

Circular Economy and Municipal Solid Waste Management in China

Dongyuan Sun *

Department of Economics, College of William and Mary, Williamsburg, U.S

* Corresponding Author Email: dsun02@wm.edu

Abstract. The circular economy is a model for sustainable economic development that places a strong emphasis on the efficient use of energy and resources, waste reuse, and recycling. It entails establishing a mutually supportive relationship between economic expansion and ecological sustainability. Both developed and developing countries are necessitated to undertake such adjustments from a linear model to a circular economy as a result of severe environmental degradation. Despite developed regions successfully implementing the circular economy (CE) principle, transitions for most of developing countries are arduous and require further investigation. China, the largest developing country, formally declared its intention to build a circular economy in 2002 and has since worked to regulate relevant industries. Its experience can be used as a foundation for other developing nations in approaching CE. Furthermore, municipal solid waste should be taken into account as it is a critical sector for promotion of CE. This paper investigates the current CE in China's municipal solid waste management to provide an integrative overview. It is structured through an overall view of CE and municipal solid waste (MSW), evaluations of current management in the context of three different key aspects of a circular economy, an analysis of the barriers to MSW management in China, and a conclusion with policy proposals.

Keywords: MSW; Circular economy; Waste reduction; Reuse; Recycling.

1. Introduction

Urbanization, inequality, economic growth, cultural and socioeconomic factors, as well as policy, governance, and institutional issues, have complicated solid waste management in developing countries, which limits the applicability of effective waste management strategies in industrialized countries [1]. The amount of waste produced in Brazil, one of the developing nations, is too much for the linear model to handle. It prevents the environment's capacity to heal on its own and causes environmental issues, necessitating the switch to a circular economy [2]. The Circular Economy is a system for enhancing how solid waste is currently managed globally. It emphasizes the idea of recycling and trash valorization as a means of accelerating developing countries' economies. The CE expands waste management prospects and has been successfully utilized in theory, practice, and policy in some of the world's developed countries [3]. The strategy is recommended for growth in large cities to promote a new type of stable employment, maintain continuous activities (i.e., the informal sector), and advance the principles of sustainable development. For several developing nations, the adjustment might not be easy. Choosing an appropriate strategy is tricky for Brazil due to the interactions of its society when defining responsibilities for different parts [4]. Due to a lack of information, the majority of African countries struggle to execute the concept. Further research into the circular economy application is necessary in light of these circumstances, and research initiatives should offer suggestions for developing nations on how to make the transition to a circular economy [4]. As the biggest developing country in the world, China can be studied for lessons on how other developing nations can achieve a smooth transition to CE. The purpose of this study is to assess the present municipal solid management system in China, a crucial sector for the circular economy, identify short slabs, and propose potential solutions to these hurdles to contribute to the growing collection of studies on the circular economy in China.

The methodology of this paper is based on regulation announcements by the government and fragmented literature reviews to form a general and integrative analysis of the practices of CE in

municipal solid waste management in China. Sources of materials include announcements by the NDRC, documents by the government of UK, Korea or German, and relevant studies.

2. Literature review

As an economic model, Pearce & Turner appear to be the first to explicitly utilize the concept of circular economy, who stressed the input of used resources or waste [5]. Then various attempts and applications in different industries or countries have been influencing the perception of circular economy and gradually form the consensus. Due to the impossibility of perfect cyclical resource utilization, the circular economy concept at the macro-level often prioritizes three principles, or 3R: the first is to improve resource utilization efficiency and minimize waste production; the second is to reuse products; the third is to recycle waste and handle non-recyclable garbage in a manner that is compatible with the environment and nature [6]. Typically, these basic tenets must operate collectively to establish a circular economy structure. In 2002, the CE has been proposed as a new development model to assist China advance into a more sustainable economic structure rather than being seen as an incrementally enhanced environmental management program. The 3R concept has received much acceptance in China. And the National Development and Reform Commission (NDRC), in collaboration with SEPA and other relevant ministries, allegedly drew up China's framework of management for the circular economy [7]. The Program for Experiment Unit of CE was officially announced in October 2005 by the NDRC, SEPA, and four other ministries. The program targeted major geographical areas, provinces, cities, parks, and businesses in the industrial sector. Seven primary industries —nonferrous metals, coal, electricity, chemicals, construction materials, and light manufacturing—are the ones that produce substantial energy consumption and pollution [7]. The key areas of management program refer to waste managements on the basis of waste reduction, reuse, and recycling and municipal waste [7]. And the most significant one is municipal solid waste management. MSW is any nonhazardous garbage from a community that has to be picked up and sent to a facility for processing or disposal (MSW). Approximately 2 billion tons of municipal solid trash are produced worldwide each year, but only about 33% of that amount is collected by municipalities [8]. On average, 0.74 kg of garbage are produced per person each day [8]. The daily amount of MSW generated in Pudong was about 1.11 kg per capita in 2006[9]. Based on the current population in China, dealing with the MSW can be the most cost-effective way to transition to a circular economy more quickly.

