PLASTIC WASTE MANAGEMENT AND BURDEN IN CHINA

February 2022

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PLASTIC WASTE MANAGEMENT AND BURDEN IN CHINA

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CONTENTS

Glossary **5**

1. Market Size **6**
1.1 Plastic Production, Use and Recycling 6
1.2 The Amounts of Imported and Exported Plastics 7
1.3 The Imports and Exports of Waste Plastics 8
1.4 The Economic Value of Plastic Recycling 9

2. The Plastic Waste Management System **11**
2.1 Overview 11
2.2 Recycling 13
2.2.1 Plastics Recycling in China 13
2.2.2 Data on Main Types 15
2.2.3 Public Engagement in China's Plastic Recycling Market and Problems 18

3. Public Costs/Expenses **20**
3.1 Plastic Waste as a Public Burden 20
3.2 Public Health Costs from Plastic Waste 20

4. Public Policies Concerning Plastic **23**
4.1 China's Plastic Pollution Management Policies 23
4.2 Laws and Policies Relevant to Plastic Consumer Products 26
4.3 International Conventions on Plastic Pollution Management and China's Action 27
4.4 4.4 Policy Advocacy 32

GLOSSARY

Term	Meaning
Waste plastic	Various discarded plastic products and materials, including the scraps and rejects generated during the production and processing of such products and materials
Plastic production	The production of plastics in primary forms or of resins
PET	Polyethylene terephthalate
PE	Polyethylene
PP	Polypropylene
PVC	Polyvinyl chloride
PS	Polystyrene
ABS	Acrylonitrile butadiene styrene

1. MARKET SIZE

1.1 PLASTIC PRODUCTION, USE AND RECYCLING

China's plastic output has increased steadily, and reached 95.741 million tons (all the tonnages herein are in metric tons) in 2019,[1] or nearly one third of the global plastic output,[2] making it the largest plastic producer globally. The five most widely used synthetic resins account for seventy percent of China's plastic production,[3] and nearly sixty percent of them are polyethylene (PE) and polypropylene (PP), which are mainly used to make disposable plastic products such as plastic packages and films (China Plastics Industry Yearbook; see Table 1 for details). In addition, the output of polyethylene terephthalate (PET) bottle chips mainly used for manufacturing plastic bottles reached 8.84 million tons.[4]

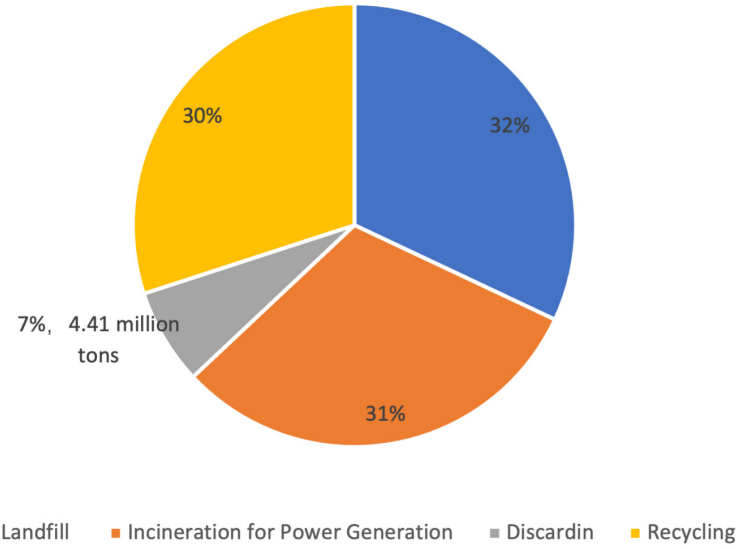

Figure. 1 The amount and proportion of waste plastics treated in China in 2019.
Source: 2019-2020 Development Report of China Plastic Recycling Industry

1 NBS. The production of plastics in primary forms [EB/OL]. 2019.
2 Plastics Europe, Plastics – the Facts 2020 [EB/OL], 2020.
3 The five major synthetic resins include PE, PVC, PS, PP and ABS.
4 www.askci.com, China Business Research Institute, the status of the Chinese market for PET bottle chips in 2021 and forecasts for its trends [EB/OL], 2020-12-01. https://www.askci.com/news/chanye/20201201/1624561297407.shtml

China's plastic products output has also grown rapidly in the past decade, albeit at a slower rate after a period of rapid growth (2011-2014). Since the tightening of environmental policies in 2017, the industry has gradually become better regulated, as small factories and non-compliant enterprises have been shut down one after another due to severe pollution and the abnormal operation of pollution control facilities. The current output is stable. In 2019, the output of plastic products reached 81.842 million tons.[5] The apparent consumption of plastic products in China is about 70 million tons.[6]

TABLE 1. THE PRODUCTION OF 5 MAJOR PLASTIC RESINS IN CHINA, 2012-2019 (IN MILLION TONS)

Year	2015	2016	2017	2018	2019
Total resins	77.182	80.182	82.136	85.58	95.74
PE	13.855	14.355	13.363	14.02	17.449
PP	16.864	18.106	19.035	20.419	23.485
PVC	16.190	16.899	17.745	18.739	20.107
PS	3.053	1.958	2.025	1.757	2.983
ABS	3.089	3.098	3.244	3.258	3.93

Source: China Plastics Industry Yearbooks published from 2016 to 2020 for synthetic resin and categorized data; the National Bureau of Statistics (NBS) for the total output of plastic products.

Huge consumption has also brought about an amazing amount of plastic waste. In 2019, China generated 63 million tons of waste plastics, of which the buried, incinerated and recycled ones each accounted for about one third, with the remaining seven percent thrown into the environment (see Figure 1).[7] The amount of recycled waste plastics reached 18.9 million tons in 2019, up 600,000 tons over 2018,[8] or about twice as much as in the EU or seven times as much as in the United States.[9] Despite this large amount, the recycling rate was only thirty percent (see Figure 1).

5 NBS. The output of plastic products [EB/OL]. 2019.

6 China Plastic Processing Industry Association (CPPIA). China Plastics Industry Yearbook. China Light Industry Press [J]. 2019.

7 The Plastic Recycling Association of the China National Resources Recycling Association (CRRA). 2019-2020 Development Report of China Plastic Recycling Industry [R]. Beijing: The Plastic Recycling Association of the CRRA, 2020.

8 The Plastic Recycling Association of the CRRA. 2019-2020 Development Report of China Plastic Recycling Industry [R]. Beijing: The Plastic Recycling Association of the CRRA, 2020.

9 Statistics about waste plastics recycling vary slightly from country to country. Such statistics in China only cover the amount of waste plastics recycled through local material-level recycling processes, that is, they exclude the amount of wastes recycled and exported and energy recovery by plastics incineration for power generation. The amount of plastics recycled in the EU is the figure in 2018 from *Plastics – the Facts 2020*. The U.S.-relevant amount is also the figure in 2018 from https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/plastics-material-specific-data.

