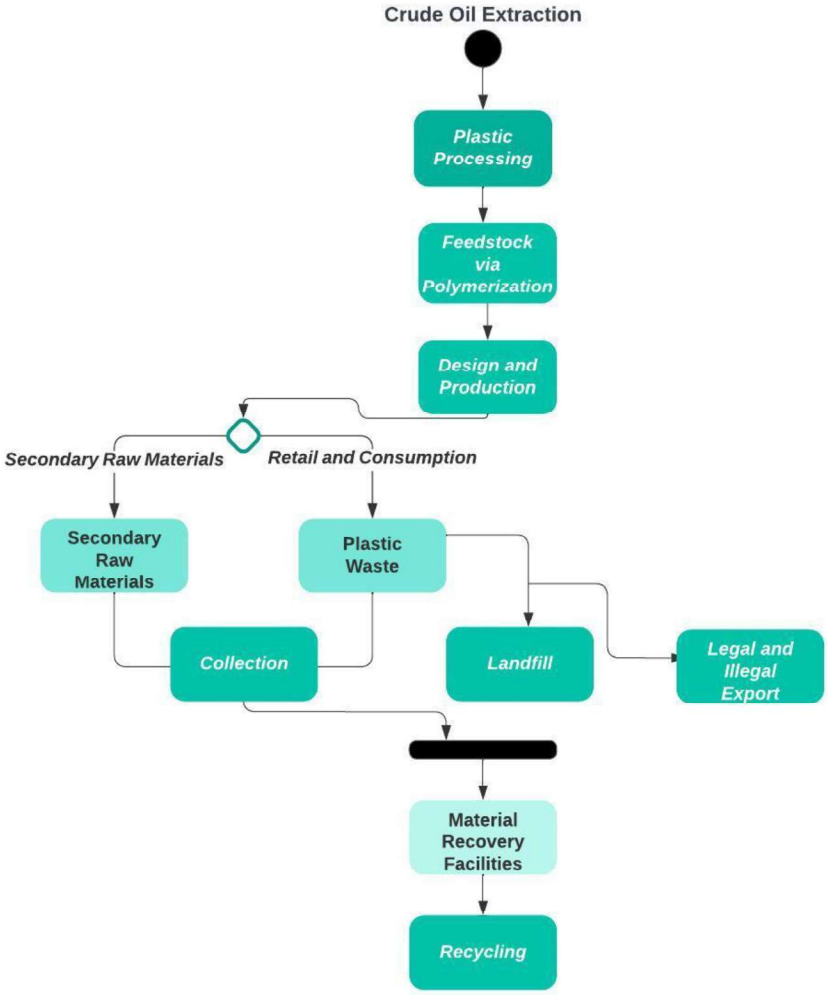


Figure-2: Concept of implementing a circular economy in the value-chain of plastics

Different stakeholders play crucial roles in Pakistan's transition to a circular economy for the management of plastic waste. Scavengers, junk dealers, and recyclers are all part of the informal sector, which is important for the collecting and recycling of plastic garbage. It is possible to ensure that plastic waste is efficiently utilized in a circular system, creating economic opportunities and lowering social challenges like child labour, by integrating and formalizing the informal sector into a formal supply chain (WWF-Pakistan, 2020). In order to create a consortium that stabilizes the supply and demand of plastics, cooperation between businesses and recyclers is essential. The circular economy can be further promoted by reducing the gap among retailers and recyclers and achieving responsible sourcing and manufacture of recycled goods (WWF-Pakistan, 2020).

Recent studies and attempts in Pakistan suggest distributed plastic recycling for open-source 3D printing technology as a potential remedy for plastic waste and the growth of the circular economy. Distributed recycling utilizes compact, coordinated recycling units, akin to a "smart grid." The successful outcomes of a closed-loop supply chain system for regional and widespread plastic recycling for 3D printing serve as proof that this strategy has the potential to provide economic and environmental advantages (Santander et al., 2020). In addition, recycling plastic waste to build roads is gaining popularity as a long-term fix. Road performance can be increased while lowering construction costs and environmental implications by adding plastic waste to asphalt mixtures. The possibility of utilizing plastic waste in infrastructure development is shown by efforts like the plastic road project launched by Coca-Cola Pakistan & Afghanistan in collaboration with Teamup and CDA (National Incubation Center).

