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SPECIAL FEATURE: REVIEW

Waste Prevention Researches

A review of waste prevention through 3R under the concept of circular economy in China

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Abstract The large waste generation has become one of the worldwide environmental problems. Circular economy has been seen as a way to tackle its urgent problems of environmental degradation and source scarcity. In recent years, under the concepts of circular economy, waste prevention through "Reduce, Reuse and Recycle" (3R) rules have attracted a broad concern in China. China has made some great achievements on waste management, and at the same time is facing many challenges. It is very necessary to share the management experiences and practices with the scholars and managers in other countries. This review covered the current situation and progress of circular economy development from the perspective of the legal regime and project practices, and the recycling practices of typical waste. The typical household wastes, including municipal solid wastes (MSW), e-waste, and end of life vehicles (ELV), were studied as the typical cases. Based on an examination of the statistical results, we also identified the potential problems and challenges for waste prevention through 3R in China. Finally, we provided some effective measures to further improve the waste management and recycling in China.

Keywords Solid waste · Circular economy · 3R rules · Experiences and challenges · China

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Introduction

The present period can be seen as the most active time regarding material production and consumption in the history of humans, although there are great differences in these activities depending on the part of the world. Increasing population, booming economy, rapid urbanization and the rising living standards have greatly accelerated the depletion of natural resources and waste generation in the world, especially in developing countries [1, 2]. How to deal with the resource scarcity and waste issues has become one of the global issues [3–9].

Through promoting the adoption of closing-the-loop production patterns within an economic system, circular economy aims to increase the efficiency of resource use, with the special focus on urban and industrial waste, to achieve a better balance and harmony between economy, environment, and society. The circular economy has most often been considered as an approach for more appropriate waste management. The circular economy is rapidly landing on the world of waste and resources management, and becoming a dominant concept to establish the sustainable society and world. So far, various literature (case studies, reviews, scientific reports, etc.) on circular economy studies have been published worldwide [10–17]. A large number of these studies concern the implementation of circular economy in China, because huge environmental, human health, and social problems posed by its rapid and continuous economic development pattern and China strongly need and commit circular economy.

The traditional way of natural resources utilization in China was to increase the product output by consuming more materials and energy, and huge amounts of waste generated during production, but it was an unsustainable development pattern. With the enormous consumption of

resources and energy, a high amount of solid waste was generated. According to the Ministry of Environmental Protection in China [18], the total solid generation was about 3454 million tons in 2014, with an average annual increasing of 11%. Meanwhile, due to the wide varieties and complex composition of solid waste, it has brought the significant threats to the environment and human health. Generally speaking, the waste has become one of the main influence factors on the environmental protection. Apart from the pollution property, waste also includes many valuable materials and resource, e.g., e-waste contains a considerable quantity of copper, iron, aluminum, gold, silver, etc., and their contents are much higher than that of natural mineral resources. With the large exploitation and consumption of natural resource, the available resources in China are becoming less and less. As the largest energy production and consumption country in the world, primary energy output summed to about 3.60 billion tons of standard coal equivalent in 2014, and the total consumption was higher, up to 4.26 billion tons of standard coal equivalent [19].The greenhouse gases (GHGs) emissions in China have a rapid growth, accounting for about 30% of global GHGs emission [20].

Waste reuse and recycle can relieve the shortage of resources and environmental pressure in China. In the case of China, the circular economy has been introduced as a new development model to help China leapfrog into a more sustainable economic structure [21, 22]. According to the *Circular Economy Promotion Law of the People's Republic of China*, the Circular Economy refers to the general term of the activities on reducing, reusing and recycling in production, circulation, and consumption. A consensus has been reached whereby China's circular economy concept in many ways, which emphasizes the benefits of utilizing residual waste materials, including energy, water, various by-products as well as information [23, 24]. Under the circular economy concepts, the treatment and recycling of solid waste in China was greatly improved.

