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Waste management and plastic waste recycling in Japan, China, Singapore and South Korea – What trends can be observed under different regulations

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ABSTRACT

Plastic pollution of oceans and seas is increasing every year and coastal countries need to pay particular attention to this problem. Four Asian countries – Japan, China, Singapore, South Korea – were analysed in terms of the amount of waste and plastic waste generated and their recycling rates. For each country, available data were collected and converted into a common unit of measurement – metric tonnes per 1,000 people. The countries' performance to date was analysed and used as a basis for projections for 2030. Based on the trends so far, Japan has seen an 11% reduction in plastics waste and a 6% reduction in waste over the period, while China has seen a 27% increase in waste and an 8% reduction in plastic waste. In South Korea, plastic waste increased by 49% and waste by 21%. In Singapore, waste decreased by 13% and plastic waste increased by 15%. On current trends, none of the countries are projected to reach their 2030 targets. However, by complying with current and newly introduced regulations, they have a chance to move closer to their targets.

KEYWORDS

pollution, waste management, plastic waste, recycling, Asia

1. INTRODUCTION

Worldwide approximately 9 million tonnes of plastic are dumped into the oceans and seas every year [1], one of the main reasons for this is the exponential increase in plastic production. The amount of poorly managed plastic waste leaking into the environment has increased exponentially in recent years, with the latest global estimates suggesting that 19-23 million tonnes of plastic are dumped into the oceans every year. This has led to a dramatic increase in suspended microplastics over the past two decades. Plastic pollution is projected to triple by 2030 without significant reductions in plastic production, consumption and disposal and without social change, leading to significant ecological, economic and social costs [2, 3]. The consequences of this pollution include the Great Pacific garbage patch, the loss of marine and ocean biodiversity, and changes in the microclimate of water environments [4-7]. The use of plastics is diverse, but we can say that 47% is used by the packaging industry [8]. As the world's largest producer of plastics, China accounted for 32% of global production in 2020 and still produces 6-8 million tonnes/month of plastic products [9]. Possible solutions to the plastic problem include recycling, using alternative materials or even turning to a circular economy (CE) [8, 10]. By improving waste and materials management, the introduction of CE will help to reduce the amount of microplastics released into the environment and plastic waste dumped at sea. CE aims to maximise the amount of materials circulating in the economy, reduce the use of new raw materials and prevent waste [11]. In the circular economy, extended producer responsibility (EPR) and deposit-fee redemption

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schemes will be a priority [8]. In this research, we examine four Asian countries from the perspective of waste management and plastic waste management. The four countries selected are Japan; China; South Korea; and Singapore. All 4 countries have different decision-making, different levels of environmental awareness and their economic circumstances. However, a common feature is that waste management policies in all four countries strongly address plastic emissions and recycling. The aim is to look at the trends in waste management and plastic waste in the countries so far and to examine their future objectives and recent policies.

From a regulatory perspective, legislation in all four countries is pushing for the introduction of '3Rs' (Reduce, Reuse, Recycle), the application of the 'polluter pays' principle and extended producer responsibility. Japan has passed a number of recycling laws since the 1990s. The first of these was the Containers and Packaging Recycling Law (1997) [12], followed by the Basic Law for the Development of a Circular Society in 2000. The latter was the first to introduce the concept of the '3Rs', which prescribes Reduce, Reuse and Recycle [13]. In 2019, the Resource Circulation Strategy for Plastics was published, followed by the Law for Promotion of Resource Circulation of Plastics, which entered into force in 2021. The law is part of the country's '3Rs' + Renewable initiative, which aims to promote the recycling of plastic resources at each stage of the life cycle of plastic products, in collaboration with all stakeholders, including municipalities, businesses and consumers [14]. China, the world's second most populous country and largest developing economy, is committed to zero waste cities [15]. Since the revision of the Law of the People's Republic of China on the Prevention and Control of Environmental Pollution by Solid Wastes in 2020, the PRC has been working to improve solid waste management through various laws, regulations, resolutions and notices [16]. China has paid more attention to the development of industrial sustainability and environmental protection in recent years. This is shown by several regulations in this area: Opinions on Further Strengthening the Clean-up of Plastic Pollution, the Implementing Plan for Improving the Mechanism to Boost Consumption 2018–2020, and the Guiding Opinions on Actively Promoting the Innovation and Application of Supply Chains; which set out the principles and national strategies. The government wants to move the plastics and packaging industry towards sustainability, environmental protection and recyclability [17]. The first regulation in South Korea was the Waste Management Law of 1986 [18]. It was in this Act that the '3Rs' were first introduced, followed in 1992 by the Act on the promotion of saving and recycling of resources, which provides for the promotion of resource recycling, proper management of waste and efficient use of resources [19]. In 2010, the Waste Control Act was introduced to help protect the environment and improve people's quality of life by reducing waste generation as much as possible and managing waste in an environmentally friendly way [20]. This measure was a major contributor to the enforcement of the polluter pays principle, followed by the introduction of extended producer responsibility (EPR), with the

ultimate goal of a Zero Waste Society [21]. In Singapore, waste management aims to create a solid waste recycling society through the '3Rs'. To achieve this goal, the Environmental Public Health Act (EPHA) was first enacted in 1987 [13] and then the Environmental Pollution Control Act (EPCA) in 1999 [22]. The Resource Sustainability Act 2019 (No. 29 of 2019) has a separate chapter on packaging waste and the requirements for submitting a '3Rs' plan [23]. Singapore's first Zero Waste Master Plan (Zero Waste Nation) maps out Singapore's key strategies for creating a sustainable, resource-efficient and climate-resilient nation. This includes a circular economy approach to waste and resource management practices and a step towards more sustainable production and consumption [24].

Previous studies that were related to at least one of the 4 countries and the research topic were collected and reviewed. The articles are summarised in Table 1.

Looking at the literature, we found that no study has yet comprehensively examined these four countries in terms of the amount of generated waste and plastic waste and their recycling rates. The uniqueness of the study lies in the fact that we look at the countries' performance to date and use this to make a forecast. By comparing this with the most recent legislation, we can conclude on the prospects for countries to meet their future targets.