3. MSW Management in China

3.1 Waste Reduction Management

In China, there is significantly insufficient force on maximizing its full potential to minimize waste production to promote circular carbon economy. Instead, it does not achieve its efficiency of resource utilization. The problems of resources overutilization from manufacturer side and household waste overproduction from consumer side are worthy to be considered when traced back to the origins of MSW.

3.1.1 Management for Producers

On the manufacturing side, excessive packaging, shown as the representative of resource overutilization, is cost-effective to be dealt with for waste reduction among other issues, when reminded of the Matryoshka doll like packaging of mooncake and tea in China. It usually exists in the forms of excessive packing layers, wide packaging gaps, high packaging costs, and poor material choices. With the beginning of paying attention to excessive packaging phenomenon, China is on the right track. The NDRC has made an announcement concerning regulations about excessive packaging, mentioning the dedication of China to forming a chain of regulating excessive packaging in 2022 [10]. For part of the regulating chain, the State Administration for Market Regulation also published

a document about Requirements of restricting excessive package—Foods and cosmetics to be enforced in 2023 [11]. However, according to the upcoming requirements, there seems to be a long way to go for China compared with other developed countries. The document indicates that China is about to set mandatory standards of only at most three layers of packaging for mooncake, zongzi, byproducts of cereal, and at most four layers of packaging for other products of food or cosmetics [11], while the Producer Responsibility laws implementing the Packaging and Packaging Waste European Directive (94/62/EC) in UK explicitly states the stringent legal obligations for business: “Packaging must meet the minimum weight and volume needed to keep the product safe and hygienic [12].” And Korea has already been enforcing a stricter mandatory standard of at most two layers of packaging for cosmetics, food, beverage, electronics, detergents, and one layer of packaging for clothes since 2022. Even more, Korea has also tightened its requirements of packaging space rate—another important aspect of excessive packaging—for a variety of products. The requirements of packaging space rate in Korea are stricter, more detailed, and more comprehensive than in China. It allows at most 15% packaging space rate of processed food, at most 10% of beverages, at most 15% of cleansing products for body and hair, and at most 10% of other cosmetics (perfume as an exception) [13]. With the same way of calculating method, the limited requirements of packaging space rate in China for food and cosmetics are based on net content of products [11]. The regulation allows less than or equal to 30% rate of packaging space for a single object of food/cosmetics with more than 50ml or g [11]. Different types of food or cosmetics have the same criteria if they fall into the same weight range [11]. For example, if net content of food or cosmetic products are more than 50g or ml, they are treated the same in packaging space rate. The regulation on excessive packaging to reduce of waste in China is at its initial stage. More stringent regulations and tougher enforcements of excessive packaging not only for food and cosmetics but also for a wider range of products should be considered too perfect related legislation, promoting a CE effectively and efficiently in China.