As the relevant implementation field of circular economy concepts, China has made great efforts, including the laws and policies, and some pilot projects, to deal with the waste issues and reduce the waste generation volume from the source In the reuse field, it mainly refers to encouraging the remanufacturing, and the Measures for the Administration of Remanufactured Product Certification Scope was released by Ministry of Industry and Information Technology in 2010. Now remanufacturing is under the pilot stage, and the critical area focuses on vehicle parts, machine tools, engineering machinery, mining machinery, agricultural machinery, metallurgical roller, copier, computer servers and remanufacturing cartridges, and drums, etc. Currently, China has accumulated some useful experiences, and is also facing with many challenges for the waste prevention. This study aims to provide some compelling information on the sustainable waste management under the concepts of the circular economy, and it is expected to be useful for the other countries. This study mainly focuses on the household waste, particularly municipal solid wastes (MSW), e-waste, and end of life vehicles (ELV). Firstly, the current situation of circular economy development from the perspective of the legal regime and pilot projects are introduced. Then, the typical household waste generation and recycling status are summarized. Finally, the potential challenges and opportunities for waste prevention through 3R in China are identified, and effective measures for future improvement are proposed.

Policies and legislations on circular economy in China

At present, over 200 national circular economy standards and laws established the systematic system of the circular economy in China, and can be divided into four levels: State laws; Administration regulations; Ministry regulations; and Local statues. The detailed legal regime of circular economy in China is shown in Fig. 1.

The first level: State laws

Since Environmental Protection Leading Group established in 1974, the waste management, treatment, and disposal were started in China. The fundamental environmental law, *Environmental Protection Law*, was enacted in 1989, which stipulated that Producers should use high resource utilization equipment and process with less pollution, and the waste should be recycled and utilized comprehensively. The laws related to circular economy mainly include *Solid Waste Pollution Prevention Law, Circular Economy Promotion Law*, and *Clean Production Promoting Law*. Thereinto, *Solid Waste Pollution Prevention Law* enacted in 1995 had already involved some basic system of circular economy. *Circular Economy Promotion Law* implemented from January 1, 2009, marked our country's legalization management track of circular economy, which takes 3R rules "reduce, reuse, recycle" and "priority to reduce" as the essential principles for China's economic and social development and puts forward the extended producer responsibility (EPR). The Circular Economy in the law refers to the general term of the activities on decrement, recycling, and resource recovery in production, circulation, and consumption. Besides, it is the third law associated with the circular economy in the world, after those of Germany and Japan [25]. Furthermore, it serves as a fundamental law guiding all circular economy policies and a solid foundation for depth development of the circular economy in China.

