

ENVIRONMENTAL BURDEN OF THE TREATMENT OF HANDLING RESIDUE ARISING FROM THE RECYCLING PROCESS

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SUMMARY: In Japan, recycling has been actively engaged in an effort to decrease the environmental burden and conserve resources. However, this activity has generated handling residue of approximately 20 to 50 percent in the process of recycling. There are a great many organic materials in the handling residue. These materials are mainly incinerated. Therefore, there is a discharge of carbon dioxide in the process of residue treatment. In this study, we estimated the emission of carbon dioxide caused by the incineration of handling residue. The emission of carbon dioxide was found to be about 1.52 Gg-CO₂/year in 2004. This number corresponds to approximately 7 percent of total emission (23.1 Gg-CO₂/year) in the waste treatment category of Japan, and is likely to have a significant impact on global warming.

1. INTRODUCTION

From FY1983 to FY1990, the amount of municipal waste generated in Japan increased rapidly. As a result, The waste Management Law was revised in 1991 to add measures for both waste reduction and to reinforce the responsibility of stakeholders. Like municipal waste, the amount of industrial waste generated increased rapidly until FY1990. Since then, it has seen no major fluctuations, hovering around the 400 million ton level per year. Having experienced waste-related crises, Japan has reinforced its policy measures toward tackling waste issues. As it proceeds in this direction, Japan has developed a policy to strengthen its “3R” (recycle, reduce and reuse) framework over the past dozen years. It has done so by seeing waste not simply as things to be disposed of, but rather as a potentially valuable resource. In this way, Japan is steadily implementing approaches toward the establishment of a “Sound Material-Cycle Society (SMS)” with “circulating resources (CRs)”, such as waste that can be properly utilized once properly treated.

The concept of extended producer responsibility is clearly stated in the Fundamental Law for Establishing a Sound Material-Cycle Society (Ministry of the Environment Government of Japan(1)). Based on this and other, related concepts, Japan is in the process of establishing recycling

systems for containers and packaging, household appliances, construction materials, food and vehicles, corresponding to the particular requirements of each product. However, in taking these steps, it has generated handling residue of 20 to 50 percent in the process of recycling. There are organic materials in the handling residue, and these materials are mainly incinerated. Therefore, there is the discharge of carbon dioxide in the process of residue treatment. In this study, we estimated the emission of carbon dioxide caused by incineration of this handling residue.

2. RECYCLING SYSTEMS IN JAPAN

2.1 The Law for the Promotion of the Sorted Collection and Recycling of Containers and Packaging

“Containers and packaging” refers to bottles, cans, PET bottles and other forms of product containers and packaging that is not needed after the product is consumed. Such containers and packaging account for approximately 60 percent of all household waste in terms of volume and approximately 20 percent in terms of weight. Aiming to reduce the waste comprised of these containers and packaging and to promote their effective use as recyclable resources, the Containers and Packaging Recycling Law was enacted in 1995. Efforts are currently underway to build a system for appropriate sorted collection of such containers and packaging, as well as their recycling.

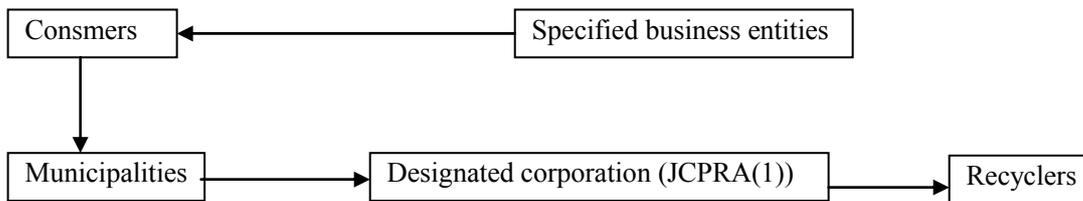


Figure 1. Recycling system for containers and packaging in Japan

2.2 The Law for the Recycling of Specified Kinds of Home Appliances

The Law for Recycling of Specified Kinds of Home appliances was enacted in June of 1998. In order to reduce household appliance waste and contribute to the effective use of resources, this law requires manufacturers and others to engage in recycling that meets or exceeds certain specified standards for four designated items: air conditioners, televisions, refrigerators and freezers, and washing machines. In addition, the law establishes a division of roles under which retailers are obliged receive these four types of appliances from consumers (waste generators) and to pass them back to the manufacturers, while consumers are obliged to pay recycling fees when they discard such items.

