Municipal Solid Waste Management in Japan

Masaru Tanaka

1 Introduction

The municipal solid waste (MSW) management in Japan was initiated upon the promulgation of the "Dirt Removal Law" in 1900. Enacted after an epidemic of dysentery, pest and other infectious diseases, this law was aimed at overcoming sanitary problems in cities. In 1954, the "Public Cleansing Law" was introduced to secure a hygienically sound living environment. Following rapid economic growth, "Waste Management and Public Cleansing Law" (hereinafter "The Waste Management Law") was enacted in 1970, was passed by the Diet during its "Pollution Session" along with other environmental restraint laws. This law constitutes the main framework of the present waste management legislation and has a widened regulatory coverage extending from MSW to waste including "industrial wastes" generated from business activities.

In the last 43 years from the enactment of the Waste Management Law, the Japanese people's lifestyle and economic structure have undergone drastic changes with their economic affluence as the background, with resultant quantitative growth and diversity in the nature of wastes. Mass-production and mass-consumption by human beings have resulted in pollution; depletion of forests, mineral and other natural resources, global warming and other forms of degradation of environmental quality. It has been realized that waste management holds the key to "sustainable society" and the target of solid waste management has been shifted to 3R (reduce, reuse and recycle) (Tanaka 1999). Issues such as compliance with the law, typically illegal dumping, responsibility of manufacturers, huge cost of management and concern about emission of toxic substances have also been raised.

Responding to these changes and situations, the policy on MSW management has shifted the target from proper treatment and disposal to establishing a Sound

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Material-Cycle society (herein after 3R society). Policy measures are changed to: (1) developing a legal system for recycling with extended producer responsibility (EPR), (2) setting a national target for MSW reduction, (3) strengthening enforcement, especially by strengthening the compliance system and responsibility of the waste discharger and (4) developing high-tech treatment facilities with subsidies from the central government for establishing a 3R society. The national subsidy policy changed its basic target to the creation of a 3R society in 2005.

Reflecting this move, the "Fundamental Law for Establishing a Sound Material-Cycle (3R) Society" was enacted in 2001 and specific recycling laws were enacted together with amendments to the Waste Management Law to further reinforce the regulatory measures.

1.1 Basic Principles

As for responsibilities of the stakeholder prescribed in the Waste Management Law, citizens shall cooperate with the central government and local governments in their activities for waste reduction. The businesses shall appropriately manage the waste left as a result of their business activities and endeavor to reduce the amount of waste. The businesses shall also assess the handling or processing difficulty of the waste generated when the products, their containers or whatever they manufacture are discarded. They shall develop such products, containers or the like which are unlikely to present handling or processing difficulty, provide information on appropriate management of the waste generated when the products, their containers or the like are discarded, or take some other actions to ensure appropriate management of the said products, containers or the like without difficulty. Municipalities shall endeavor to perform waste management work efficiently by improving the ability of the management personnel, consolidating disposal facilities and developing operation techniques.

As for measures on waste reduction and other proper waste management, first, waste generation shall be restrained as much as possible, then waste that is generated shall be utilized as much as possible in the order of reuse, recycle and heat recovery while taking into account the prevention of improper management as well as reduction of the load on the environment by decreasing the quantity of their disposal. Restraint of waste generation and the proper recycling shall be thoroughly carried out, and it is fundamental that the proper disposal shall be ensured for those which still cannot be recycled (Ministry of the Environment 2001).

1.2 Definition and Waste Classification

According to the Waste Management Law, waste is defined as, "refuse, bulky refuse, ashes, sludge, excreta, waste oil, waste acid and alkali, carcasses and other

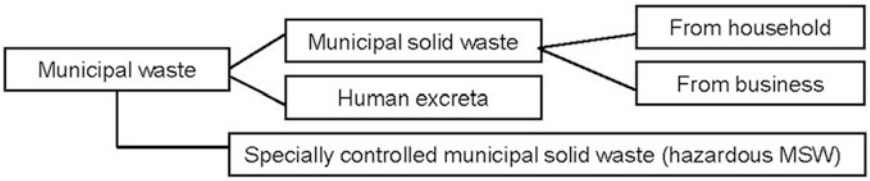

Fig. 1 Classification of MSW

filthy and unnecessary matter, which are in solid or liquid state (excluding radioactive waste and waste polluted by radioactivity)." Waste is divided into municipal waste and industrial waste. Municipal waste refers to waste other than industrial waste, while industrial waste refers to waste generated in the course of business activities classified according to the type of substance and generation source as follows: (1) ashes, sludge, waste oil, waste acid, waste alkali, waste plastics and others specified by a Cabinet Order and (2) imported waste. Wastes which are explosive, toxic, and infectious or of a nature otherwise harmful to human health or the living environment are defined as "specially controlled municipal waste" or "specially controlled industrial waste."