The Government of Pakistan has performed research studies and started baseline scoping studies to address the problem of managing plastic trash, working with groups including WWF-Pakistan and The Coca-Cola Foundation. These studies provide information to inform policy development and the execution of efficient waste management strategies by outlining the current plastic waste generation and management supply chain, identifying stakeholder views and perspectives, and mapping out stakeholders' thoughts and opinions (WWF-Pakistan, 2020). To increase the recovery and recycling of PET bottles, it is advised that Fast Moving Consumer Goods (FMCG) corporations create plastic recovery facilities, particularly in big cities. Furthermore, public awareness programs via various media platforms can aid in informing the public about the consequences of irresponsible discarding of plastic and encourage separation of waste at the source (Arshad et al., 2020). Pakistan has a lot of potential for implementing a circular economy approach to managing plastic waste. Pakistan may move towards a more sustainable and ecologically friendly plastic waste management system by utilizing cutting-edge technologies, involving important stakeholders, and enacting supportive government laws and regulations.

Challenges and Barriers to Implementing a Circular Economy for Plastic Waste in Pakistan

The implementation of a circular economy for plastic waste in Pakistan has major obstacles due to economic and budgetary constraints. Plastics are a desirable material for many sectors because they are affordable, strong, and accessible. However,

switching to alternatives or putting recycling and upcycling processes in place calls for investments in infrastructure, building capacity, and technology. Allocating money and resources for the required activities is difficult due to the weak economy and scarce resources. A further obstacle to developing a circular economy for plastic waste in Pakistan is the lack of collaboration among stakeholders. Several parties are involved in managing plastic waste, including the government, waste management organizations, informal sector workers, consumers, and industries. The efficient collection, classification, and recycling of plastic waste is hampered by the lack of a coordinated and integrated methodology. To handle the complexity of the plastic waste management system, cooperation and collaboration among stakeholders are essential. In Pakistan, social and cultural variables significantly influence how people behave and what they consume in terms of plastic waste. Plastics are ubiquitous in daily life, and consumer preferences and behaviors are frequently hard to alter. Single-use plastics are commonly used and accepted due to their price and ease. Changing societal attitudes and raising awareness of the negative environmental effects of plastic waste are necessary for the implementation of a circular economy. Effective plastic waste management requires addressing social and cultural issues as well as encouraging responsible consumption (Alam, personal communication).

The implementation of a circular economy for plastic waste in Pakistan has obstacles due to technological constraints and infrastructure needs. Modern technology and specialized infrastructure are needed for the recycling and upcycling of plastic waste. The magnitude and complexity of managing plastic waste, however, may be beyond Pakistan's existing technological capacity and infrastructure. To promote a circular economy for plastic waste, it is important to upgrade technology, establish recycling facilities, and build-out a substantial infrastructure network. Multiple obstacles and constraints stand in the way of Pakistan's adoption of a circular economy for plastic waste. Significant barriers include technology restrictions, social and cultural barriers, lack of collaboration among players, and economic limits. A multifaceted strategy comprising regulatory changes, monetary investments, stakeholder cooperation, behavior change initiatives, and technical developments will be needed to meet these problems. To create a sustainable and eco-friendly plastic waste management system in Pakistan, it is essential to address these issues (Alam, personal communication).

III. Recommendations for Overcoming Challenges and Promoting a Circular Economy

Promoting a circular economy for plastic waste in Pakistan requires improving waste management facilities and infrastructure. This entails making investments in recycling and upcycling facilities, setting up effective systems for collection and segregation, and putting in place suitable waste disposal procedures. The construction and improvement of infrastructure to support the circular economy approach should be a top government priority, in cooperation with waste management corporations and other stakeholders (Alam, personal communication).