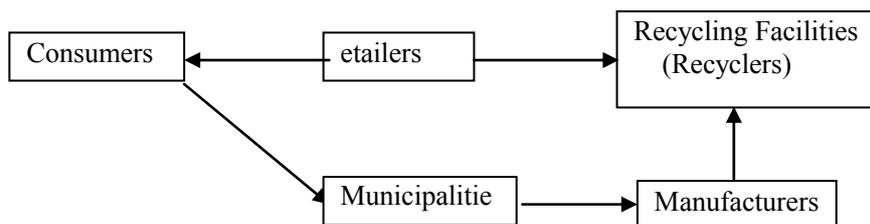


Figure 2. Recycling system for specified kinds of home appliance in Japan

2.3 The Law for the Recycling of End-of-Life Vehicles

Illegal dumping of end-of-life vehicles is occurring with considerable frequency due to the skyrocketing cost of disposing of the remnant materials that are generated during the process of the treatment of the vehicles. Such dumping is becoming a major social problem. To address this problem, the Law for the Recycling of End-of-Life Vehicles was enacted in July 2002.

The law requires vehicle manufacturers and importers to recycle Freon, airbags and remnant materials (destruction in case of Freon). Moreover, as recycling goals, the law establishes that the remnant materials recycling rate shall be over 70 percent and the airbag recycling rate over 85 percent by 2015.

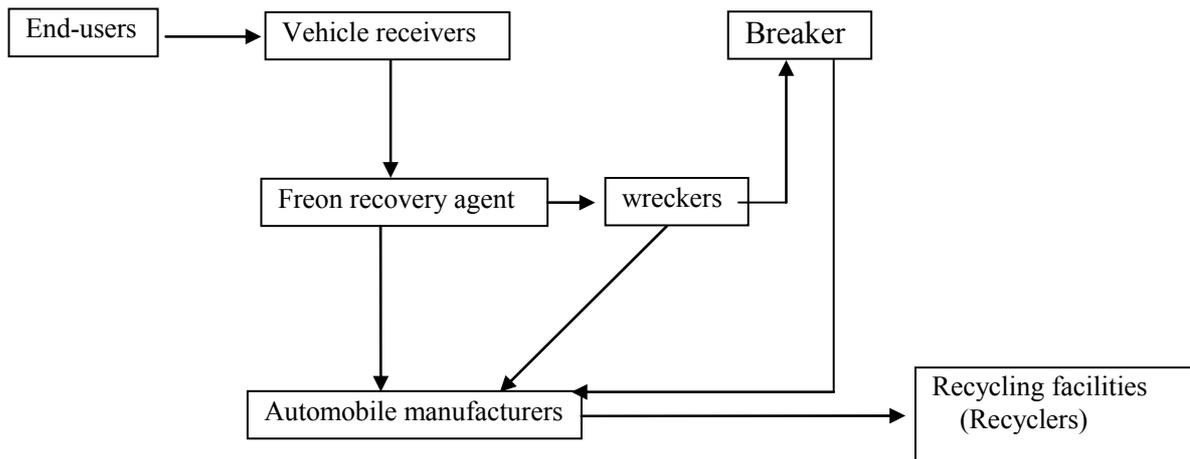


Figure 3. Recycling system for end-of-life vehicles in Japan

3. HANDLING RESIDUE GENERATED IN THE PROCESS OF RECYCLING

Wasted products generated through manufacture, distribution and consumption are collected by municipalities first, and then recycled at recycling Facilities after sorting. As shown in Figure 4, handling residue is generated in the course of both sorting and recycling.