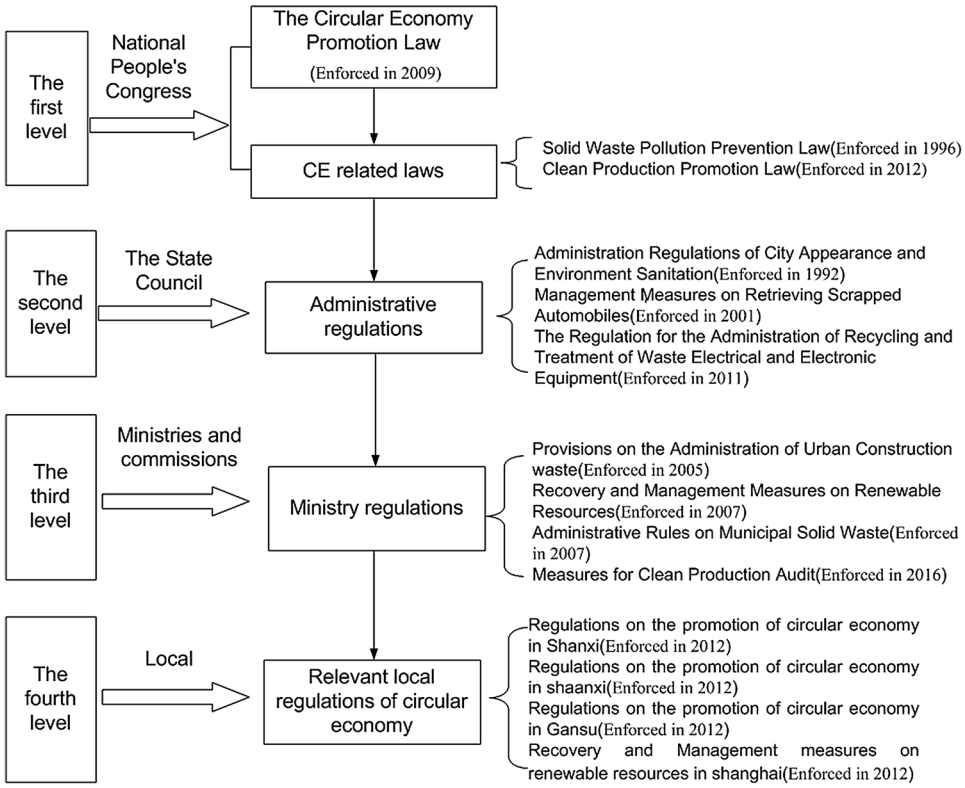

Fig. 1 The main legal regime of circular economy in China

The state also formulated related development planning and policies to promote the development of the circular economy. The twenty-third chapter of *12th Five-Year plan for national economic and social development of the People's Republic of China* is energetically developing the circular economy. And the State Council also adopted a *12th Five-Year plan for the development of the circular economy* in 2012, which cleared the primary objective, essential tasks and safeguard measures of the development of the circular economy. *Several Opinions on Accelerating the Development of the Circular Economy* was a programmatic document for the development of circular economy in China.

The second level: Administration regulations

The second level in the legal regime of the circular economy are some regulations and administrative measures approved by State Council, including *Regulation for the Administration of Recycling and Treatment of Waste Electrical and Electronic Equipment, Management Measures on Retrieving Scrapped Automobiles* and *Administration Regulations of City Appearance and Environment Sanitation. The Regulation for the Administration of Recycling and Treatment of Waste Electrical and Electronic Equipment* (2009), which is known as Chinese WEEE, was implemented since January 1, 2011. The purpose of this regulation is to improve the recovery and disposal of e-waste, facilitate the comprehensive utilization of resources, and protect the environment and human health. The related Catalog, Multi-collection, Centralized Treatment, Development Plan, Qualification Licensing, Treatment Fund, and other supporting system on the e-waste management have also been carried out.

The third level: Ministry regulations

Besides the above-mentioned laws and regulations, some ministries and commissions also issued regulations and measures to promote the circular economy implementation. For instance, *Recovery and Management measures on renewable resources* stipulated that governments would encourage all urban and rural residents to recover renewable resources, promote the renewable resource recycling under an environmentally sound way, and support the scientific research, recycling technology development of renewable resources. Moreover, some other rules such as *Administration Regulations of End of Life Vehicles Collecting and Dismantling* (*exposure draft*), and *Remanufactured Product Management Interim Measures are* still under the formulation and modification process.

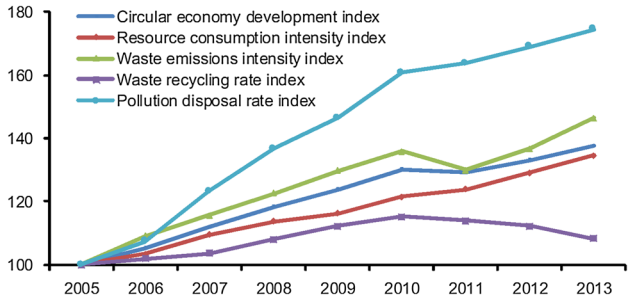

Fig. 2 Circular economy development index in China from 2005 to 2013

The fourth level: Local statues

Some local governments issued the regulations successively, but most provinces and cities have not enacted any regulations for the development of the regional circular economy. *Regulation on the Construction of Crcular Economy Eco-city Ordinance* implemented on 1st January 2004 in Guiyang City, Guizhou Province is the first local circular economy regulation in China. After that, other provinces such as Shanxi Province, Shaanxi Province, and Gansu Province also issued the regulations to improve the circular economy of their local governments. Beijing, Yunnan Province, and Jiangxi Province, etc. promulgated the implementing rules of cleaner production audit. Shanghai enacted the *Recovery and Management Measures on Renewable Resources in Shanghai*. Meanwhile, some industrial parks have also issued their own rules, such as *Administration for Tianjin Ziya Circular Economy Industrial Zone* enacted in 2012. The establishment of local laws and regulations has laid a good legal basis for the development of the circular economy.

The development of circular economy on waste prevention through 3R

From 2011 to 2015, energy consumptions reducing rates per ten thousand yuan GDP increased from 2.0 to 5.6%, and the clean energy consumption rates to the total energy consumption rose from 13.0 to 17.9%. National Bureau of Statistics of the People's Repubic of China firstly released the circular economy development index of China. This index took 2005 as the base year (the index in 2005 equals to 100), and reached 137.6 in 2013 with an average annual increase of 4% (Fig. 2), which indicated the significant achievements of circular economy development in China.