2. MATERIALS AND METHODS

We started the research with a systematic literature review, which allowed us to narrow down the area to be investigated. After identifying the four countries to be studied and defining the topic, data were collected. Data on the amount of waste generated in the four countries, its recycling rate, and the amount of plastic waste generated and recycled were collected using several databases (Statista, NEA). In two cases we found information on how plastic waste is being recycled. In the case of Japan, the main method is thermal recycling, while South Korea recycles more than 60% of its plastic waste as material or energy. Since the data were often given in different orders of magnitude or in different units of measurement, the first step was to bring them into a common unit of measurement (metric tons). As our aim was to be uniform and to be population-based, we have used annual population data (worldbank) for each country. Data are therefore used in metric tonnes per 1,000 people in the following. First, we looked at the data available so far for each country and analysed the trends. In each case, these were illustrated by a bar graph, which includes population data with line chart. The next step was to test whether the data were suitable for forecasting (exponential trend line, $R^2 \geq 0.8$). The value of R^2 was chosen to be 0.8 because it assumes a strong relationship and thus the prediction can be made. In the cases where this condition was true, a forecast was produced using the Microsoft Excel forecast.ets statistical analysis command (4 cases in total). In the other cases, an exponential smoothing was carried out in the first round, and the resulting data were then suitable for

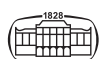


Table 1. Result of the literature analysis

Article	Country	Topic
Zhou et al., 2022 [48]; Bai et al., 2002 [46]	Singapore	waste management practices
Sinha et al., 2022 [62]	Japan	solid waste management
Jang et al., 2020 [43]	South Korea	solid waste management
Kurniawan et al., 2022 [35]; Ding et al., 2021 [13], Tan et al., 2021 [16]	China	waste management
Le Lee and Wong, 2023 [49]; Yap et al., 2023 [50]	Singapore	End-of-Life
(Thanos) Bourtsalas et al., 2019 [42]	South Korea	Waste-to-Energy
Zhang, D. et al., 2010 [22]	Singapore	comparing Singapore–Berlin
He, H. et al., 2023 [36]	China, Singapore	comparing China–Singapore
Yabar et al., 2012 [54]	Japan, China	comparing Japan and China in terms of environmental policies
Fitch-Roy et al., 2021 [57]	South Korea	CE policy regulation
He, S. et al., 2023 [47]; Ogunmakinde 2019 [55]	China	CE policy regulation
Jang et al., 2023 [56]	South Korea	management of plastic waste
Ishimura 2022 [53]; Kawai et al., 2022 [14]	Japan	plastic waste recycling
Ko et al., 2020 [61]	South Korea	waste recycling and related policies
Usui, 2008 [52]	Japan	waste recycling and related policies
Xiao and Zhou, 2020 [63]	China	waste generation of the express delivery industry
Brooks et al., 2018 [58]	China	Chinese import ban
Liang et al., 2021 [30]	China, Japan, Singapore, South-Korea	Asia in terms of plastic waste trade and management

Source: own editing.

forecasting. The results are presented in bar charts, which also show the targets set by countries (for 2030). We compared the results with data and findings in the literature and discussed the options for countries. At the end of the Results and Discussion section, a brief analysis of the Chinese plastic ban is summarised.

3. RESULTS AND DISCUSSION

3.1. Past trends

Japan has had a recycling law since the 1990s. In fact, since 2000, CE has been enshrined in basic law. Figure 1 shows the trends in Japan's household waste and recycling and plastic waste and recycling. The data are measured in metric tonnes per 1,000 people per year for the period 2014–2020. The population trend has also been plotted.

This shows a slight decrease in the amount of waste generated from year to year, with the exception of 2019, when 1% more waste was generated than in the previous year. The amount of waste recycled is in steady decline, well below the amount of waste generated. In general, the rate is around 20%, and has fallen below 20% in 2018 and 2019. At the same time, the population has declined slightly over the years. Interestingly, with a slight decrease in population, the amount of waste generated has decreased by almost 6% over the years. Regarding plastic waste, after 2014, there is a decrease of 5 tonnes/year in plastic waste generation per thousand people, followed by an increase of less than 1% in 2017 and then a decrease again. The amount of recycled

waste fluctuates over the years, with a decrease (2017, 1%), followed by stagnation (2018–2019, 57 tonnes/1,000 persons/year) and then a decrease again (2020, 1%). It can be noted that this almost constant recycling rate of 80% for plastic waste is quite good. Kawai et al. (2022) present that Japan recycled only 27% of its plastic waste in 2018 [14], which contrasts with the 84% we present. In contrast, Liang et al. (2021) in their paper also report a rate of 84% [30]. The amount of plastic waste generated has decreased by almost 11% over the years.

For China, we had no data available on the recycling rate of waste and only limited data on plastic waste. Figure 2 shows the data collected.

In this case, we looked at the trend in the amount of waste generated between 2014 and 2021. The amount of waste generated increase until 2019, in 2020, there was a 4% decrease, but then it started to increase again. Kurniawan et al. (2022) in their study, report that in 2020 the recycling rate of waste in China was 4.4% [35]. In contrast, He, H. et al. (2023) in their study, report a recycling rate of 30.4% [36]. Ding et al. (2021) report that the recycling rate was 12.1% in 2006; 17% in 2011 and 15.6% in 2015 [13]. Based on these data, it can be said that after an initial increase, there was a big drop in waste recycling, except if we take the recycling rate of 30.4% into account, when there was an increase. Meanwhile, the population grew by nearly 3% during this period. The amount of waste generated has increased by nearly 27% over the years. For plastic waste, we had data for the period 2017–2020. The amount of plastic waste fluctuates from year to year, increasing from one year to the next (4 tonnes/1,000 people between 2018 and 2019)