1.2 THE AMOUNTS OF IMPORTED AND EXPORTED PLASTICS

Although the output of plastic raw materials, also known as plastics in primary forms or synthetic resins, has increased year by year, China still relies on imports when it comes to certain synthetic resins, and shows an upward trend in this respect. In 2019, China imported 33.668 million tons of synthetic resins and exported 6.543 million tons, with net imports of 27.125 million tons, up 14.1 percent year-on-year (YoY). The amounts of the five major resins imported and exported were 24.384 and 1.679 million tons respectively, with net imports of 22.704 million tons, which accounted for 83.7 percent of the total net imports of synthetic resins. Of them, the amount of imported PE was 16.666 million tons, which rose by 18.8 percent YoY and accounted for 49.5 percent, or the largest share, of the total imports of synthetic resins. On the side of exports, PVC took the first place with 714,000 tons, down 7.8 percent YoY.[10]

TABLE 2. THE IMPORTS AND EXPORTS OF SYNTHETIC RESINS IN CHINA (IN MILLION TONS)

Year	Imports	Exports	Net Imports
2019	33.668	6.543	27.125
2018	29.955	6.191	23.764
2017	31.959	6.18	25.779
2016	31.825	5.74.2	26.083
2015	31.872	4.981	26.891

Source: China Plastics Industry Yearbook 2020

TABLE 3. THE IMPORTS AND EXPORTS OF THE 5 MAJOR RESINS IN CHINA (IN MILLION TONS)

Year	Imports	Exports	Net Imports
2019	24.384	1.679	22.705
2018	21.408	1.683	19.725
2017	18.506	2.012	16.494
2016	16.197	2.058	14.139
2015	16.595	1.666	14.929

Source: China Plastics Industry Yearbook 2020

10 CPPIA. China Plastics Industry Yearbook 2020.

1.3 THE IMPORTS AND EXPORTS OF WASTE PLASTICS

2017 marked the turning point of the imports of waste plastics in China. Before 2017, China once accounted for nearly 60 percent of global waste plastics trade, as it imported a cumulative total of 170 million tons of waste plastics from 1992 to 2016.[11] With the release of the Implementation Plan for Banning the Import of Wastes and Promoting the Reforming of the Solid Wastes Import Management System (GBF [2017] No. 70) (hereinafter referred to as the Ban on Wastes), the imports of waste plastics in China dropped by 21 percent YoY to 5.8291 million tons in 2017, to 70 thousand tons in 2018 and to zero in 2019 (see Table 3). China has since been no longer a major importer of waste plastics.

Although China no longer imports waste plastics, there is growing market demand for recycled plastic particles made of waste plastics. As global brands promise to reduce the use of virgin plastic while increasing that of recycled plastic as an alternative, the demand for recycled plastic particles is soaring around the world, which has also led to fast-growing imports of such particles in China. In 2019, the amount of recycled plastic particles imported into China was about 3.5 million tons, according to statistics from the Plastic Recycling Association of the CRRA.[12]

TABLE 4. THE IMPORTS AND EXPORTS OF WASTE PLASTICS IN CHINA (IN MILLION TONS)

Year	Total Imports	Total Exports
2019	Negligible	0.03
2018	0.076	0.03
2017	5.829	0.037
2016	7.3472	0.0301
2015	7.3542	0.0304
2014	8.2542	0.0427
2013	7.8813	0.042
2012	8.8777	0.0329
2011	8.3842	0.0255
2010	8.0097	0.0258

Source: The annual versions of China Customs Statistics Yearbook

11 This figure was calculated by analyzing data from the UN Comtrade Database.

12

1.4 THE ECONOMIC VALUE OF PLASTIC RECYCLING

The total value of recycled waste plastics has gradually increased since 2015, with a high of over RMB 110 billion, according to data from the Plastic Recycling Association of the CRRA. In 2019, the average price of recycled plastics decreased slightly due to the Sino-US trade war and the decline in international crude oil prices. As a result, the value of recycled waste plastics decreased by about 12.5 percent compared with the level in 2018, but it still exceeded RMB 100 billion.[13]

TABLE 5 THE VALUE OF RECYCLED WASTE PLASTICS IN CHINA

Year	Value of Recycled Waste Plastics (in billion yuan)
2019	100
2018	114.3
2017	108.13
2016	95.78
2015	81

Source: 2019-2020 Development Report of China Plastic Recycling Industry

13 The Plastic Recycling Association of the CRRA. 2019-2020 Development Report of China Plastic Recycling Industry [R]. Beijing: The Plastic Recycling Association of the CRRA, 2020.

2. THE PLASTIC WASTE MANAGEMENT SYSTEM

2.1 OVERVIEW

The sources of waste plastics can be classified into industrial, medical, agricultural and domestic ones. Waste plastics from industrial sources mainly refer to scraps or rejects generated by plants, and are generally characterized by high quality and purity and ease of collection; most of them are directly reused within the plant or shipped to certain plastic recyclers. Waste plastics from medical sources need to be recycled by qualified organizations since they may be the sources of infection and/or contain toxic, radioactive or otherwise harmful substances. Waste plastics from agricultural sources mainly refer to waste mulch films, greenhouse films, pipelines, packages and others for agricultural purposes, which are difficult to collect and treat after use. Part of such waste plastics has long been excluded from statistics about the collection, transport and treatment of municipal solid waste (MSW), and has become, to a certain extent, a blind spot of China's efforts in managing pollution from plastic waste generated on land. Waste plastics from domestic sources refer to plastic waste generated in daily life, and are the focus of this chapter.

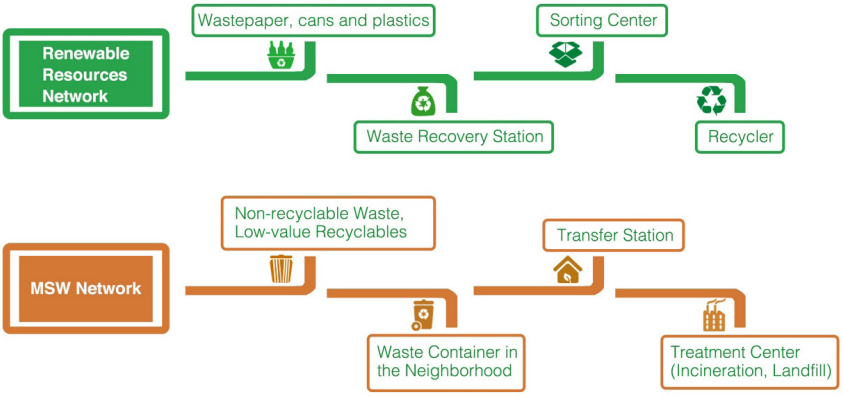

Figure 2. The Recycling System

The recycling of domestic waste plastics in China is mainly based on two systems, namely, the renewable resources recovery system, and the MSW collection and transport system (see Figure 2). For a long time, individual recoverers played the leading role in recovering renewable resources, as they collected wastes with economic value in a door-to-door manner. After being classified, the recovered wastes were purchased and further sorted by downstream recoverers, and then were sent to resource recyclers for processing and utilization. After several rounds of environmental rectification, transformation and upgrading, China's renewable resources industry is gradually evolving from family-run shops to large-scale enterprise clusters, and is transforming toward the model where upstream recovery outlets are set up by large companies. The MSW collection and transport system is run by the urban management department, and the MSW enters waste transfer stations through centralized collection and transport by the urban sanitation system. The transfer stations sorts valuable recyclables including waste plastics for a second time, and send the remaining garbage to the MSW treatment facility. At present, sanitary landfill and incineration are the main MSW treatment methods.

A large proportion of high-value recyclables will be taken by the resource recovery system before entering the waste collection and transport system, while the domestic garbage transported by the MSW collection and transport system is mainly low-value recyclables at present. Before the implementation of waste classification, recyclables with either high or low value in the mixed garbage are prone to pollution by organic waste, making it difficult for sorting centers to sort out waste plastics worth recycling. Most of the polluted waste plastics are directly sent to landfills or incineration facilities. Effective waste classification can separate residual waste from organic waste on the front end, and also enables more waste plastics worth recycling to be recycled.