Municipal waste is classified as follows. In this chapter, in principle, the term "municipal solid waste" refers to municipal waste which is in the form of a solid and does not include human excreta (Fig. 1).

2 Waste Generation and Composition

Total quantity of MSW generated in Japan was 46.3 million tons in FY2010 and the quantities of waste collected or disposed of by municipalities add up to approximately 42.6 million tons. That is about 0.98 kg of waste capita per day. The 71 % of MSW is generated by households and the rest by businesses. From the total MSW generated, 93 % went though intermediate treatments, mainly incineration in 2010. Material recovery by voluntary groups in local communities was 2.7 million tons. Promotion of intermediate processing led to a decrease in the quantity of waste disposed of at landfill sites to 4.8 million tons (Ministry of the Environment 2012) (Figs. 2 and 3).

3 Collection and Transportation

Method of MSW collection depends on the respective municipalities. Collection service usually covers all urbanized areas. The waste collection vehicle with a compactor is the most popular in Japan and has a compression device to automatically push waste into the container.

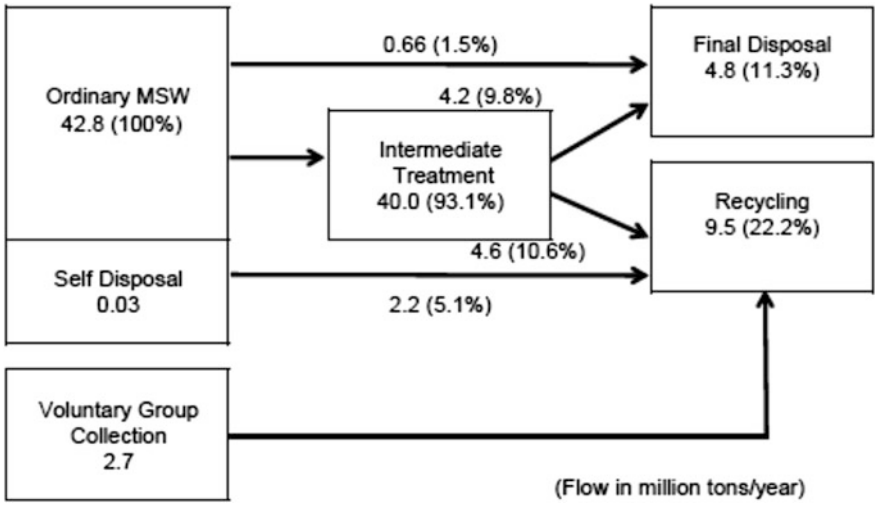

Fig. 2 Flow of MSW in Japan (FY2010). *Source* Ministry of the environment 2012

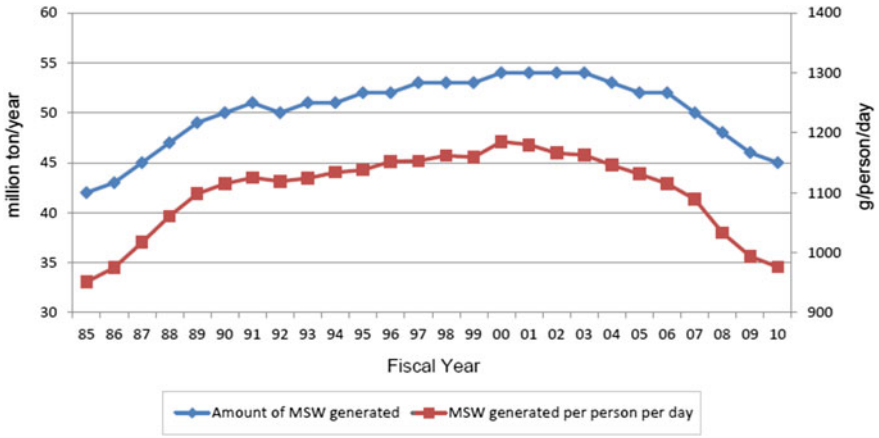

Fig. 3 Trend of MSW generation in Japan. *Source* Ministry of the environment (2012)

Separation of waste into several items at source is very popular, while ways of separation depends on municipalities. More than half municipality requests a generator for separating their waste into more than 10 kinds of items [Ministry of the Environment 2008]. Municipalities collect waste typically separated into combustibles, non-combustibles and recyclable items such as paper, glass bottles, metal, PET bottle, etc. Part of such waste is further sorted at recycling facilities.