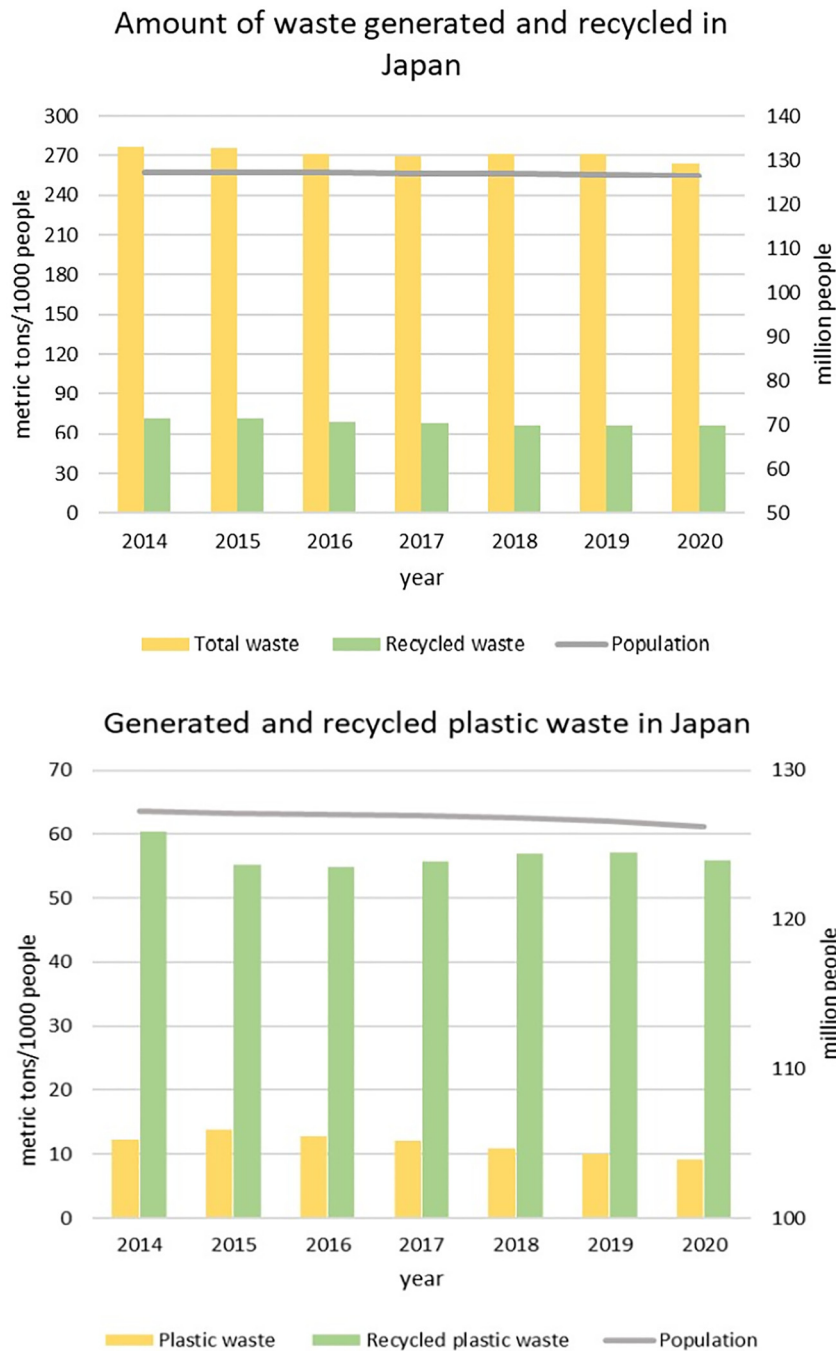


Fig. 1. Waste management trends in Japan
 Source: own editing, based on Statista and worldbank database [25–29].

and then decreasing the following year. This is also true for the amount recycled, with recycling rates ranging between 20 and 30%. The amount of plastic waste generated has reduced by almost 8% in these few years, which is good.

South Korea has had a waste management law since 1986. In 1992, the law on resource conservation and recycling was introduced. Then, in 2010, a law on waste reduction and environmentally friendly management was enforced. Figure 3 shows the trends in South Korea for waste generation and recycling and plastic waste.

Here we can see that the amount of waste (between 2015 and 2020) is increasing quite steeply, but the many waste

management and recycling laws are having an impact, with recycling rates hovering around 85%. The amount of waste generated first increases, then decreases by 1% in 2017 and increases again from then on. This trend is not followed by the amount recycled, which is constantly increasing. (Thanos) Bourtsalas et al. (2019), in their study, report that recycling was 24% in 1995 and increased to 58.8% in 2015 [42]. However, it is worth noting that they also mention that the recycling rate was 61% in 2009, which shows that there is a fluctuating trend. During this period, the amount of waste generated increased by 21%. Population increased by 2% during this period. There has