In this study, the circular economy development index consists of resource consumption intensity, waste emission intensity, waste recycling rate, and waste disposal rate. In 2013, the resource consumption intensity index was 134.7 in China, 34.7% higher than that in 2005. The average annual growth was 3.8%, which indicated that the resource consumption was being reduced steadily. The waste emission intensity index was 146.5 in 2013, with a mean annual improvement of 4.9% since 2005. This index contains four secondary indexes which mainly indicate the waste generation per unit, such as the wastewater discharge per GDP; and an increase in the index means a reduction in emissions. Due to the significant growth of the industrial solid waste emissions, the waste emission intensity index of 2011 was decreased 6 points compared with that of 2010, and then the index was significantly rebounded in 2012 and 2013. Compared with 2005, the waste reduction effect was apparent. The pollution disposal rate index was 174.6 in 2013 with an average annual increase of 7.2% compared to 2005, which showed the pollutants disposal level was improved significantly. The waste recycling rate index consists of four main components: the recovery rate of energy, the recycling rate of waste resources, the recycling rate of industry water, and the comprehensive utilization rate of industrial solid wastes. This index was 108.2 with the smallest improvement in the four indexes, and it continued to decrease from 2011 because of the decline of waste resource reuse rate. The results of those indexes demonstrated that the circular economy development in China had made some good improvements, but the progress of waste reuse was still slow and should be paid more attentions on.

Waste disposal investment situation

According to the data of National Bureau of Statistics of China [26], the total pollution control investment was increased year by year in China, from 238.8 billion yuan in 2005 to 957.55 billion yuan in 2014. The total environmental pollution investment ratio, accounting for the total GDP, increased from 1.31% in 2005 to 1.59% (2013), but the investment proportion of solid waste treatment declined to 1.51% in 2014 (Fig. 3). At present, the EU 27 countries invested more than 80 billion euros per year in environmental protection, accounting for more than 2.25% of GDP. The gap is noticeable, comprising more than 2% of environmental investment in developed countries. As for the investment for solid waste disposal, the trend was uncertain. In 2011, the investment for solid waste treatment reached the highest, after that began to decline in 2012 and 2013, and there was a slight increase in 2014. On the whole, the investment on solid waste pollution control only accounted for 1.6% of gross investment in the industrial pollution control in recent years, while the investment rate of waste water and waste gas were about 12 and 80%, respectively, much higher than solid waste investment.

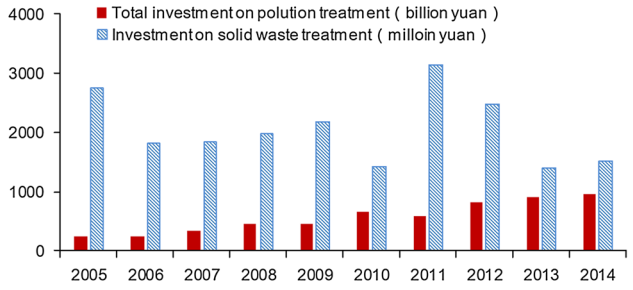

Fig. 3 Investment on pollution treatment in China

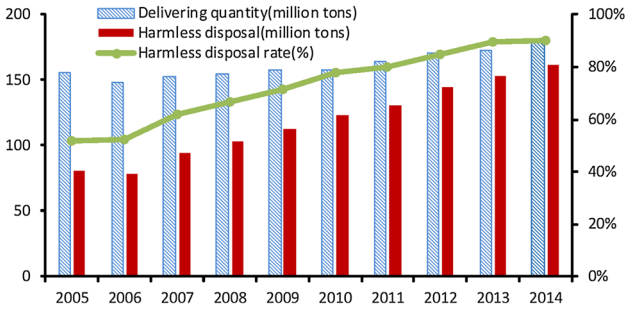

Fig. 4 MSW collection and harmless disposal in China

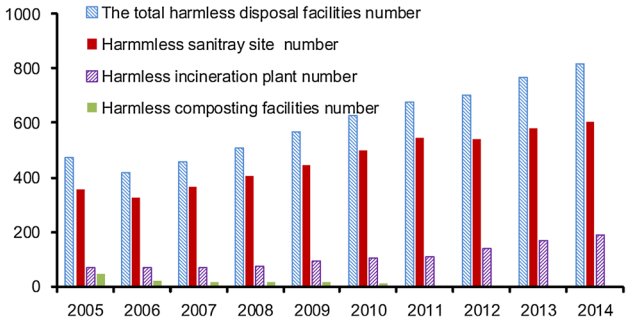

Fig. 5 MSW harmless disposal facilities in China

The circular economy pilot projects

According to *Accelerating the Development of Circular Economy* approved by the state council, National Development and Reform Commission and other six commissions, two batches of Circular Economy demonstration pilots, 60 circular economy development cases, were carried out in 2005 and 2007. Meanwhile, from 2010 to 2015, the National Development and Reform Commission and the Ministry of Finance had also approved six batches of a total of 49 "urban mining" national demonstration bases.