The renewable resources recovery and MSW collection and transport systems have existed in parallel for a long time. However, the increase of MSW year by year has caused growing pressure on waste treatment, and the renewable resources industry is gradually changing into a community service industry. China's 13th Five-Year Plan (FYP) proposed to strengthen the connection between MSW classification and recovery and the recovery of renewable resources. Many Chinese cities have begun to include the integration of the two networks into their urban development plans, and to explore connections between the renewable resources industry chain and the MSW network, to increase the utilization of low-value recyclables as resources and reduce the burden of MWS treatment. The integration of the two networks is still being explored, but there have been successful cases in some areas, which effectively increase the utilization of wastes as

resources. The combination of the renewable resource recovery and MSW collection and transport systems will also be a trend of waste management in China in the future.

WASTE PLASTIC RECOVERY AND RECYCLING TECHNOLOGY LEVELS

Waste plastic recovery can be categorized into materials and energy recovery. As an international standard offering guidance for recovery, ISO 15270:2008 divide recovery technologies into four levels by priority (see Figure 3).

Levels I and II are physical recovery methods. As for Level I, waste plastics are processed into products identical or similar to new materials in terms of performance. This is what is commonly known as recovery to the same level, or closed-loop regeneration. Level II is about processing plastics waste into products with lower performance. Level III is chemical recovery, which makes chemical monomers or fuels with plastics waste. Level IV involves burning plastics waste to recover energy.[14] Physical recovery is the main method of recovering high-value plastics waste in China, and this waste is used depending on its ingredients. Table 4 details the real-world applications of regenerated particles from plastics waste recovery.

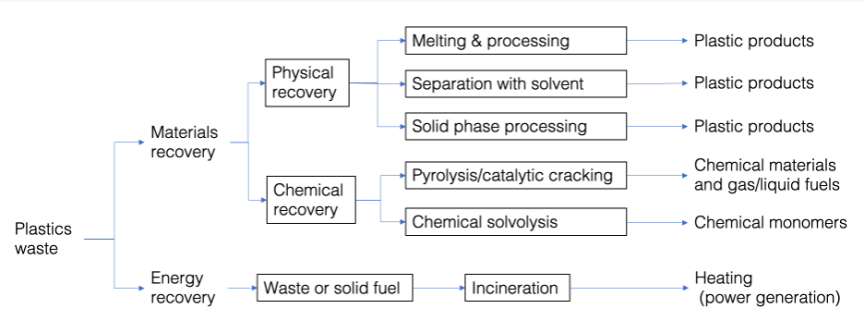

Figure 3. Plastics Waste Recovery and Recycling Technologies[15]

14 Wani K A, Ariana L, Zuber S M. Handbook of research on environmental and human health impacts of plastic pollution [M]Pennsylvania: IGI Global, 2020.

15 Qi, W. Shares overview (see Fig. 3). , Jinping, Q., Bi, S., Ning, C., Min, N. & Shuangqiao, Y. On China's plastics waste pollution management strategy [J].Strategic Study of CAE, 2021, 23 (01): 160-166.

TABLE 4. THE RECOVERY METHODS FOR AND USES OF PLASTICS OF DIFFERENT TYPES[16]

Type	Recovery Method	Status	Use
PE	Melting, granulation and regeneration; liquid fuel production by catalytic cracking; processing into wood-like composite materials	Industrial use	Regenerated PE granules can be used to produce agricultural films, plastic greenhouse materials, industrial packaging films, lactic acid beverage bottles, chemical fertilizer bags, garbage bags, regenerated agricultural water pipes, tree supports, barrels, geotechnical materials, etc.
PVC	Melting and granulation Vinyl chloride recovery by cracking	Industrial use Test	Plastic door and window profiles, pipes, building materials, etc.
PP	Extrusion molding; liquid fuel production by catalytic cracking Benzene, toluene and xylene production by heating decomposition	Industrial use	It can be used to manufacture buckets, trash cans, baskets and food containers for microwave ovens, woven bags, packing belts, ropes, etc., depending on its quality
PS	Crushing, granulation and regeneration; modified production of adhesives, quick-drying paints and waterproof coatings Styrene monomer production by pyrolysis	Industrial use	Used to make building materials, stationery, rollers, cups and boxes for drinks in fast food restaurants or disposable tableware
PET	Granulation and regeneration; dimethyl terephthalate production by ethylene glycol/methanol decomposition	Industrial use	Used to make Coke, Sprite and other beverage bottles, pillow cores, mattresses, sleeping bags, felt, etc.; glass fiber reinforced materials with good heat resistance and mechanical strength, which can be used to make automobile parts

16 Shuyan, Y., Lili, L. & Jinhui, L. Enhance plastics waste recovery to reduce environmental pollution [J]. World Environment, 2018 (05): 23-25.

2.2 RECYCLING

2.2.1 Plastics Recycling in China

Although all plastic materials are theoretically recyclable, only a portion of hard plastics such as plastic bottles and boxes can actually be recycled, while most soft plastics such as plastic films and bags are usually not sorted out for they need special equipment to avoid winding in the crushing process, and are far lower than hard plastics in terms of the economic benefits of recycling. Instead, soft plastics will be sent to incineration plants or landfills with other wastes. Given that China currently lacks direct statistics on plastics waste production, this paper estimates the annual production of waste plastics according to the annual outputs of plastic products from the previous versions of China Plastics Industry Yearbook in combination with the service life distribution function of different usage conditions (see Table 5). Overall, waste plastics production has a certain correlation with the output of plastic products three to five years ago.

TABLE 6 PLASTIC PRODUCT OUTPUTS AND PLASTICS WASTE PRODUCTION IN CHINA (IN MILLION TONS)

Year	Plastic Product Output Statistics	Est. Plastics Waste Production
2019	81.842	63
2018	60.4215	67.78
2017	75.1554	41.06
2016	72.675	42
2015	75.607	46
2014	74.858	40.2
2013	68.788	32.92
2012	57.303	34.13
2011	53.044	28.71

Source: Estimation of plastics waste production based on plastic product consumption in conjunction with the service life distribution function of plastic products

The renewable resources recovery system is the main path to recycling waste plastics, and includes waste plastics recoverers and recyclers. Today, small companies are being replaced by large ones, and the whole industry is growing in size and becoming increasingly standardized. In 2019, there were more than 3,000 companies registered in China which engaged

in waste plastic processing, and 300 of them were able to process over 10,000 tons of recycled plastics per year, including 50 companies each with an annual processing capacity of more than 50,000 tons.[17] There are recovery outlets across China able to recover more than six million tons of plastics waste per year. Large plastics recycling marketplaces and processing/distribution centers are mostly in the provinces of Zhejiang, Jiangsu, Shandong, Hebei and Liaoning, and are evolving into recovery and processing clusters with increasingly centralized transactions.

China's plastic recycling industry is also facing many problems though the increasing attention of the international and domestic communities to pollution from waste plastics has brought more opportunities for plastic recovery, recycling and regeneration. The local recovery system and waste plastics regulation remain imperfect, making it impossible for large plastic recyclers to obtain sufficient waste plastics. This has resulted in serious overcapacity. Excessive tax burden also reduces corporate profits and hinders the industry's growth. Although several environmentally compliant, large plastic recycling enterprises have emerged in the industry, non-compliant small ones have led to the unstable quality of recycled plastic products. The overall management in the industry has yet to be refined, and it is necessary to strengthen the standardization and information disclosure of product identification and raw material traceability. Some companies will indicate the proportions of recycled materials when using a mixture of primary and recycled materials to make plastic products. The term "PP-R-30," for example, means that 30 percent recycled PP materials were added. Nonetheless, the plastic products processing industry currently does not force the identification of the proportions of recycled plastics in plastic products, making it difficult for users to obtain detailed information on their types and shares.