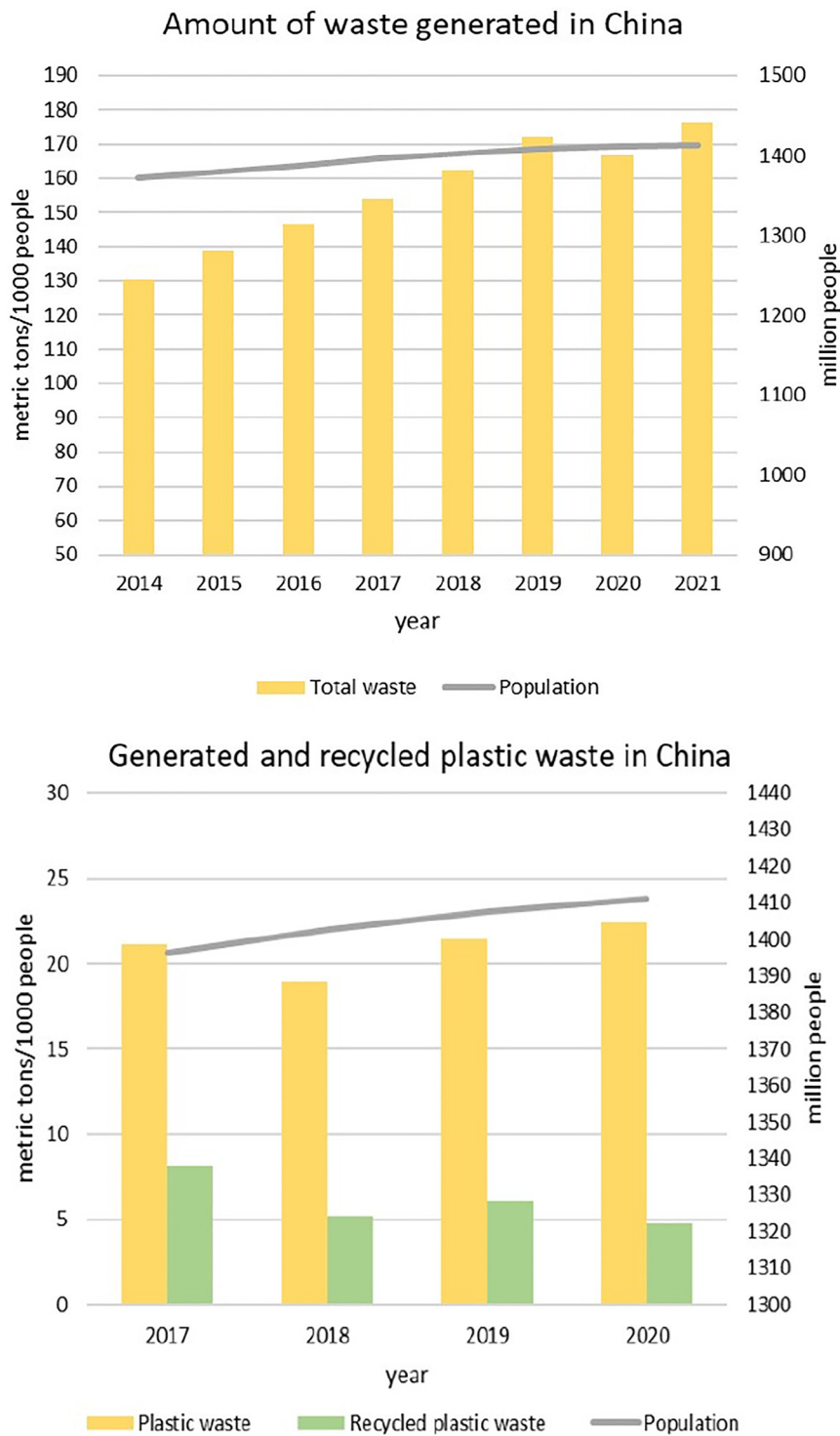


Fig. 2. Waste management trends in China
 Source: own editing based on Statista and worldbank database [31-34].

been a steady increase in both the amount of plastic waste generated and the amount of plastic waste recycled. In their study, Jang et al. (2020) report that in 2017, South Korea generated 2.98 million tonnes of plastic waste, but we found 12.85 million tonnes in our database [43]. They say the recycling rate is 13.5%, which contrasts with our results (57%). Over this period, the amount of plastic waste generated increased by 49%.

Singapore also presented us with a highly limited database. The data can be presented between 2017 and 2021. Singapore was an early adopter of environmental legislation (EPHA in 1987, EPCA in 1999). Trends in waste management and plastic waste are shown in Fig. 4.

For Singapore, we can see that both the amount of waste generated and the amount of waste recycled decrease by 2020. In 2021, the two quantities increase again. Zhang, D.



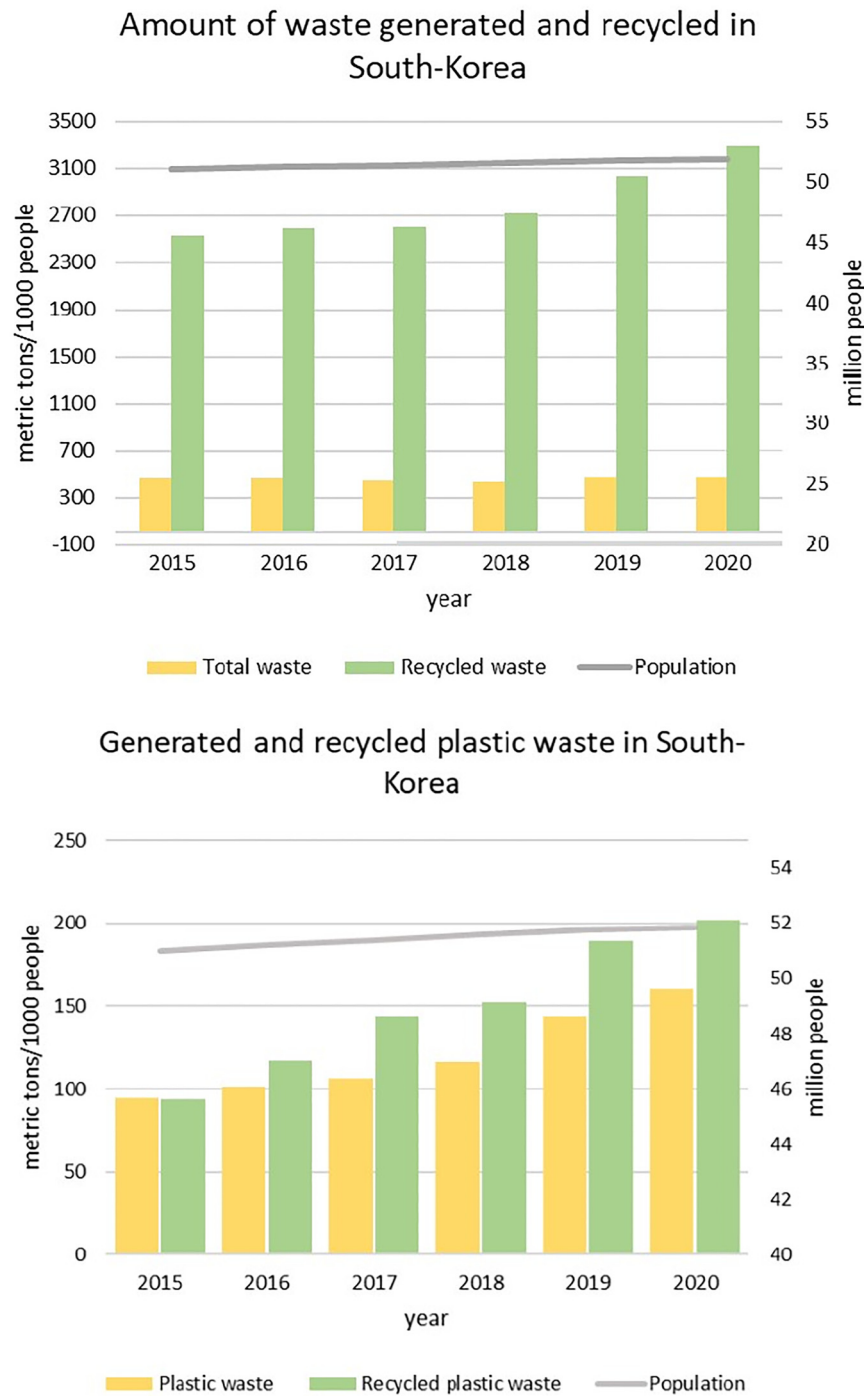
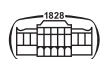


Fig. 3. Waste management trends in South Korea
 Source: own editing, based on Statista and worldbank database [37–41].

et al. (2010) reported that between 1996 and 2008 the amount of waste generated increased steadily [22]. Thus, a positive change is the consequence of a decline until 2020. The value of the waste generated and recycled moves together, with recycling rates ranging from 52% to 62%. The highest rate was reached in 2018 (62%) and the lowest in 2020 (52%). In 1999, this rate was 40.3% [46], so we can say that recycling has improved in the country. He, H. et al. (2023) report a recycling rate of 60% in 2012 [36]. This is almost the same proportion as in the period we studied.