3.1.2 Management for Consumers

In addition to the manufacturing side, regulations on the consumer side, or the end of management chain for CE, to reduce MSW has been weak: insufficient economic incentives are given for consumers. One of the important aspects is MSW charging standards. While the comprehensive standards, MSW tax policies, and implementations of them are still in the establishment stage in China, other developed countries are at the stage of maturation. To be more specific, For Korea, it has long since changed from a fixed fee in the form of taxes levied on consumers to a transformed meterage fee for household waste in 1995. The government introduced a VBWF system to charge fees of household waste in proportion to the amount of waste production by people since then [14]. People must buy VBWF bags to throw their waste and, consequently, have motivations to reduce their kitchen waste production. On the strength of practices by these developed countries, China, indeed, follows the examples of charging fees. The NDRC was in consider of charging people for waste production in 2018 and it published a document proposing a creation of pricing structure – meterage- for MSW before 2020 [15]. But the reports of the 19th National Congress of the Communist Party of China reveals that local governments did not implement the expected outcome, the practice of meterage standards. The majority cities still charge amount of fees per household or person with ratio charge mode: thirty-three cities are having set standards of fees for household waste disposal; three cities charge based on water consumption coefficient method; Shenzhen charge based on sewage volume [16]. The fixed amount of fees of MSW by these cities are relatively low to disincentive citizens or noncitizens to produce household waste in China, for fees charged to people are almost independent of the amount of waste produced by them. People are neither punished nor rewarded on account of their different performance in reducing household waste. In this case, most people in China lack extrinsic motivations to change their behaviors, not to mention their inadequate environmental protection awareness and intrinsic motivations to reduce household waste. In addition, there are limited regulations on domestic carbon: most residents in rural areas are using straws and coals, which have higher percentage of carbon. Many restaurants are still using the disposable

dishware with no mandatory provisions. In general, it is a common phenomenon of overutilization of resources by consumers with the weak force on regulations about waste reduction at a national level.

3.2 Waste Reuse and Recycle Management

As an indispensable part of CE, waste reuse and waste recycling are essential for the closed loop. To achieve the goal of resourcing, comprehensive waste recycling management for MSW is a necessary tool. The management of household waste recycling and reuse happens through by means of a combination of the following ones: household waste classification, collection, transportation, and treatment. Each step is supposed to be considered carefully for reuse and recycling. Based on the 2019 China Waste Recycling Industry White Paper, the rate of recycling and reuse in China is only 35%, much lower than the 90% in German of which has 68% of reusing in 2020 [17]. The key differences come from a variety of forms.

3.2.1 Successful Applications in German

Waste classification, in German, is guaranteed with its perfect laws, regulations, and environmental awareness. The waste classification standards are more complicated and detailed and include 6 types of household waste: organic waste, light packaging, paper, toxic waste, waste glass, and other garbage. More specially, waste glass can be divided into three subtypes: the different color of glass corresponds to different bins with indications and provisions by the public [18]. If residents want to own their trash can, there will be individual designs and appointments about waste recycling time for each household by the people in charge. In German, waste classification makes it easy for later processing procedures. There are also some innovations in waste collection, such as specific collecting points for bulky waste-watching TV, etc. Residents throw bulky waste at an assigned time for people in charge to collect. For bottles, people buying drinking usually must pay a few deposits [18]. To get deposits back, they need to return bottles back through the empty bottle recycling machine at stores. After collecting, private companies are responsible for transporting the recycling and reusing waste to different industries based on their specific types. This whole process enables all the people in the society to fully participate in the promotion of the recycling and reusing process, which is based on the cooperation between government, companies, and individuals.

3.2.2 Inadequate Situations in China

For household waste classifications in China, the requirements are less comprehensive, and their situations vary among cities in China. Generally, the household waste classification covers more than 70% of all neighborhoods in 46 pilot cities. 11 pilot cities have published local legislation [19]. Since 2019 legislation about household waste classification in Shanghai, the attainment rate in residential areas has improved from 15% to 90% [18]. However, there is still much room for improvement in the standards. In essence, no uniform standards at a national level create barriers for people to classify. Among the pilot cities, Fuzhou is enforcing a 5-principal method of other waste, bulky waste, hazardous waste, kitchen waste, and recycle waste; Guanyuan is enforcing a 3-principal method of recycling waste, non-recycle waste, and hazardous waste; other cities are enforcing a 4-principal method of different appellations for different waste [19]. Such chaotic situations make it difficult for mobilized people to clearly know the standards for different cities and to classify them correctly. Another aspect is that with only residential household waste receiving much attention, household waste in public areas, such as office areas, is ignored. People in the working areas without canteen usually order takeout food. After finishing, they throw all the disposable tableware into the same 'others' utility instead of classifying them. Based on the 2018 statistics about household waste treatment, only 28% of restaurant waste, the second major source of household waste in Shenzhen, has been recycled and reused. Most household wastes are still classified by workers for waste treatment instead of by residents [20]. This leads to the phenomenon of a hybrid collection of household waste and decreased efficiency for household waste treatment in a later stage. Admittedly, the recycling cycle and reuse of bulky waste have been mature in Shenzhen, with the same statistics reports in 2018 indicating a 100% rate of recycling and reuse in Shenzhen [20]. However, whether