17 The Department of Distribution Industry Development, the Ministry of Commerce (MOFCOM). Development Report of China Renewable Resources Recycling Industry 2018 [R]. Beijing: The Department of Distribution Industry Development, the MOFCOM. 2018.

2.2.2 Data on Main Types

Of all the types of waste plastics in 2019, PET saw the largest recovered amount at 6.3 million tons, including 4.22 million tons of waste PET bottles and 2.08 million tons of the other kinds of waste PET. It was followed by waste plastics from packaging films at 3.4 million tons and those from electric and electronic products at 1.5 million tons (see Figure 4).

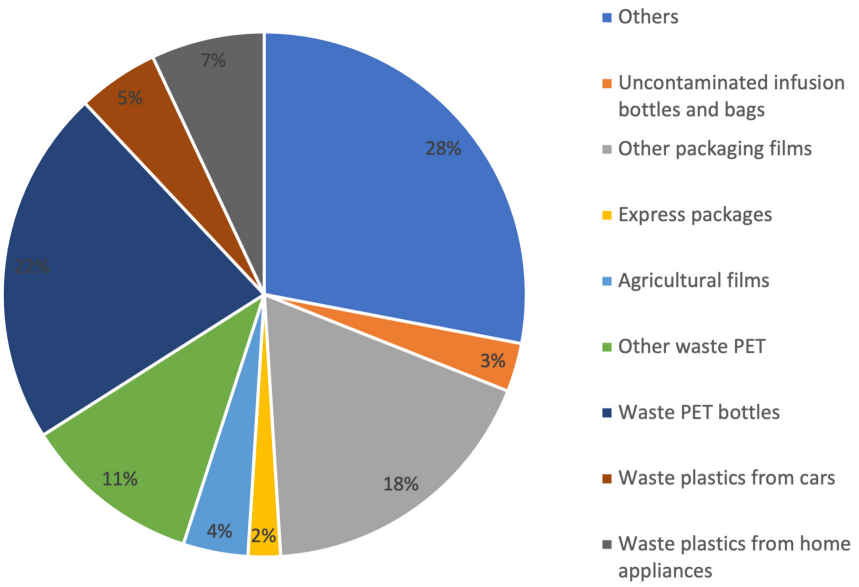

Figure 4. Shares of recovered waste plastics in China. Source: The Plastic Recycling Association of the CRRA

PET bottle recovery

The gross amount of PET bottles recovered across China in 2019[18] was 4.22 million tons. The recovery rate of PET bottles varies significantly from method to method. The average PET bottle recovery rate is 75 percent, according to statistics from the Plastic Recycling Association of the CRRA. That compares with over 94 percent estimated in the Report on PET Beverage Package Recycling in China published by the China Beverage Industry Association (CBIA).[19] Despite the lack of an exact recovery

18 It is generally difficult to remove water from PET during recovery. Generally, PET bottles with a water content less than six percent are acceptable in the recovery industry.

19 Weixing, X. The report on PET beverage package recycling in China: The PET bottle recovery rate is over 94 percent [J]. Beverage Industry, 2020, 23 (05): 78-79.

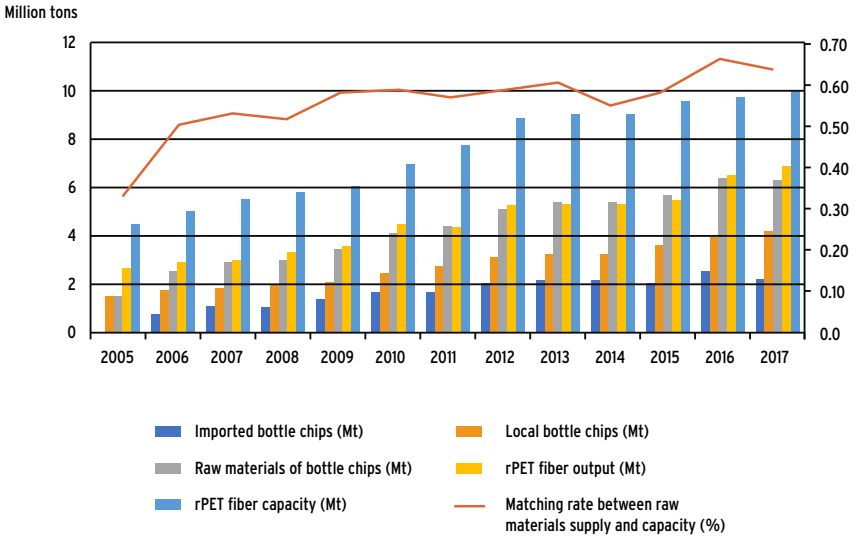

Figure 5. Raw materials supply vs. capacity in China's rPET industry, 2005-2017. Source: Ccfei.com, China Chemical Fibers Association (CCFA)

rate, it is indisputable that the recovery rate of PET bottles is higher than those of the other types of plastics waste. This is mainly attributable to the few types of products to be recovered, a relatively sound recovery system and a more mature downstream recycling industry.[20]

In 2017, materials recycled from waste PET bottles were the main raw materials of recycled chemical fibers, as they accounted for about 60 percent of the total production capacity (see Figure 5). China had the world's highest recycled chemical fiber production capacity at over 10 million tons in 2017, when it produced six million tons, or about 80 percent of the global annual production.[21]

Electronic waste

Electronic waste, also known as e-waste, refers to discarded electrical and electronic equipment that is no longer in use. Unlike ordinary MSW,

20 The Plastic Recycling Association of the CRRA. 2019-2020 Development Report of China Plastic Recycling Industry [R]. Beijing: The Plastic Recycling Association of the CRRA. 2020.

21 Li, A. Attention: The recycled chemical fiber industry is entering a strategic, new era of high-quality development [N]. China Strategic Emerging Industry. Dec. 12, 2018. http://www.chinasei.com.cn/ad/ad9/201901/t20190114_24394.html

electronic waste has complex ingredients and contains large amounts of metals such as gold, silver, copper, mercury, lead and cadmium, polychlorinated biphenyls (PCBs), halogen flame retardants, plastics and asbestos. If not handled properly, it may cause serious environmental pollution and ecological damage. Plastics are widely used in electrical and electronic products because of their light weight, stable chemical properties and ease of forming.

A total of 6.2 million tons of common types of e-waste were recovered across China in 2019, including 1.5 million tons of waste plastics, of which PS, PP, ABS and others accounted for 55 percent, 25 percent, 12 percent and eight percent respectively.[22]

As many as 100 million to 120 million home appliances are scrapped across China annually, and this number is growing by 20 percent per year on average. Plastics waste, in particular, account for nearly 40 percent of all materials recovered from scrapped appliances.[23] Using them as resources or reusing them to form a real closed-loop economy will become a trend in the future. Home appliances contain various plastics (see Figure 6). Considering plastics recycling in the early design stages of electric and electronic equipment can significantly increase the plastic recovery rate while reducing the difficulty of recycling. This includes carefully using additives and fillers, minimizing the use of dark pigments, composite or multilayer materials, etc.

22 The Plastic Recycling Association of the CRRA. 2019-2020 Development Report of China Plastic Recycling Industry [R]. Beijing: The Plastic Recycling Association of the CRRA. 2020.