Regulatory authorities support waste recycling campaigns – “Let’s Reuse Together”, “Recycling Corner” [48], which can contribute to the improving trend. The amount of waste generated decreased by 13% over this period, while the population increased by 3%. Singapore performs very weakly in the recycling of plastic waste (5–6%). The amount of plastic waste generated itself shows a fluctuating trend, rising, then falling and then rising again, and in the meantime increased by 15%. Le Lee and Wong (2023) and Yap et al. (2023) also highlight in their study the 4% recycling rate by



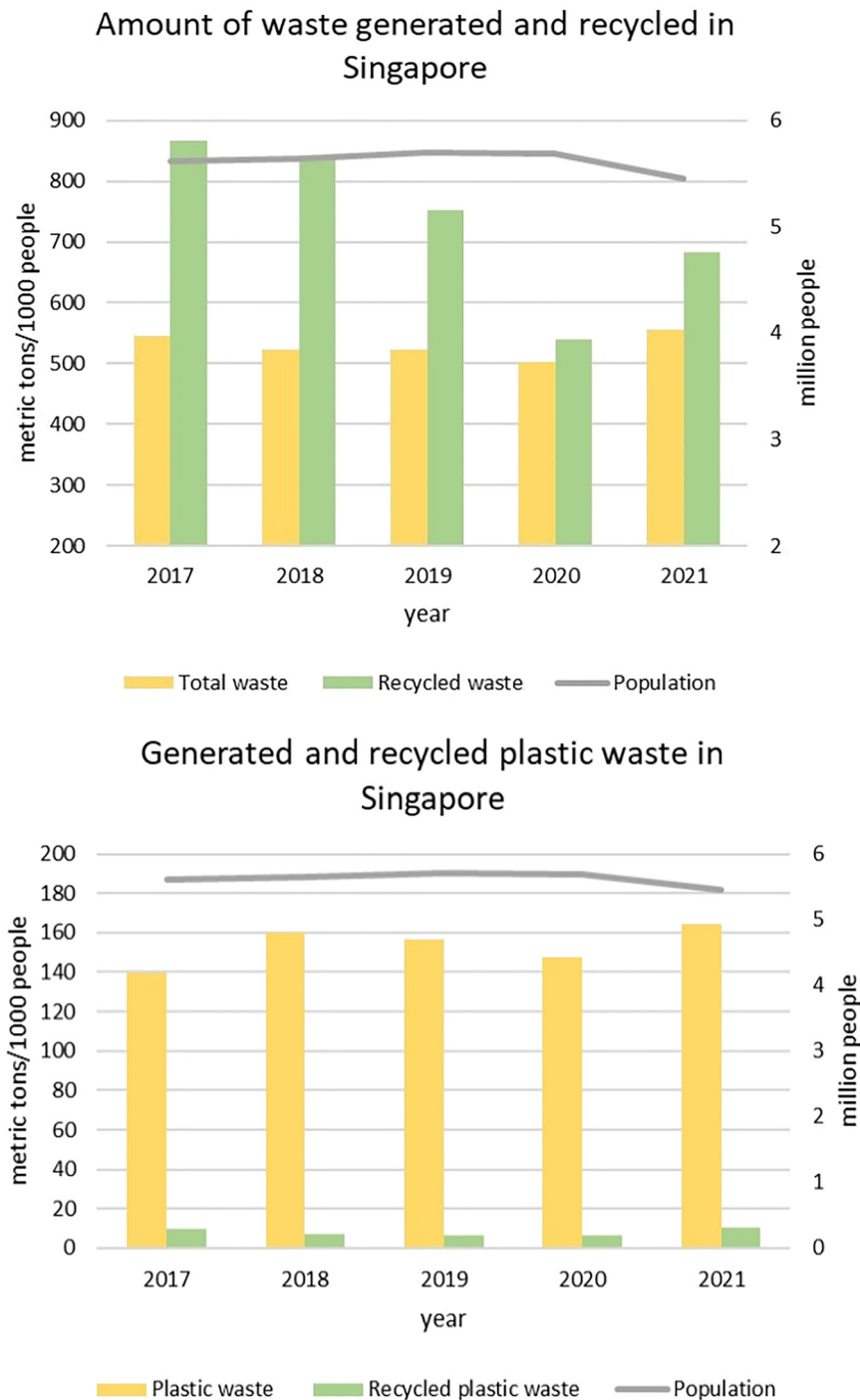


Fig. 4. Waste management trends in Singapore

Source: own editing, based on NEA and worldbank database [44, 45].

2020 [49, 50]. Both note the importance of improving the recycling rate of plastic waste to reach the 30% recycling target by 2030.

3.2. Targets and forecasting

The future targets for the four countries are summarised in Table 2.

Our projections based on the four countries' data so far (in darker colour) are illustrated on slide graphs, where we

have also plotted the targets set in Table 1 (in red shades). First, we present the results of countries that have set plastic waste reduction targets. Figure 5 shows our projections for Japan and South Korea.

Japan aims to reduce single-use plastic generation by 25% and achieve 60% recycling. It is true that the amount of plastic waste generated is projected to increase. The 25% reduction is plotted on the chart using the 2020 data, which should be 48.82 tonnes/1,000 people, but is projected to be 66.72 tonnes/1,000 people in 2030. The recycling rate is



Table 2. Waste and plastic waste management targets for 2030 by country

Country	Waste management	Plastic waste management
Japan		The cumulative 25% reduction of single-use plastics generation; 60% recycling rate of plastic containers and packaging [43]
South Korea		Reduce plastic wastes by 50% and recycle 70% of the waste plastics [51]
Singapore	Achieve a 70% waste recycling rate [12] and reduce waste to 30% [50]	
China	Reduce waste to 30% [35]	

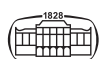
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forecast to be 83.75%. In Japan, the introduction of the Containers and Packaging Recycling Law has led to increased collection of recyclable materials; uniform pricing schemes have acted as an effective incentive for households [52]. After the introduction of the Law for Promotion of Resource Circulation of Plastic, most municipalities still do not collect and recycle plastic waste, as recycling companies trade at reverse charges and the government does not provide financial support. In addition to policies targeting households, policies with financial incentives for municipalities can also play an important role in recycling [53]. Yabar et al. (2012), argued that the introduction of specific indicators based on solid waste management and material flow analysis had contributed to increased recycling levels in the country [54]. Japan's vision for sustainability includes the following 4 areas: nature, economy, society and welfare. After CE was introduced in Japan, it followed a top-down approach. These included educational courses in schools, businesses and communities; recycling laboratories in schools; public cooperation through the use of incentives and recycling stations. A zero-emission recycling scheme is being developed, supported by legislation and regulations. A national life cycle framework exists to guide businesses and consumers on waste management [55]. Liang et al. (2021) argue that emphasis should be placed on the management and recycling of internally generated and imported waste [30]. Social participation in the development of CE, plastic waste collection and processing should be encouraged. Legislation has been enacted in 2019 and 2021 to promote the recycling of plastic resources at all stages of the life cycle of plastic products, in partnership with all stakeholders, including municipalities, businesses and consumers [26]. However, the country is doing very well in recycling plastics, the problem is they will not meet their target to reduce plastic waste generation. If the new laws are implemented, we believe that they will be able to achieve their goals, as the recycling target will be far exceeded.