The circular economy demonstration pilot project had greatly promoted the development of waste utilization industry. There are over 6700 renewable resources enterprises, 230,000 registered recovery network points, more than 5300 collecting and processing plants, and 1.9 million employees. It has made significant progress from the perspectives of the industrial scale, technology level, and development patterns. According to Report on the development of China's renewable resources recovery industry (2015) [27], the total amount of resource recovery including e-waste, ELV, steel scrap, and other ten categories was about 2.45 million tons in 2014, with the economic benefits of over 644 billion yuan.

Current situation on typical waste generation and recycling

Municipal solid wastes

MSW refer to the solid waste generated in urban daily life or activities to provide services, as well as the solid waste regarded under the laws and administrative rules in China. The amount of MSW increased very fast in China owing to its rapid urbanization and industrialization, and the growth rate ranks first in the world and its total amount ranks at the forefront of high-yielding countries [28]. According to the data from National Bureau of Statistics of China [26], the annual MSW collection and disposal in China keeps the fast increasing, as shown in Fig. 4. Until 2014, the delivering quantity of MSW was 179 million tons with average annual growth rate of 1.0%. The components of the MSW in China are involved and can divide into organic matter (such as food residue) and inorganic matter which account for about 60% and 40%, respectively [29].

The trend of harmless disposal of MSW was also increasing yearly, and the disposal rate increased from 51.7% in 2005 to 90.3% in 2014. The safe disposal quantity was 163 million tons in 2014, including landfill disposal amount of 105 million tons (65%), incineration disposal quantity of 53 million tons (33%), and the remaining treatment (2%). The rest of waste, with no harmless disposal, was often stacked or ended in a simple landfill. According to the data of National Bureau of Statistics of China, the number of MSW harmless treatment facilities is shown in Fig. 5, and the total number increased from 471 in 2006 to 818 in 2014. The number of MSW landfill site grew from 356 to 604. Until 2014, the treatment capacity of landfill facilities was about 335,000 tons/day; the number of MSW incineration plants increased from 67 to 188, and the capacity was 186,000 tons/day. Landfill capacity is stable with a slight growth in the last ten years, and it is still the mainstream processing technology; the waste incineration were keeping rapid growth; however, the garbage composting facilities decreased in China. In future, the

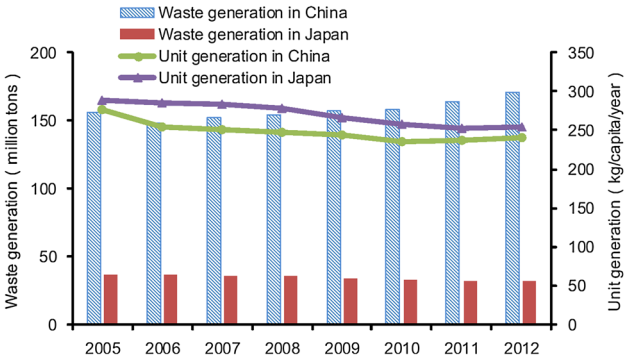

Fig. 6 MSW generation in China and Japan

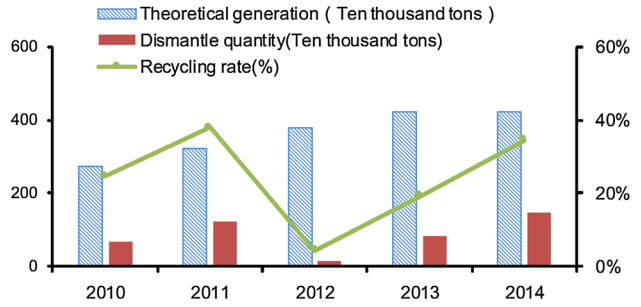

Fig. 7 Theoretical e-waste generation and dismantling quantity in China

comprehensive treatment technologies and facilities of municipal solid waste, including landfill, incineration, and composting technologies together, will be the new development trends.