23 Sen, C. On the applied technology for housing plastics from e-waste [D]. Southwest Jiaotong University, 2014.

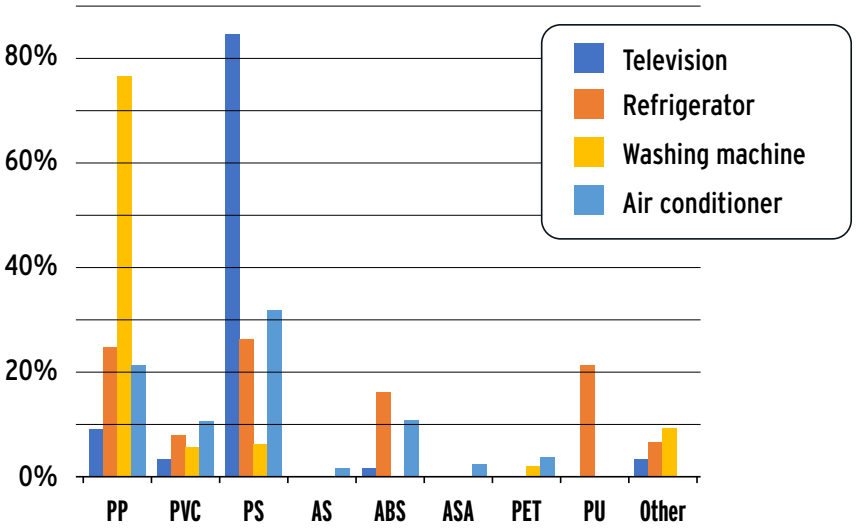

Figure 6. The proportions of plastics used in home appliance.[24]

2.2.3 Public Engagement in China's Plastic Recycling Market and Problems

Public participation in plastic recycling can be discussed in two parts. First, classify waste plastics for recovery to help improve the quality and recovery rate of waste plastics. Second, encourage the consumption of recycled plastic products to promote the growth of the market for recycled plastics.

Waste plastics recycling is gradually upgraded to become intelligent and automatic thanks to policy incentives, and intelligent PET bottle recovery equipment has become available in some cities, although self-employed individuals and scavengers will still dominate the recovery and sorting of high-value waste plastics in the short term. First of all, there are so many kinds of plastic materials that it is difficult for most consumers to

24 Ziya, X. On the compatibility between ABS and HIPS in housing plastics from e-waste [D]. Shanghai Polytechnic University, 2018.

distinguish them. The existing Resin Identification Codes (RICs)[25] on plastic products came into being in the mid and late 20th century, and are not enough to cope with waste generated in the highly developed plastic product industry. In addition, public participation and support for waste classification have much to do with community waste management. Residents' awareness of waste management, the accuracy of MSW classification and confidence in waste management have all improved in the past three years, according to "The report on urban residents' confidence index and awareness of MSW management 2020"[26] published by Vanke Foundation. Given the great differences between cities, however, community waste management still needs to be strengthened.

Regarding waste reuse, the research report pointed out that 78 percent of residents had said they would use products made of recycled materials. This also provides more markets for the resources reuse industry chain. When it comes to recycled plastic products, however, there are still many people who think of the plastic recycling industry as consisting of many small, ill-regulated companies which cause severe pollution. Public trust in and understanding of recycled plastic products also require more effective government guidance and education. It is also necessary to make the public realize that plastic recycling is a must-do for our transition from a linear economy to a circular economy and a demand for sustainable development.

25 An identification system which denotes a series of recyclable plastics, such as PET, high-density polyethylene (HDPE) and PVC, with the numbers 1 through 7 surrounded by "chasing arrows" in a triangular shape. Originally designed for plastic product recycling in the United States in the mid- and late 20th century, this system is no longer comprehensive enough to cover common plastics such as polycarbonate (PC), polyurethane (PU) and polyamide (PA), and a new plastic recycling standard is needed.

26 Vanke Foundation, Beijing Dataway Horizon Co., Ltd. The report on urban residents' confidence index and awareness of MSW management 2020 [R]. 2020. https://baijiahao.baidu.com/s?id=1690030384996806935&wfr=spider&for=pc

3. PUBLIC COSTS/EXPENSES

3.1 PLASTIC WASTE AS A PUBLIC BURDEN

High-value plastic waste will be treated by the resources recycling system because recycling can generate high profits. In contrast, more low-value plastic waste, such as different types of packaging waste arising from new industries such as e-commerce, express delivery services, and takeaway in more recent years, will largely remain part of MSW due to low profits from recycling. From a weight perspective, the current proportion of plastics in MSW is generally close to 15 percent, or even nearly 20 percent in first-tier cities.[27, 28] Correspondingly, the costs of plastic waste collection, transport, and disposal are equivalent to 15-20 percent of the costs of MSW collection, transport, and disposal.

3.2 PUBLIC HEALTH COSTS FROM PLASTIC WASTE

The public health costs caused by plastic waste pollution can be discussed from three aspects:

- Environmental pollution caused incineration and landfilling;
- Pollution resulting from entering the environment due to ineffective collection and transport management;
- Human health risks arising from excessive pollutants, such as heavy metals, in recycled plastic products due to ineffective regulation on the front end.

First, the current main waste treatment methods in China are landfill and incineration. In 2019, for example, MSW buried and incinerated in Chinese cities and counties accounted for 52 percent and 44 percent of all such waste respectively.[29, 30] Studies have shown that pollutants such as hydrogen chloride (HCl), heavy metals, and polycyclic aromatic hydrocarbons (PAHs) as well as persistent organic pollutants (POPs) such as polychlorinated dibenzodioxins and polychlorinated dibenzofurans (PCDD/

27 Rong, F., Zhiqiang, G., Guoguang, X. & Tianfeng, W. Composition and calorific value analysis of domestic waste in an eastern Chinese city. Guangdong Chemical Industry 40–41 (2018).
28 Na, Y., Liming, S. & Pinjing, H. Analysis of the water contents of MSW ingredients in China and their characteristics. China Environmental Science 26, 90-102 (2018).
29 The Ministry of Housing and Urban-Rural Development (MOHURD): China Urban Construction Statistical Yearbook 2019, Dec. 31, 2020.
30 MOHURD: China Urban Construction Statistical Yearbook 2019, Dec. 31, 2020.

DF), PCBs, polybrominated diphenyl ethers (PBDEs) and hexabromocyclododecanes (HBCDs) will be released during plastic waste incineration.[31, 32, 33] Of these pollutants, only HCl, heavy metals, and PCDD/DF are included in the current pollution control standards for incineration of domestic, medical, and hazardous wastes in China, that is, PAHs, PCBs, PBDEs, and HBCDs are left unregulated.[34, 35, 36]

To improve the performance of plastic products, many additives, such as perfluorinated compounds (PFCs), phthalates, and PBDEs, are used in their production. Landfills are important sources and sinks for these additives. Studies have shown that China is the country with the highest concentration of PFCs in leachate reported in the literature,[37] for example. If they are volatile or semi-volatile, these pollutants can enter the atmospheric environment through volatilization or along with the gas production process during landfill, causing air pollution over the landfill site or even in areas far from it. Once they enter the leachate, they may flow and migrate into the nearby surface water and groundwater, and then cause extensive secondary pollution. After volatilization into the atmosphere and migration into the water environment, they can appear in the soil environment near the landfill site through atmospheric dry and wet deposition and vertical upward migration with groundwater.
Second, the leakage of waste plastics must not be ignored. On the one hand, coastal farming and beach waste from tourism has brought about 20,000 tons of marine plastic pollutant leakage in China every year. On the other hand, agricultural films and plastic pesticide bottles are widely used in agricultural activities, and more than half of the plastic wastes generated cannot be effectively recycled. Given that agricultural films are difficult to recycle and offer low added value, few scavengers or recoverers are willing to recover them. Every year, about 400,000 tons of land-based agricultural plastic wastes enter soils across China, which not only pol-

31 Xuefeng, Y., Xiaodong, L., Jiansong, L., Shengyong, L., Yueling, G., Jianhua, Y., Mingjiang, N. & Kefa, C. The effects of incineration methods on PAHs and PCDD/Fs emissions during plastics waste incineration [J]. Journal of Combustion Science and Technology, 2008, {4} (05): 436-440.