South Korea aims to reduce plastic waste by 50% and achieve a 70% recycling rate by 2030. In the light of the data analysed, which show an increasing trend in plastic waste generation, our forecast shows that, based on the facts, the target is not expected to be met. To reduce the amount of plastic waste generated by 50% – based on the 2020 value – 181.15 tonnes/1,000 people of waste would have to be generated, and the forecast is for 748.67 tonnes/1,000 people. The recycling rate is projected to be 55.92% if the trend remains unchanged, well below 70%. In the case of South Korea, despite the CE certification of products, the measures taken by local authorities to promote “resource circulation”, waste management charges are not entirely innovative and have been criticised for not integrating the whole life cycle of the product. Nevertheless, the country supports policy commitments to low-carbon green growth [56]. However its regulatory system lacks specific definitions and scope for single-use plastics. To promote plastic waste reduction, a ‘waste market’ has been established in Seoul, where recyclable plastic waste is traded [43]. With regard to CE, the measures proposed by the government promote the reuse of packaging materials, but laws and policies are needed to actively involve companies [57]. South Korea's goal is to achieve a Zero Waste Society, which on current trends looks a long way off. The forecast shows a steep increase in the amount produced, with a parallel increase in recycling. The projected values are high compared to the target set. To get closer to the target, they should address the problems listed (innovation in waste management fees, rules on single-use plastics).

Now, we present the results of countries that have set waste reduction targets. Figure 6 shows our projections for China and Singapore.

China aims to reduce the amount of waste generated by 30% by 2030. Based on its current trend, this will not be met, as the forecast shows exponential growth. It is expected to produce 227.51 tonnes/1,000 people by 2030, but to reach its target it would need to reduce this to 123.26 tonnes/1,000 people compared to 2021 data. The current challenge in China is to reduce consumption to prevent waste generation and increase recycling rates, as traditional technological practices are not sufficient to manage waste sustainably. To make CE more effective, a waste recycling programme based on digitalisation could help. China also has waste-to-energy, but it is limited by its emissions. The low recycling rate may be due to the lack of a market for secondary materials and the lack of official initiatives for recycling. In 2008, the production, sale and use of plastic bags was banned. With the legislative changes, the laws on environmental resources do not meet the requirements of sustainable development. The principles of solid waste management are not flexible [35]. Ding et al. (2021) concluded that systematic waste separation should be introduced for the successful implementation of an integrated waste management system [13]. In 2019, the “Zero Waste City” pilot project was officially launched, requiring provinces, cities and municipalities to have a system of grading lists, an integrated solid waste management system with a division of labour, clear



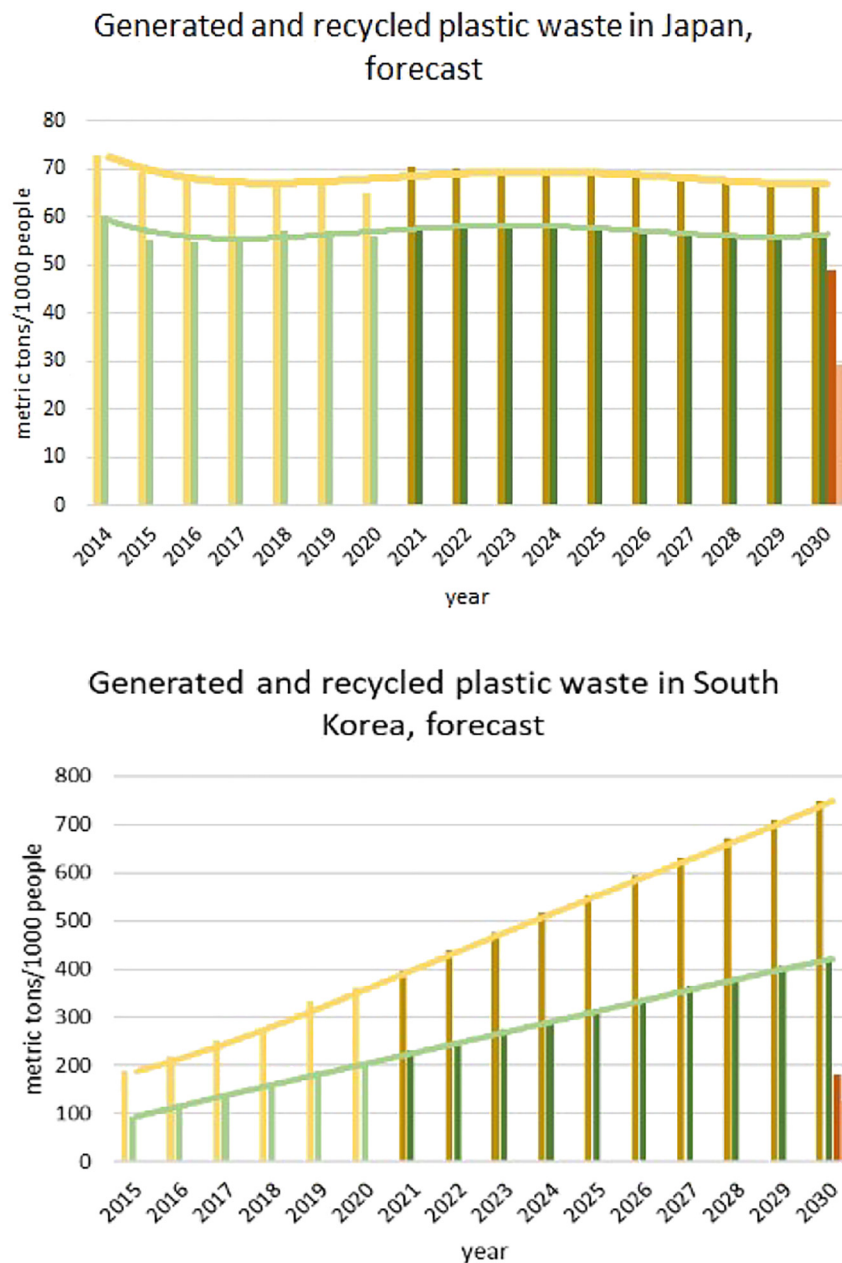


Fig. 5. Forecast for Japan and South-Korea

Source: own editing, based on Statista and worldbank database [27–29, 39–41].