Based on the data of Ministry of Environment of Japan [30], we do some comparisons of the MSW generation between China and Japan, as shown in Fig. 6. The discharge quantity in Japan presented a downward trend from 36 million tons in 2005 to 32 million tons in 2012, and the annual MSW generation per capital also decreased from 288 to 254 kg. In China, although the total MSW generation is much higher than Japan, the annual MSW generation per capital is lower and also showed a decline trend since 2005. In addition, the Japanese minimization rate of MSW were up to above 98% in those years, and the recycling utilization rate is about 20% [30]. Meanwhile, because the MSW has been made an excellent classification when people throw them away, many valuable materials, mainly including polyethylene glycol terephthalate (PET), tin, aluminum cans, glass bottles, paper, plastic in the MSW can be directly recovered However, in China, the waste sorting collection system still need to be improved [31]. Different from Japan, at present, most of the urban MSW sorting facilities in China are simple, and the trash classification is too academic. For example, the expressions "organic" and "inorganic," "recyclable" and "unrecyclable," and so on, makes most of the residents impossible to identify and put the trash on the right cans [32]. Due to the lack of awareness on waste classification recycling, the MSW was mixed collected mostly. While, at the same time, for the existence of waste pickers or informal recycling staffs who pick up and purchase the recyclable resources in MSW, the recycling utilization rate in China is not low actually. According to the projection [33], in 2007, the waste pickers recovered about 3.6 million tons waste in Beijing accounting for 37% of the total generation.

E-waste

The theory generation amount of typical e-waste, including television (TV), refrigerator (RF), washing machine (WM), air conditioner (AC), and personal computer (PC) was estimated, shown in Fig. 7. It suggests that the expected e-waste generation has increased steadily from 2010 to 2014, and 149 million units of five kinds of e-waste, about 4.22 million tons, were generated in 2014.

Up to the end of 2015, 109 enterprises covering 29 provinces have been listed as WEEE subsidy funded companies. The total processing capacities exceeded 100 million units, and over 70 million e-waste (the main five types) were dismantled and recycled in 2014. Figure 7 shows the recycling rate of e-waste dismantling amount in the formal recycling enterprises to theoretical e-waste generation in China. It indicates that the recycling rate has increased from 24.64% in 2010 to 34.6% in 2014. Due to the "Old for New" policy, there was a significant increase in the collection and dismantling quantities in 2011. The dismantling amount of TV was 58.39 million of China which is higher than the theoretical e-waste generation of that year. That is because the dismantling amount of TV had actually included the history accumulations, and the subsidy of TV in the subsidy of e-waste treatment (2012 version) was relatively high. The TV dismantling amount contributed over 80% to the total quantity. But the other four appliances recycling rates were still low: the AC recycling rate was only 0.28%, and the recycling rate of the three kinds of electrical appliances were varied in the range of 12–18%. From the first batch of WEEE subsidy funded companies was announced in 2012, a processor-based recovery model has been formed. And the recycling rate increased from less than 5–34.6% in 2014.

According to the data of Eurostat Database and other reports [34–36], the recycling rates of e-waste in different countries are shown in Fig. 8. The recycling rates of Norway, United Kingdom, Denmark, and Germany are calculated according to the e-waste collection quantity and