32 Ting, M. & Hui, Z. The overview of PBDE and HBCD emissions during the incineration of post-consumer plastic waste [J]. Environmental Science and Technology, 2016, 39 (03): 170-175+181.

33 Vejerano E P, Holder A L, Marr L C. Emissions of polycyclic aromatic hydrocarbons, polychlorinated dibenzo-p-dioxins, and dibenzofurans from incineration of nanomaterials [J]. Environmental Science and Technology, 2013, 47(9): 4866-4874.

34 The Ministry of Environmental Protection (MEP) & the General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ): The Pollution Control Standard for Domestic Waste Incineration (GB 18485-2014), May 16, 2014.

35 The Ministry of Ecology and Environmental (MEE) & the State Administration for Market Regulation (SAMR): The Pollution Control Standard for Medical Waste Treatment and Disposal (GB 39707-2020), Nov. 26, 2020.

36 MEE & SAMR: The Pollution Control Standard for Hazardous Waste Incineration (GB 18484-2020), Nov. 26, 2020.

37 YAN H, COUSINS I T, ZHANG C, et al. Perfluoroalkyl acids in municipal landfill leachates from China: Occurrence, fate during leachate treatment and potential impact on groundwater [J]. Science of the Total Environment, 2015, 524-525: 23-31.

lutes the environment but also causes soil hardening, resulting in crop reduction as well as direct and indirect financial losses.[38]

Third, the supply chain of the plastics recycling industry currently lacks traceability regulation, standardization, and management, and the sources of waste cannot be completely controlled, which also leads to potential safety risks associated with recycled plastics. Brominated flame retardants have been detected in toys made of recycled plastics in the EU and China, for example. Such problems do not just have potential health impacts, but make it even more difficult to popularize compliant safe recycled materials.[39, 40, 41, 42, 43]

38 Figures in this paragraph were from calculations of the School of Environment, Tsinghua University.
39 DiGangi, J. and J. Strakova, Recycling of plastics containing brominated flame retardants leads to contamination of plastic childrens toys. Organohalog Compd, 2016. 78(2016): p. 9-11.
40 Petrlík, J., et al., Toxic Soup - Dioxins in Plastic Toys. 2018, Arnika, IPEN, HEAL, BUND: Berlin, Brussels, Prague, Gothenburg. p. 28.
41 Rensheng, L., Qifei, H., Yufei, Y., Zhenwu, T., Shulei, T., Jie, H. & Feng, L. Pollution characterization of PBDEs in plastic products for daily use and the resulting human exposure risks [J]. Research of Environmental Sciences, 2015, 28 (01): 74-81.
42 Duoduo, L. & Guiyan, S. Simultaneous measurement of the contents of 15 PBDEs in plastic products using the GC-MS/MS method [J]. Modern Chemical Industry, 2019, 39 (12): 237-242+247.
43 Yanjun, Z. Measurement of the contents of 18 PBDEs in plastic products using the GC-MS/MS method [J]. Plastics Science and Technology, 2019, 47 (11): 134-139.

4. PUBLIC POLICIES CONCERNING PLASTIC

4.1 CHINA'S PLASTIC POLLUTION MANAGEMENT POLICIES

China has released and implemented a series of policies and regulations on plastic pollution management in recent years. The most recent ones are represented by the Opinions on Further Strengthening Plastic Pollution Management officially released in 2020. It is primarily characterized by orderly conducting plastic pollution management by region, time, and industry. This document marks a new stage of more stringent plastic pollution management across China and will be followed by supportive, specific policies and programs (see Table 7).

TABLE 7

Time	Policy	Purpose
Jun. 2008	The Chinese government issued the Circular on Restrictions on the Production and Sale of Plastic Shopping Bags (the Restrictions on Plastics), which requires that free plastic bags be not provided and that the recycling rate of waste plastics be raised.	As China's very first specific measures introduced to manage the pollution of plastic products, it has led to plastic bag consumption reduction by more than one million tons. Nonetheless, it specifies few management targets and lacks a sustainable updating mechanism.
Aug. 2008	The State Council, or China's cabinet, announced the Administrative Regulations on Waste Electrical and Electronic Product Recovery and Treatment, which was put on trial from Jan. 1, 2011, and revised in Mar. 2019.	The Extended Producer Responsibility (EPR) was first introduced into the fields of appliances and electronics to promote the comprehensive utilization of resources and the growth of a circular economy.
Dec. 2016	The State Council issued the Circular on Releasing the Extended Producer Responsibility Implementation Plan, covering paper-based composite packaging products for appliances, electronics and beverages.	The EPR was further implemented.

Time	Policy	Purpose
2017-2019	The Implementation Program for Banning Waste Import and Promoting the Reforming of the Solid Waste Import Management System was introduced in 2017.	Given the environmental impact of the imported waste plastics, the Chinese government will no longer allow waste import. After this policy was introduced, the waste plastic import into China sharply dropped to 76,000 tons with 99% year-on-year reduction in 2018.
Feb. 2019	With a typical island ecosystem, Hainan Province released the Implementation Program of Hainan Province for Comprehensively Banning the Production, Sale and Use of Disposable, Non-degradable Plastic Products, with a list of the banned products. It requires to stop the production, sale and use of all the listed products across the province by the end of 2020.	This policy can be regarded as the forerunner of similar policies in China.
May 2019	The pilot Waste-free Cities project was launched across the board.	This pilot project focuses on solid waste management where there have long been management gaps. Waste plastic recycling, in particular, has been covered in numerous cities involved in this project.
Jun. 2019	China's nine ministries such as the MOHURD jointly released the Circular on Implementing Comprehensive Domestic Waste Classification in Cities at the Prefecture and Higher Levels, making it clear that a domestic waste classification and treatment system will be phased in for each of these cities, or nearly all the medium- and large-sized Chinese cities.	With the roll-out of the domestic waste classification system and the separation of kitchen garbage from the recyclable, the local conditions for recovering common things in daily life such as waste plastic will be significantly improved.
Jan. 2020	The National Development and Reform Commission (NDRC) and the MEP jointly and officially released the Opinions on Further Strengthening Plastic Pollution Management.	This document marks a new stage of more stringent plastic pollution management across China, and will be followed by supportive, specific policies and programs.