and how other cities can use it as a reference is yet to be tested. Transportation systems are also needing its rectifications, due to some of the classified wastes are not transported based on the original classifications. And similar situations are also seen in other cities. As a result, most recycle and reuse MSW are landfilled, which is the major way of treating 'non-recycle' waste. 3.2.3 The key differences between the models in China & German

Compared with China, the household waste classification standards in German are more detailed and consistent across the country, providing residents convenience to follow the more constraining regulations instead of confusing relatively ineffective standards. Different innovations about reuse and recycle, which targets to specific types of waste, have been in effect to promote efforts by residents, enabling all individuals to fully engage in. And utilities and equipment are adequate to facilitate the pre-treatment process. All makes it easier to speed up the reuse and recycling of MSW more effectively and efficiently.

4. Barrier of MSW Management in China

The promotion of a circular economy in China is a top-down process due to the basic context of the Chinese context: it requires optimal decision-making by regulators and sequent coordination among individuals within the whole society. The core of the Chinese government is to design every section in the MSW management chain in response to its ideology of CE and to figure out a way to appeal to its countrymen. However, based on the status quo, many challenges have been preventing the implementation of such a concept from top to the bottom. Asymmetric information exists as a barrier for the government: it lacks an efficient information system to get feedback in time. Instead, their collection is delayed. This stops the government from improving its regulations with timely responses about regulations in effect from the public. If the Chinese government were able to know space for tightening its excessive packaging regulations with reliable information provided rapidly, it would raise its regulations to a more effective level within a shorter period. After the government introduces a new regulation or legislation, access to feedback for the government from executors at the intermediate level or the masses is not guaranteed. Sometimes, the regulations may have been outdated or ineffective and waiting for revisions. Another challenge lies in that the regulations themselves are relatively weak. For the chain of MSW management process, the Chinese government is far behind to follow the steps of other developed countries, such as the similar southeast Asian country-Korea. The reluctance to use effective economic incentives by the Chinese government in the steps of waste reduction, reuse and recycling slows down the process of MSW management and CE. Enterprises utilizing resources and treating MSW, consumers producing MSW and classifying them for recycle and reuse, and executors taking charge of supervision are short of extrinsic motivations such as reward or punishment to comply with the administration of CE. Consumers, without constraint, still randomly produce and do not classify household waste and industries see little stimulus to save resources, reuse, design recycling products, or transform their economic structures to reduce waste. S.F. Express or other express delivery with excessive packaging remains hesitant to initiate actions about packaging reuse or recycling. Enterprises see insufficient economic incentives for innovation to treat non-recycle waste in a more environmentally friendly way. The lack of environmental awareness for institutions or individuals to participate fully in environmental-related programs or campaigns is also worth consideration. In German, kids in kindergarten are educated about waste classification standards. The Chinese government, however, has been ignoring the necessity of childhood in a rooted environmental protection awareness for sustainable environment importance and publicity about MSW classification standards for all citizens, which prevents the process.

5. Conclusions and Policy Implementations

With severe environmental issues such as extreme climate change or exhaustion of resources, many developed countries have been transitioning to a circular economy with progress. China, facing the same issues as well, formally accept and implement the circular economy strategy in 2002. Since then, various studies have been conducted on evaluating the practices of a circular economy. Municipal solid waste management as a big picture of waste management, one of the most significant parts to achieve a sustainable economy or zero carbon emissions, need more attention. However, most of the studies on it do not keep abreast with times or partially. Integrative and latest investigations are needed based on current situations. The aim of this paper is to provide a current overview of the practices of circular economy in the areas of municipal solid waste and analysis about potential barriers slowing down the process of transitioning from a linear structure to a circular economy in China. The results indicate that current practices of municipal waste management for a circular economy in China are not ideal from aspects of waste reduction to its reuse or recycling. The government ought to figure out a way to perfect the regulations in the areas of municipal solid waste reductions, reuse, and recycling for a closed loop of the promotion of a CE in MSW, giving full play to the initiatives of both citizens and enterprises on participating fully in the whole process of regulations.