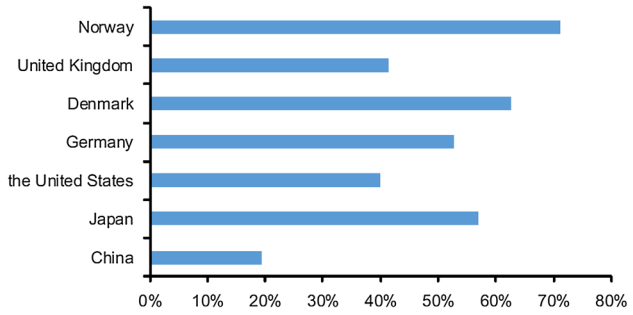

Fig. 8 E-waste recycling rate of different countries in 2013

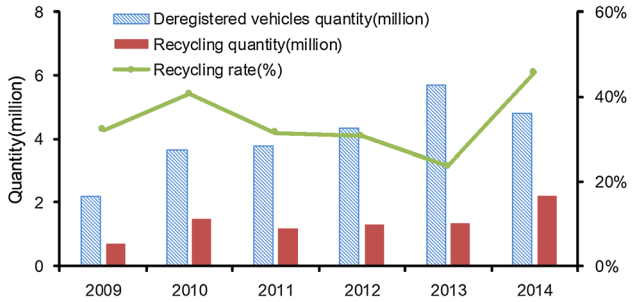

Fig. 9 Theoretical deregistered vehicles and recycling quantities in China

electronic products sale date. The electronic products market of developed countries has been basically saturated, so electronic product sales data are used instead of waste data. The recycling rates of European Union countries and Japan are higher than 40%, especially in Norway (>70%) and Japan (>67%). And the recycling rate in the United States is nearly 40%. Comparing with the other countries, China's recycling and dismantling rate are still low, in the future, the formal e-waste recovery and treatment still has a long way to go [37].

End of life vehicles

The situation of the auto market in China maintains steady growth, the auto production, and sales keep the first position of the world for six years, and were 23.7 million units and 23.5 million units in 2014, respectively. At the same time, the quantity of end of life vehicles is also enormous. According to Industry Development Report of Recycled Resources in China, theoretical deregistered vehicles amount is shown in Fig. 9. From the figure, it can be seen that the recycling number of end of life vehicles present a growth trend. While due to the implementation of national policies such as *Auto Replacement Approach*, the large accumulation of ELV went into retirement program in a short time, and made the larger fluctuations of recycling volume. The recycling amount of ELV in 2010 reached 3.64 million. From 2011 to 2013, the recycling amount kept stable. In 2013, the State Council issued the *Notice on the issuance of the air pollution control action plan*; it required to accelerate the elimination of yellow label vehicles[1] and old vehicles, and it speeded up the rate of the vehicle scrapped. Then the next year the deregistered vehicles quantity came back an average growth level while compared with 2013, the number decreased somewhat to 4.81 million. In 2014, the dismantling amount and recycling rate reached the highest. The theoretical deregistered vehicles number was 4.81 million in China [38], and the recycling and dismantling ELV was 2.2 million, 45.7% of the deregistered vehicles.

The ELV recycling industry in China developed steadily; the qualified enterprises amounted to 597 in 2014 with an increase of 3.5% compared with 2013. Also, the recovery outlets have reached 2432 increased by 1.4% to 2013, and the ELV collection and recycling network have covered more than 80% areas in China. Moreover, the recycling and dismantling quantity of ELV increased that year. There were three final destinations of the ELVs in China: about 40% of the officially deregistered vehicles were dismantled in authorized facilities, and the others were illegally dismantled or flowed into the underground market, with the proportion of about 30% [39].

In 2013, the Japanese ELV deregistered amount is about 4.91 million, and dismantling quantity is 3.43 million [40], the dismantling rate was over 69%. The rate refers to the proportion of the normally disassemble number in deregistered amount. In the United States, 95% of ELV are recycled and the recycled parts weight up to 75% of the total weight of each recovery vehicle. However, in China, the dismantling rate was only 46%. The Japanese government enforced the ELV Recycling Law in January 2005. It explicitly stipulates the typical automobile shredder residues (ASR), airbags, chlorofluorocarbons/hydrofluorocarbons (CFCs/HFCs) should be collected and recovered by vehicle manufacturers and importers during the process of recycling ELV. The average recycling rate of ASR increased from 59% in 2005 to 94% around 2012, and airbag average utilization rate remained at about 94%. However, in China little attention had been paid to the recycling and management of the ASR and airbags. Although the "Automotive Products Recycling Technology Policy" stipulates that the components with potential toxic substances, such as batteries, airbags, catalyst, coolant, and so on, must

[1] Yellow label is the nickname of highly polluting emissions vehicle, and it refers to gasoline vehicles which are not up to the I emission standard, or diesel vehicles which do not meet the III diesel emissions standards.

be handled by qualified enterprises. In fact, part of waste fluid and toxic materials often discharged directly into soil without any treatment in some place [41]. Furthermore, the ELV recycling mainly focused on the scrap metal recovery and the recycling rate is below 70% in China [42].