Time	Policy	Purpose
Apr. 2020	To promote the implementation of the Opinions on Further Strengthening Plastic Pollution Management, the NDRC worked with other relevant authorities to conduct the drafting of the Catalog of Plastic Products of Which the Production, Sale and Use Will Be Banned or Restricted (the Version for Comments) to publicly seek advice.	The catalog for Phase I has been worked out. It was also made clear that, as a dynamic updating mechanism, it will offer updates from time to time.
Apr. 2020	The amended Law of the People's Republic of China on the Prevention and Control of Environmental Pollution by Solid Wastes was enacted at the Seventeenth Session of the Standing Committee of the Thirteenth National People's Congress. Effective from Sept. 1, 2020, it includes provisions on banning or restricting the production, sale, and use of disposable, non-degradable plastic bags.	With the inclusion of plastic pollution management into legal provisions, waste plastic product management is legally supported.
Jul. 2020	China's nine ministries such as the NDRC co-released the Circular on Effectively Promoting Plastic Pollution Management to monitor local governments' efforts in developing local feasibility plans for the implementation of this document.	Local efforts have been made to effectively promote plastic pollution prevention and control since the COVID-19 pandemic broke out, to meet the targets for 2020 specified in the Opinions on Further Strengthening Plastic Pollution Management.
2019-2020	The following standards relevant to waste plastic recovery and treatment were announced: GB/T 37547-2019 Waste Plastic Classification and Coding GB/T 37821-2019 Technical Specification for Recycling Waste Plastics GB/T 39171-2020 Technical Specification for Recovering Waste Plastics	They aim to regulate plastic recycling

TABLE 8 NATIONAL STANDARDS AND REQUIREMENTS FOR PLASTIC PRODUCTS

Applicability	Regulations and Standards
Common plastic products	GB/T 37866-2019 Green Product Assessment: Plastic Products
Plastic materials to which foods are exposed	GB 4806.1-2016 General Safety Requirements for Materials to Which Foods Are Exposed and Relevant Products
	GB 4806.6-2016 Plastic Resins to Which Foods Are Exposed
	GB 4806.7-2016 Plastic Materials to Which Foods Are Exposed and Their Products
	GB 4806.11-2016 Rubber Materials to Which Foods Are Exposed and Their Products
	GB 9685-2016 Standards for the Use of Materials to Which Foods Are Exposed and Additives for Their Products
Infant feeding bottles	GB 28482 Safety Requirements for Infant Pacifiers
	The Announcement of the Ministry of Health and Five Other Authorities on Prohibiting the Use of Bisphenol A in Infant Feeding Bottles (No. 15 of 2011)
Children's plastic toys	GB 6675.1-2014 Part 1 of Toy Safety: Basic Requirements
Stationery for students	GB 21027-2020 General Safety Requirements for Student Supplies
	T CSSGA 1001-2017 Book Films and Covers
	T CSSGA 1002-2017 Erasers
Clothes	GB 18401-2010 National Basic Safety Technical Code for Textile Products
	GB 31701-2015 Safety Technical Code for Textile Products for Infants and Children
	GB 30585-2014 Safety Technical Code for Children's Shoes
Plastic furniture	GB 28481-2012 Limits of Harmful Substances in Plastic Furniture
Recycled plastic products	GB/T 40006.1-2021 Plastics - Recycled Plastics - Part 1: General Principles
	GB/T 40006.2-2021 Plastics - Recycled Plastics - Part 2: PE Materials
	GB/T 40006.3-2021 Plastics - Recycled Plastics - Part 3: PP Materials

4.2 STANDARD LIMITS RELATED TO PLASTIC CONSUMER PRODUCTS

Plastic is an important basic material widely used in production and life. Non-compliant production, use, and disposal of plastic products will cause resources and energy wastage, bring about environmental pollution, and even threaten public health and safety. On January 16, 2020, The NDRC and the MEE jointly issued the Opinions on Further Strengthening Plastic Pollution Management, proposing to increase the supply of green products while requiring plastic product manufacturers to make plastic products that meet relevant standards in strict accordance with the governing laws and regulations and to not use non-compliant chemical additives harmful to human health and the environment (see Table 8).

4.3 INTERNATIONAL CONVENTIONS ON PLASTIC POLLUTION MANAGEMENT AND CHINA'S ACTION

In August 2017, the former MEP took the lead in adjusting the Catalogue of Solid Wastes Whose Import Is Prohibited by adding four types of solid wastes, namely, plastic wastes from domestic sources, unsorted waste paper, waste textile raw materials, and vanadium slag, which were previously restricted from import, with notification to the World Trade Organization (WTO) according to legal procedures.[44] This ban has since produced a series of impacts on the international waste trade. Large amounts of solid waste have been piled up in many developed countries. Now that it is difficult for local companies to cope with such waste and environmental costs have increased sharply, these countries, which used to rely heavily on waste export, have taken measures to promote waste reduction and recycling, and at the same time are shipping the waste to developing countries, especially those in Southeast Asia and Africa.

In September 2018, Norway first proposed an amendment to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (hereinafter referred to as the Basel Convention),[45] in an attempt to delete entry B3010 Solid Plastic Waste from Annex IX of the Convention.

In 2019, the Conference of the Parties (COP) adopted a plastic waste-relevant amendment to the Basel Convention, which included non-recyclable and contaminated plastic waste into what is controlled under the Conven-

44 MEP, MOFCOM, NDRC, the General Administration of Customs (the Customs) and AQSIQ: The Circular on Releasing the Catalog of Waste Import Management 2017, Circular 2017 No. 39.

45 Bingyu, L. A milestone in regulating the transboundary movements of plastics waste: The impact of the amendment to the Basel Convention [J]. Business and Economic Law Review, 2020, {4} (02): 47-59.

tion and took effect on January 1, 2021. The state parties should accordingly take measures such as source reduction, environmentally sound management, and transboundary movement control. With the insistence and efforts of the Chinese delegation during the negotiations, statements similar to "The Parties may have stricter requirements" and "The import of plastic wastes can refer to and follow relevant international and national technical documents" were written into the annexes of the Convention. In other words, the Parties have the right to determine whether to ban the import of such wastes or not according to their conditions.[46]

At the same time, the 2019 COP adopted decision BC-14/13 on further actions to address plastic waste under the Basel Convention, which put forward a global management plan for plastic waste from the perspective of the whole life cycle, including green design and production of plastic products, control over transboundary movements of plastic waste, environmentally sound management and others. Relevant resolutions under the Basel Convention have brought global plastic waste control into the stage of implementation, and a global framework for preventing and controlling plastic waste pollution has been fundamentally established.[47]

From the Restrictions on Plastics[48] released in 2007 to the ban on waste import in 2017, China has been paying close attention to plastic pollution. In 2017, the State Council launched the EPR implementation plan aiming to promote a transition toward circular economy in four industries including beverage packaging covering all stages of the product lifecycle ranging from product design to recycling.[49] In January 2020, the NDRC and the MEE jointly released the Opinions on Further Strengthening Plastic Pollution Management (hereinafter referred to as the New Restrictions on Plastics),[50] to further prohibit or restrict the production, sale and use of certain plastic products, and to regulate the recycling and disposal of plastics waste. Unlike the previous regulations focusing on individual aspects and fields, the policies and measures included in the New Restrictions on Plastics cover nearly all processes and dimensions relevant to plastic products such as manufacturing, distribution, use, recovery, and disposal, reflecting the systematic nature and integrity of product lifecycle management (PLM). This is conducive to establishing a long-term mechanism for managing plastic pollution.

46 The record of a routine press conference of the MEE in May 2019, MEE, May 29, 2019.
47 Jinhui, L. It is time for global cooperation on strengthening plastic pollution management [N]. China Environment News, Sept. 1, 2020 (003).
48 The Circular of the General Office of the State Council on Restrictions on the Production and Sale of Plastic Shopping Bags, GBF [2007] No. 72.
49 The Circular of the General Office of the State Council on Releasing the Extended Producer Responsibility Implementation Plan, GBF [2016] No. 99.
50 The Opinions on Further Strengthening Plastic Pollution Management, FGHZ [2020] No. 80.

The focus of attention should be on the fact that, for the first time, the New Restrictions on Plastics put forward the requirement of strengthening control over toxic and harmful plastic additives. It stipulates that plastic product manufacturers should work in strict accordance with the governing laws and regulations to make plastic products that meet relevant standards and that they must not use any chemical additives harmful to human health or the environment.

Of the many chemical additives, short-chained chlorinated paraffins (SCCPs), hexabromocyclododecane (HBCD), PBDEs, per- and polyfluoroalkyl substances (PFAS), etc., are internationally recognized POPs. Listed in Annex A or B to the Stockholm Convention on Persistent Organic Pollutants (hereinafter referred to as the Stockholm Convention), they are required to be prohibited, eliminated or strictly restricted.