Tightening the regulations can be the most efficient and effective one: more stringent regulations about waste reductions, reuse and recycling for consumers and industries or producers. The government can enforce more limited excessive packaging, higher standards of waste classifications, requirements of waste reuse and recycling design by industry, and constraint on following uncooperative behaviors by consumers. And the government ought to provide enough economic incentives for regulations in each process. Therefore, given sufficient rewards and punishment, industries may avoid the occurrence of resources overutilization and innovate product design in a reusable or recycling way with rewards; consumers reduce their waste reductions with a higher cost of producing waste and cooperate in the process of waste reuse or recycling with effective punishment or reward. In the meantime, a feedback channel or information system should be available for the government to know timely updates on the effectiveness of their regulations into force from the public-executers, enterprises, or individuals, promoting revisions in time to raise efficiency. More importantly, the government needs to focus on the ideology of citizens and its importance in MSW management and CE. Environmental education should not only stay on the surface in the form of a slogan but to pay attention to childhood education and publicity about the serious consequences of their uncooperative and unsustainable behaviors.

References

- [1] Marshall, R. E., & Farahbakhsh, K. Systems approaches to integrated solid waste management in developing countries, 2013.
- [2] Silva, W. D. O., & Morais, D. C. Transitioning to a circular economy in developing countries: A collaborative approach for sharing responsibilities in solid waste management of a Brazilian craft brewery, 2021.
- [3] Ezeudu, O. B., & Ezeudu, T. S. (2019). Implementation of circular economy principles in industrial solid waste management: Case studies from a developing economy (Nigeria), 2019.
- [4] Ferronato, N., Rada, E. C., Portillo, M. A. G., Cioca, L. I., Ragazzi, M., & Torretta, V. Introduction of the circular economy within developing regions: A comparative analysis of advantages and opportunities for waste valorization, 2019.
- [5] Pearce, D.W. and R.K. Turner, Economics of Natural Resources and the Environment, 1990.
- [6] Su, B., Heshmati, A., Geng, Y., & Yu, X. A review of the circular economy in China: moving from rhetoric to implementation, 2013.
- [7] Yong, R. The circular economy in China. Journal of material cycles and waste management, 2007.

- [8] Atlas, W. Waste management for everyone. *Recuperadoel*, 5, 279-282.
- [9] Minghua, Z., Xiumin, F., Rovetta, A., Qichang, H., Vicentini, F., Bingkai, L. & Yi, L. Municipal solid waste management in Pudong new area, China. *Waste management*, 2009.
- [10] NDRC. The announcement on strengthening the governance for the excessive packaging of products, 2022.
- [11] The State Administration for Market Regulation. Requirements of restricting excessive package--Foods and cosmetics, 2023.
- [12] The Secretary of State in UK. The Packaging (Essential Requirements) Regulations 2015.
- [13] Ministry of Environment in Korea. Regulations on Product Packaging, 2021.
- [14] Ki-Yeong Yu. Volume Based Waste Fee (VBMF) System for Municipal Solid Waste, 2017.
- [15] NDRC. The announcement on innovations and improvements of price mechanisms to promote green development, 2018.
- [16] NDRC. The research and suggestions on the cost of municipal solid waste treatment, 2020.
- [17] Ye, S. The 2019 China Waste Recycling Industry White Paper,
- [18] Tolga Kagan. Germany's garbage sorting and recovery system, 2018.
- [19] Waste Classification platform in Fujian. Compilation of policies and regulations in 46 pilot cities of domestic waste classification in China, 2020.
- [20] Wang, H. Analysis of source for household waste and its resource utilization path in Shenzhen, 2020.