responsibilities and effective coordination. The new development concept would promote green development and lifestyles, improve laws and regulations at the government level, promote extended producer responsibility, and improve public participation [16]. Ogunmakinde (2019), in his paper reports on China's drive for cleaner production, eco-industrial parks and low-carbon cities. The role of consumers is essential in ensuring that materials circulate continuously at the end of their life cycle, thus minimising pollution. Chinese consumers are encouraged to adopt low-carbon lifestyles, buy green, share and rent. Since the 2020 Law on the Prevention and Control of Environmental Pollution by Solid Waste, China has made a number of regulations, resolutions and announcements to further reduce the environmental impact of waste [55]. If these laws

and regulations are put into practice, there is a chance that the country will be closer to its goal than predicted.

Singapore's target is a 70% waste recycling rate, but our projections show that it will reach 55.95% if it makes no changes in the trends. In order to recycle 70% of the projected expected waste generation, instead of 649.55 tonnes/1,000 people, 812.63 tonnes/1,000 people would have to be recycled. The target of a 30% reduction in the amount of waste generated is projected to be missed, but less than 15%. In Singapore, to encourage waste recycling and raise environmental awareness, household waste disposal fees have been increased, waste recycling schemes based on a number of economic incentives have been strengthened, "Cash for Trash" has been launched and many supermarkets offer bottle recycling. Singapore has developed an efficient

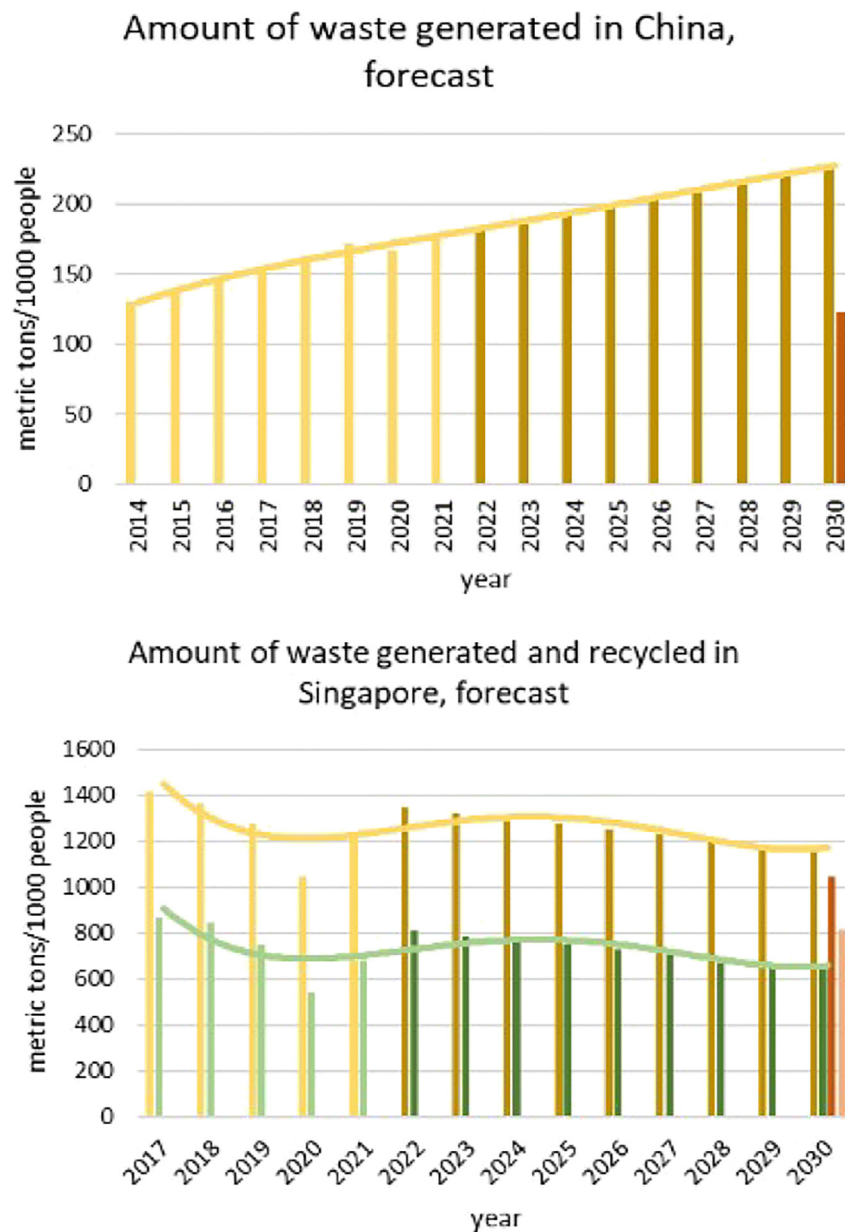


Fig. 6. Forecasts for China and Singapore

Source: own editing, based on Statista, worldbank and NEA database [33, 34, 44, 45].

district-based waste collection system, systematically regulating the collection and transport system according to the different types of waste sorted. Significant efforts have been made to improve the recycling industry's facilities and infrastructure, education of the population and urban development [48]. As early as 1992, a green labelling scheme was established to help consumers [46]. For the future, Singapore has committed to a number of climate policy targets, including a commitment to achieve net zero emissions by 2050 [49]. To improve recycling rates, a beverage container return system is planned to be introduced by 2024 as a first step towards extended producer responsibility for managing packaging waste, including plastic [50]. Our forecast is that they will not fall far short of the target, with the amount of waste generated 10% lower and the recycling

rate 21% lower. The good practices mentioned will certainly bring the country closer to its targets.