Regarding the chemicals listed in Annex A or B to the Stockholm Convention that can be used as plastic additives, as shown in Table 9, China has banned the production, distribution, use, import and export of tetrabromodiphenyl ether (TeBDE), pentabromodiphenyl ether (PeBDE), hexabromodiphenyl ether (HexaBDE) and heptabromodiphenyl ether (HeptaBDE),[51] and prohibited the production, distribution, use, import and export of perfluorooctane sulfonate (PFOS), its salts and perfluorooctane sulfonyl fluoride (PFOSF) except for specific exemptions and acceptable purposes (see the relevant annex).[52] Also, the production, use, import, and export of HBCD will be completely banned from December 26, 2021.[53]

SCCPs, PFOS, its salts and PFOSF, HBCD, decabromodiphenyl ether (DecaBDE)[54] as well as PFOA, its salts and relevant compounds[55] have been included in the List of Chemicals Prioritized for Control; SCCPs,

51 MEP, the Ministry of Foreign Affairs (MFA), NDRC, the Ministry of Science and Technology (MOST), the Ministry of Industry and Information Technology (MIIT), MOHURD, the Ministry of Agriculture (MOA), MOFCOM, the National Health and Family Planning Commission (NHFPC), the Customs, AQSIQ and the State Administration of Work Safety (SAWS): The Circular on the Entry into Force of the Amendments to Annexes A, B and C Intended to Add Nine Types of Persistent Organic Pollutants to the Stockholm Convention on Persistent Organic Pollutants and the Amendment to Annex A Intended to Add Endosulfan (Circular 2014 No. 21), Mar. 25, 2014.

52 MEE, MFA, NDRC, MOST, MIIT, MOHURD, the Ministry of Agriculture and Rural Affairs (MOARA), MOFCOM, the National Health Commission (NHC), the Ministry of Emergency Management (MEM), the Customs and SAMR: The Circular on Prohibiting the Production, Distribution, Use, Import and Export of Persistent Organic Pollutants such as Lindane (Circular 2019 No.10), Mar. 4, 2019.

53 The General Offices of MEE, MIIT, MOHURD and SAMR: The Notice on the Implementation of the Ban on the Production and Use of Hexabromocyclododecane under the Stockholm Convention on Persistent Organic Pollutants (HBGTH [2021] No. 237), Jun. 4, 2021.

54 MEP, MIIT and NHFPC: The Circular on Releasing the Catalog of Chemicals Prioritized for Control (Batch 1) (Circular 2017 No. 83), Dec. 27, 2017.

55 MEE, MIIT and NHC: The Circular on Releasing the Catalog of Chemicals Prioritized for Control (Batch 2) (Circular 2020 No. 47), Oct. 30, 2020.

PFOS, its salts and PFOSF, and HBCD have been listed into Catalog of Toxic Chemicals Strictly Restricted from Import and Export in China (2020);[56] TeBDE, PeBDE, HexaBDE, and HeptaBDE have been included into the Catalog of Products Prohibited from Export (Batch 6) and the Catalog of Products Prohibited from Import (Batch 7).[57]

TABLE 9

No.	Chemicals	Effective Date in China	Implementation Plan	Elimination Status	The Catalog of Toxic Chemicals Prioritized for Control	The Catalog of Strictly Restricted Toxic and Hazardous Chemicals (2020)	The Catalog of Products Prohibited from Import	The Catalog of Products Prohibited from Export
1	PFOS, its salts and PFOSF	Mar. 26, 2014	Supplement Plan released on Dec. 17, 2018	Production, distribution, use, import, and export are banned except for acceptable purposes.	√	√		
2	HexaBDE and heptaBDE	Mar. 26, 2014		Fully eliminated			√	√
3	TeBDE and PeBDE	Mar. 26, 2014		Fully eliminated			√	√
4	HBCD	Dec.26, 2016		To be fully eliminated by Dec. 26, 2021	√	√		
5	BDE-209	Yet to take effect			√			
6	SCCPs				√	√		
7	PFOA, its salts and PFOA-related compounds				√			

56 MEE, MOFCOM and the Customs: The Circular on Releasing the Catalog of Strictly Restricted Toxic Chemicals in China (Circular 2019 No. 60), Dec. 30, 2019.

57 MOFCOM, the Customs and MEE: The Catalog of Products Prohibited from Import (Batch 7) and the Catalog of Products Prohibited from Export (Batch 6) (MOFCOM Circular 2020 No. 73), Dec. 30, 2020.

ANNEX - ACCEPTABLE PURPOSES FOR PFOS, ITS SALTS AND PFOSF

The acceptable purposes on PFOS, its salts and PFOSF pursuant to the Stockholm Convention include:

- Photo-imaging;
- Photo-resist and anti-reflective coatings for semiconductors;
- Etching agent for compound semiconductors and ceramic filters;
- Aviation hydraulic fluids;
- Metal plating (hard metal plating) only in closed-loop systems;
- Certain medical devices (such as ethylene tetrafluoroethylene copolymer (ETFE) layers and radio-opaque ETFE production, in-vitro diagnostic medical devices, and CCD colour filters);
- Fire-fighting foam.

Except for the POPs, in China, BPA is restricted from polycarbonate baby feeding bottles and other infant feeding bottles since 2011. According to GB 9685-2016 "National Food Safety Standard for the Use of Additives for Food Contact Materials and Products", when bisphenol A is used as an additive in adhesives and paint coatings, its specific migration limit (SML) is 0.6 mg/kg, when bisphenol S is used as an additive in paint coatings, its SML is 0.05 mg/kg.

Announcement of the National Development and Reform Commission on the public solicitation of opinions and suggestions on the revision of the "Recycling Economy Promotion Law of the People's Republic of China"

4.4 CONCLUSIONS AND RECOMMENDATIONS FOR THE GOVERNMENT

If no action is taken, China's plastic production and plastic waste will continue growing. The destination of plastic waste is still mainly incineration and landfill, with some leakage into the ocean and soil, and only a small portion and a single category of plastic can enter the recycling system. However, the existing recycling industry in China suffers from overcapacity and inconsistent quality of recycled products. In addition, the additives used by the plastics industry pose environmental and health risks throughout the life cycle of plastics, whether they are manufactured, used, recycled, leaked into the environment, or disposed of in landfills or incinerators.

The existing plastic pollution management policies and control measures for additives have not yet been able to reduce the amount of plastic waste, increase the amount of plastic recycling and the quality of recycled products, nor can they fully guarantee the safety of plastic products. Therefore, we propose the following recommendations.

1. Control the total amount of plastic products, especially single-use plastics.

2. Consider plastic recycling and reclamation at the early stage of product design, such as careful use of toxic and harmful additives, choosing a single material, reducing the use of non-recyclable and hard-to-recycle materials, avoiding the use of dark pigments that cannot be sorted by machines, etc.

3. Implement measures to ban additives such as perfluorinated compounds, brominated flame retardants, and short-chained chlorinated paraffins that are persistent organic pollutants.

4. Ensure that the quality of products with limited use of additives is qualified.

5. Incorporate disposable plastic packaging manufacturers into the extended producer responsibility system and increase the recycling rate.

6. Pilot programs for recycling plastic agricultural film, pesticide bottles, and waste fishing nets to reduce the leakage of plastic garbage.

7. Establish a quality certification system for recycled products to improve the quality of recycled products and increase public acceptance.

8. Establish a tracking system for plastic products to control the whereabouts of plastic waste.

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