The two main proposals for developing a circular economy are increasing public awareness and encouraging active participation in the management of plastic waste. To educate the public about the negative environmental effects of plastic waste and the

advantages of recycling and upcycling, extensive awareness campaigns and educational initiatives should be launched. Communities can be inspired to adopt responsible consumption patterns and actively participate in waste management projects by involving and empowering individuals (Arshad et al., 2020).

To overcome technological constraints and advance a circular economy for plastic waste, funding research and development of cutting-edge recycling technology is essential. Pakistan may promote the development of effective and affordable recycling technology by funding scientific research and encouraging cooperation between government, business, and academics. These technologies ought to concentrate on overcoming the difficulties associated with sorting plastic waste, enhancing the value of recycled materials, and facilitating the recycling of various plastic kinds (Self et al., 2022).

For Pakistan to create a circular economy for plastic waste, cooperation and collaborations amongst stakeholders are essential. To create cooperative efforts and strategies, local communities, NGOs, waste management businesses, industry organizations, and government organizations should collaborate. Synergistic efforts can be made to improve waste management practices, foster innovation, and establish a favourable environment for the circular economy by utilizing the knowledge, networks, and resources of many stakeholders (Alam, personal communication).

Regulations and policy changes are essential for facilitating the transfer of plastic trash to a circular economy. The government ought to develop and put into effect comprehensive policies that reward sustainable behavior, such as extended producer responsibility (EPR) initiatives, goals for reducing plastic waste, and financial incentives for recycling and upcycling. To ensure compliance and accountability, these rules should be supported by strong enforcement measures and continual monitoring (Arshad et al., 2020).

IV. Conclusion

In conclusion, managing plastic waste and moving towards a circular economy are urgent concerns in Pakistan and around the world. Action must be taken right away to address the serious environmental and health hazards posed by the contamination of plastic waste. In order to achieve a circular economy for plastic waste in Pakistan, this review study has looked at the opportunities, challenges, and recommendations. The study emphasized the potential advantages of using a circular economy strategy to handle plastic waste, such as the production of innovative and sustainable materials by chemical recycling and upcycling. The importance of cooperation and partnerships between governmental organizations, waste management firms, business groups, NGOs, and local communities was emphasized. It also identified important players and their responsibilities in the transition. The adoption of a circular economy is, however, hampered by numerous difficulties and obstacles in Pakistan. The main issues include technological restrictions and infrastructure needs, social and cultural factors impacting behaviour and consumption patterns, economic and budgetary constraints, and a lack of cooperation among parties. A multifaceted strategy will be needed to address these issues, including tactics for enhancing waste management infrastructure, increasing public awareness through educational initiatives and campaigns, encouraging the

creation of cutting-edge recycling technology, fostering stakeholder cooperation, and putting supportive policy measures in place. It is essential to make investments in waste management infrastructure and facilities, increase public participation through awareness campaigns and educational programs, support research and development for recycling technologies, encourage stakeholder collaboration and partnerships, and create policy frameworks that reward sustainable practices in order to overcome these challenges. With the help of these suggestions, Pakistan's future can be more sustainable while also promoting the circular economy for plastic waste. The ban on plastic bags and the research study carried out by WWF-Pakistan and The Coca-Cola Foundation, among other initiatives, demonstrate Pakistan's commitment to addressing plastic waste management in light of present situation. The findings of this review study emphasize the significance of Pakistan's plastic waste management transition to a circular economy and show the potential for a more sustainable future. In order to overcome the obstacles and challenges identified, Pakistan must give priority to implementing the suggested methods and policies. Pakistan may help to a cleaner and healthier environment for both the present and future generations through reducing plastic waste, encouraging responsible consumption and waste management practices, and other means. A circular economy for plastic waste in Pakistan and a more sustainable and prosperous future for the country depend on cooperation, innovation, and public involvement. Overall, this review study offers insightful information about the possibilities, difficulties, and suggestions for establishing a circular economy for plastic waste in Pakistan. In order to promote sustainable plastic waste management practices and support a circular economy strategy, it acts as a guide for decision makers, governmental organizations, waste management companies, industry stakeholders, and the general public. Pakistan may make tremendous progress towards reducing plastic pollution and creating a more sustainable and environmentally conscious society by putting the suggested recommendations into practice.

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