3.3. Chinese ban on plastic waste imports

China introduced an increasingly stringent waste import policy before 2010, before introducing a temporary restriction on waste imports in 2013. The latter was known as the "Green fence". The aim was to improve the quality of plastic waste entering China and reduce illegal foreign smuggling and illegal trade [58]. In July 2017, the Chinese government announced a ban on transporting plastic waste from outside the country into China to protect the environment and public health, as toxic substances were often found in mixed plastic waste streams. In 2016, China received plastic waste

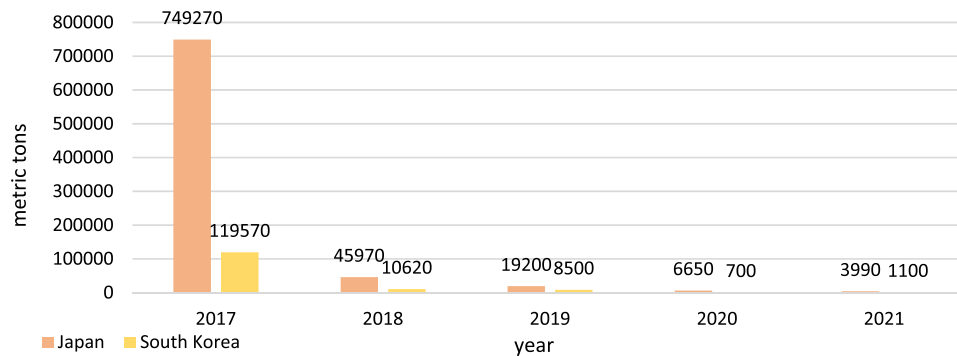


Fig. 7. The amount of plastic waste transported to China
Source: own editing, based on Statista database [59, 60].

from 43 different countries, amounting to 7.35 million tonnes [58]. The ban has left plastic waste once shipped to China for recycling and treatment as an unresolved problem in these countries [43]. Two of the countries examined (Japan and South Korea) were affected by this sanction. The amount of plastic waste they shipped to China is illustrated in Fig. 7.

We can see that Japan shipped 749,270 tonnes of plastic waste to China in 2017, compared to 119,570 tonnes for South Korea. Both quantities are very high, but Japan supplied 6 times as much as South Korea. Following the introduction of the sanctions, the two countries have not stopped importing plastic waste, but they have shipped significantly less since then. Between 2010 and 2017, South Korea shipped 1.19 million tonnes of plastic waste to China [59], and Japan shipped another 2,880 tonnes to China in 2022 [60]. Jang et al. (2023) reports that plastic waste exports from South Korea have decreased by 90% [56]. This is confirmed by the fact that the data available show that 91.12% less plastic was exported to South Korea China in 2018. However, it is important to note that the ban led to a solid waste crisis in South Korea, as consumers were unable to recycle and did not receive municipal assistance at the time [61].

4. CONCLUSION

The aim of the research was to examine waste and plastic waste management in Japan, China, South Korea and Singapore, as well as to examine their future targets and regulations. The importance of this research is shown by the fact that we did not come across any study that comprehensively examined this in our literature search. Across the four countries – Japan, China, South Korea, Singapore –, the '3Rs', the polluter pays principle, extended producer responsibility (EPR) and the glass return system are all present in their legislation. Japan has had recycling regulations in place since the 1990s. The most recent is 2021, which sets a target for recycling plastic resources. In China, there have been a number of recent regulations aimed at moving the plastics and packaging industry towards sustainability. In South Korea, the first such regulation dates

back to 1986, but there has not been a more recent one since 2010. Singapore has established several panels (EPHA, EPCA) and in 2019 introduced a law on resource sustainability. Currently, the Zero Waste Master Plan is in force.

Looking at their trends so far, we found the following. Japan's performance so far in terms of waste management and recycling shows a slight decrease in generation, while the recycling rate is only around 20%. With a slight decrease in population, the amount of waste generated has decreased by almost 6% over the years. For plastic waste generation and recycling in Japan, there has been a decrease in generation and recycling is above 80%. The amount of plastic waste generated has decreased by almost 11% over the years. In China, we were able to look at the amount of waste generated, with a steady increase until 2019, followed by a decline in 2020, but waste started to increase again in 2021. The population grew by nearly 3% during this period, while the amount of waste generated has increased by nearly 27%. China's plastic waste generation varies from year to year, with recycling rates ranging from 20 to 30%. The amount of plastic waste generated has reduced by almost 8% in these few years (2017–2020), which is good. For South Korea, waste generation is on the rise, in turn recycling is around 85%. During this period, the amount of waste generated increased by 21%, population increased by 2%. In the case of South Korea's plastic waste, there is an upward trend, with recycling tend to be around 50%. The amount of plastic waste generated increased by 49%. In Singapore, the amount of waste generated and recycled decrease until 2020, but increase again in 2021. The amount of waste generated decreased by 13% over this period, while the population increased by 3%. Singapore performs very weakly in recycling plastic waste (5–6%), and the amount of plastic waste generated itself shows a fluctuating trend. The amount of plastic waste increased by 15% over all.

We used factual data to make forecasts and compared them with the targets set for each country. Japan aims to reduce single-use plastic generation by 25% and achieve 60% recycling. Although the country is doing very well in recycling plastics, our forecast showed that it will not reach its target for reducing plastic waste production. However, if the new laws are successfully implemented, we believe they will be able to meet their targets as the recycling target will be far

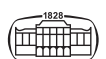
exceeded. South Korea aims to reduce plastic waste by 50% and achieve a 70% recycling rate by 2030. The projected values are well above the target. To get closer to the target, they need to address the problems, including innovation in waste management fees and rules on single-use plastics. China aims to reduce the amount of waste generated by 30% by 2030. In China, regulations have been introduced over the past few years to further reduce the environmental impact of waste. If these laws and regulations are put into practice, we see a chance that the country will be closer to its goal than we predicted. Singapore's target is a 70% waste recycling rate. Our forecast showed that Singapore would not fall far short of its targets. Based on current trends, waste generation will be 10% less than the target and recycling rates 21% behind the target. The good practices mentioned (e.g. "Cash for Trash", supermarkets offer bottle recycling) will certainly bring the country closer to its targets.

Finally, the Chinese plastic ban (2018) was mentioned. Two out of the four countries – Japan, South Korea – were directly affected, as they shipped large quantities of plastic waste to China. It can be said that in 2017 Japan supplied 6 times as much as South Korea. Following the introduction of the sanctions, the two countries have not stopped importing plastic waste, but they have shipped significantly less since then. From South Korea 91.12% less plastic was exported to China in 2018. However, it is important to note that the ban led to a solid waste crisis in South Korea.

Limitations of this article include the lack of data on solid waste recycling for China, and the limited timeframe of data available and used for all 4 countries. The research was made difficult by the limited data available for countries, especially China and Singapore. As a further research option, we propose and plan to carry out a study on this topic using a broader data base, possibly involving several Asian countries.

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