In this study, we discussed handling residue generated by both sorting and recycling.

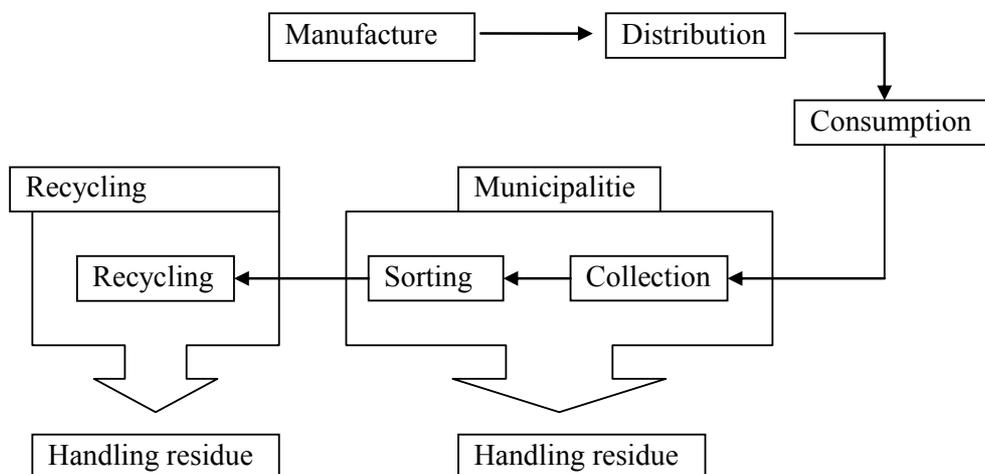


Figure 4. Handling residue which developed in the process of sorting and recycling

3.1 Generated residue at the sorting facilities

The sorting of PET bottles is mainly conducted by hand, therefore, the residue tends to be of lesser volume. The composition of residue is mostly organic materials such as plastic films, dirty PET bottles, bottles cap and so on. In the case of glass bottles, the residue is contained in pieces of glass, dirty bottles, small size bottles with caps and the like. These residues are treated as noncombustible.

The discharge rate of the residue in the process of PET bottle sorting varies from one collection system to another, and ranges from about 10 to 20 percent.

3.2 Generated residue in the recycling facilities

3.2.1 Materials concerned with the law for the promotion of the sorted collection and recycling of containers and packaging

The residue from PET bottles and plastic containers is especially high and hence a subject of the law. According to the FY 2004 statistics data of JCPRA, the residue from PET bottles recycling was about 44,029 tons a year. The residue of plastic containers was also about 234,000 tons a year. These residues were mostly organic materials such as waste plastics, and the disposal of these was carried out by combustion and/or landfill.

3.2.2 Waste appliances concerned with the law for the recycling of specified kinds of home appliances

The residue from refrigerators and washing machines is especially high and subject to the law. The rate of residue in refrigerator recycling is about 40 percent, and 40 percent also for washing machine recycling. Almost all of these residues was in the form of waste plastics, which were incinerated.

3.2.3 Materials concerned with the law for the recycling of end-of-life vehicles

It is estimated that the amount of car waste generated in 2004 was approximately 5 million-cars per year. About 4 million of these cars were demolished and crushed. As a result, it is estimated that the amount of Automobile-shredder-refuse (ASR) generated is approximately 1.2 million tons per year in Japan. Most of this ASR was incinerated by combustion equipment. There are great deal of sand and glass contained in ASR. The rate of incinerated residue was about 40 percent (approximately 0.5 million tons) a year.