Problems and challenges

Under the concept of circular economy, China has made inspiring achievements in waste management; however, at the same time, there are still some problems and challenges. Regarding waste management, the policies, and regulations system in China is still imperfect, there are only some basic laws and lack of special regulations about the particular waste like ELV, packaging waste and so on. Besides, the legislations are not very clear for some contents. The coordination of relevant laws and regulations is insufficient, and solid waste disposal responsibilities are unclear. As for some waste recycling industry like ELV recycling, the incentives from policies are still inadequate, and the tax is so high that it weakens the motivation of industry development.

The investment in environmental pollution control accounted for about 1.5% of GDP in China, which is far below other developed countries, and the national investment on solid waste treatment is smaller than that of waste water and air. Circular economy demonstration pilot projects have highly promoted the development of waste utilization industry. But the space layout of pilot projects was not reasonable, and made the transportation distance between waste resources and recycled products too long, which affected the economic performance and significantly reduced the overall efficiency.

Under the current waste generation and recycling situation, the MSW generation annually continued to increase from 156 million tons to 179 million tons from 2005 to 2014. However, most of the MSW was mixed collected in China. Hence, it caused a waste of the resources to a certain degree. Source reduction of the MSW is the most fundamental way to solve the MSW problems. In future, the waste sorting collection and source prevention still need to be improved in China.

The dismantling quantities and recycling rate of e-waste have made great improvement, but when compared with developed countries, China's formal recycle and dismantling rate is still low. The informal sector occupies most of the recycling channels. Lack of business model in the channel of resources recovery is still the biggest problem in some waste recycling and dismantling enterprises like e-waste. In the future, the formal e-waste recovery and treatment still has a long way to go.

The theoretical quantity of ELV in China is enormous, but recycling and dismantling part in qualified enterprises only accounted for 1.42% of the vehicle's ownership. Comparing with the developed countries such as Japan whose rate was about 7%, it was relatively low. And very little attention had been paid to the recycling and management of the ASR and airbags.

Except for the above aspects, another challenge is that the overall technology and equipment employed for resources regeneration from waste is still at a relatively low level. For example, in ELV dismantling industry, there is no standardized industrial dismantling line, and many companies still use manual dismantling, while a large proportion of the dismantling process in the developed countries are conducted with automotive equipment. Meanwhile, some solid waste recycling technology standards need to be improved, like the rare and precious metals extraction and hazardous substances removal. The absence of supervision measures on the comprehensive utilization of solid waste also hindered the development of the technological innovation to some extent.

On the other hand, the collection channel of "Internet+Collection"[2] mode gradually emerged, especially for e-waste. Through the internet service platform and offline service system, the online of delivery waste and offline of logistics under the "Internet+" collection mode were gradually changing the traditional small, scattered, and poor condition of recycling. Moreover, waste prevention through 3R as the primary coverage of circular economy can alleviate environment and resource pressure, cultivate new economic growth points, and realize the operation mode of circular economy. And accompany with the rapid development of renewable resources utilization, source classification, further improvement of the recycling system, environmental education, and the implementation of the production responsibility system, the proportion and quantities of renewable resources recovery will be further developed.

Conclusions and suggestions

In past ten years, remarkable achievements in circular economy development in China have been obtained, and a relatively perfect legal system of circular economy has been established. Moreover, the effectiveness of waste recycling and utilization is obvious. The quantity of MSW treated with a harmless way, is continuously increasing, but the

[2] "Internet+" is the innovation on the Internet with the depth of the economic society in various fields, to promote technological progress, promote the real economy innovation and productivity to form more widely on the Internet for infrastructure and innovation elements in new form of social and economic development.

annual waste generation per capita shows a trend of decline at the same time. The recycling rates of e-waste and ELV increased from 24.64 and 32.4% in 2010 to 34.6 and 45.7% in 2014, respectively.

However, there is still a gap in the development level of the Circular economy between China and other developed countries, e.g., related management policies and regulations are still insufficient. Some effective measures should be carried out to improve the current waste management and recycling situation. First, it is necessary to continue to promote the establishment of legal framework on the circular economy, and gradually achieve "zero waste" society. Secondly, available technologies are the keys for the efficient resource recycling and sanitary disposal; more research funds should be invested to enhance technology innovation and development. Thirdly, waste management infrastructures, including domestic waste sorting collection facilities, waste separation facilities and disposal facilities, are the essential basis for achieving the waste reduction, resource recovery, and safety disposal. Strengthen the construction of waste treatment facilities will promote the development of waste management significantly.

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