4. THE EMISSION OF CARBON DIOXIDE CAUSED BY THE INCINERATION OF HANDLING RESIDUE

4.1 Generated residue in the process of sorting at municipality facilities

Every organic residue consisting of waste plastics was incinerated in municipality facilities. It is estimated that the moisture content of organic residue in the process of PET bottle sorting was about 4 percents. Therefore, if the rate of residue is to be estimated as 10 percent, the emission of carbon dioxide caused by incineration would be as follows.

$$\text{CO}_2 \text{ emission} = 2.69 \text{ (t-CO}_2\text{/t)} \times 23,966 \text{ (t/year)} \times 0.96 = 0.06 \text{ (Mt-CO}_2\text{/year)}$$

* Emission factor of CO₂ caused by plastic incineration (Ministry of the Environment Government of Japan(2))

** Amount of residue generated in the process of PET bottle sorting

4.2 Generated residue in the recycling facilities

4.2.1 PET bottle recycling

The amount of residue generated in the process of recycling was 47,932(JCPRA(2)) tons per year. The emission of carbon dioxide was as follows.

$$\text{CO}_2 \text{ emission} = 2.69 \text{ (t-CO}_2\text{/t)} \times 44,029 \text{ (t/year)} \times 0.96 = 0.11 \text{ (Mt-CO}_2\text{/year)}$$

4.2.2 Plastic container recycling

The amount of residue generated in the process of recycling was 234,000(JCPRA(2))tons per year. It is estimated that the half of this residue was incinerated. As a result, the emission of carbon dioxide was as follows.

$$\text{CO}_2 \text{ emission} = 2.69 \text{ (t-CO}_2\text{/t)} \times 117,000 \text{ (t/year)} \times 0.96 = 0.30 \text{ (Mt-CO}_2\text{/year)}$$

4.2.3 Home appliance recycling

The amount of residue generated in the process of refrigerator and washing machine recycling was 69,000(JCPRA(2)) , 38,000(JCPRA(2))tons per year, respectively.

- **refrigerator**

$$\text{CO}_2 \text{ emission} = 2.69 \text{ (t-CO}_2\text{/t)} \times 69,000 \text{ (t/year)} \times 0.96 = 0.18 \text{ (Mt-CO}_2\text{/year)}$$

- **washing machine**

$$\text{CO}_2 \text{ emission} = 2.69 \text{ (t-CO}_2\text{/t)} \times 38,000 \text{ (t/year)} \times 0.96 = 0.10 \text{ (Mt-CO}_2\text{/year)}$$

4.2.4 ASR recycling

The amount of incinerated plastics in ASR was 360,000 tons per year, if the plastic content of ASR is estimated 30 percent. It is also estimated that the moisture content of ASR is approximately 20 percent.

$$\text{CO}_2 \text{ emission} = 2.69 \text{ (t-CO}_2\text{/t)} \times 360,000 \text{ (t/year)} \times 0.80 = 0.77 \text{ (Mt-CO}_2\text{/year)}$$

In addition, the total amount of landfill disposal by both the sorting and recycling process was estimated to be 0.54 million tons a year.

5. CONCLUSIONS

1. Handling residue of approximately 20 to 50 percent is generated in the process of recycling. There are a great many organic materials in the handling residue. These materials are mainly incinerated. We estimated the emission of carbon dioxide caused by handling residue

incineration. The emission of carbon dioxide was approximately 1.52 Gg-CO₂/year in 2004. This number corresponds to approximately to about 7 percent of the total emission (23.1 Gg-CO₂/year) in the waste treatment category of Japan (Ministry of the Environment Government of Japan(2)), and is likely to have a significant impact on global warming.

2. Power generation occurs in the process of organic residue incineration to compensate the CO₂ emission with heat recovery.

3. It is estimated that the total amount of landfill disposal by both the sorting and recycling process was 0.54 million tons a year. This number corresponds to approximately 1.4 percent of total landfill disposal (38.5 million tons/year) in Japan (Ministry of the Environment Government of Japan(3)).

REFERENCES

Ministry of the Environment Government of Japan (1): Sound Material-Cycle Society

Ministry of the Environment Government of Japan (2):National Greenhouse Gas Inventory Report of Japan, August, 2006

Ministry of the Environment Government of Japan (3):State of Generation and Treatment of Municipal Solid Waste and Industrial Waste in FY2004

JCPRA (1): The Japan Containers Packaging Recycling Association, The Containers and Packaging Recycling Law

JCPRA (2): Statistics data