In addition, part of MSW from businesses is also brought to intermediate treatment and recycling facilities run by municipal authorities.

4 Treatment and Disposal

4.1 Situation of Treatment and Disposal

Japan is quite a densely populated country in comparison with other countries in the world, and its industries and population are concentrated in urban areas. In large cities, waste generation density is high, but space is very scarce and there is a "not in my backyard" attitude against waste management facilities. Acquisition of suitable site for waste treatment or disposal becomes a challenge each year. It is more severe for final disposal sites which demand a larger space. In order to prolong service lives of landfill sites, extra efforts have been made to reduce landfilled waste by various pre-treatments. Incineration, which can reduce the volume of waste and make waste hygienic enough to prevent biological hazards, is utilized extensively as an intermediate treatment process.

Consequently, incineration is very popular and 79 % of generated MSW went through incineration in FY2010. The number of incineration plants was 1,221 in FY2010 and 306 of them recovered energy from MSW for power generation. Other popular methods of intermediate treatment are crushing of bulky waste and turning waste to refuse derived fuel (RDF) (Ministry of the Environment 2012).

The amount of final disposal (sum of direct disposal and residue after intermediate treatment) was 4.8 million tons in FY2010 and has been decreasing year by year. The number of landfill sites was 1,775 in FY2010 (Ministry of the Environment 2012).

4.2 Incinerators and Dioxin

Emission of dioxins due to waste incineration and other source has been drawing keen attention of society since the late 1983. This has called for the formation of a new legal framework necessary to take measures to control dioxins. The law for special measures against dioxins was promulgated in 1999 and enforced in 2000 (Tanaka 1999). This law calls for the establishment of the tolerable daily intake (TDI) and the environmental quality standards for dioxins. The facilities which may generate dioxins, including the MSW incinerators are designated by a cabinet order and the emission standards for exhaust and effluents were set for various types of facilities. The TDI of dioxins was determined to be 4 pg-TEQ/kg-body/day, and environmental standards in air, water and soil were set at 0.6 pg-TEQ/m^3, 1 pg-TEQ/L and 1,000 pg-TEQ/g, respectively. For waste incinerators, the strictest emission standard is 0.1 ng-TEQ/m^3, which is applied to newly constructed waste incinerators having a capacity of 4 tons/hour or more (Fig. 4).

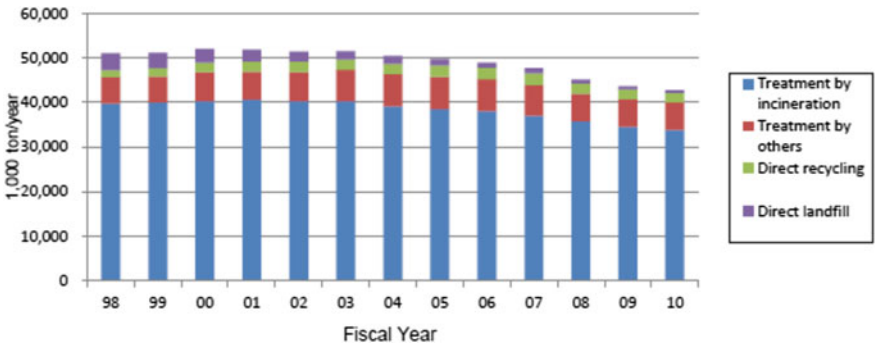

Fig. 4 Trend of treatment and disposal in Japan. *Note* "Treatment by others" includes recycling through sorting, treatment of bulky waste, composting and waste to fuel. *Source* Ministry of the environment (2012)

4.3 Illegal Dumping

Huge accumulation of illegally dumped waste was discovered in several sites in Japan and this became a topic for heated debate in the late twentieth century. Most of the cases were that of industrial waste. Who should take responsibility for cleaning up the waste when illegal dumpers cannot be identified or cannot pay for? The illegal dumping problem exposed the fact that business activities in industrial waste management were conducted in a disorganized manner and bad money (contractors) drove out the good ones.

There was a very serious problem on Teshima Island in Kagawa prefecture in the western part of Japan. More than half a million tons of industrial waste had been dumped illegally on the island and it caused serious conflict with the residents who brought the case to the court. Originally, the waste management company stated that the dumped items were recyclable and that almost all of them could be recovered, but actually those were more likely hazardous waste. Owners of the company were convicted, but they did not have the ability to clean up all the waste. The Governor of Kagawa prefecture agreed to take responsibility for the clean up program, which has now been implemented with the support of the central government.

To respond to illegal dumping, several measures are taken: (1) strengthening regulations and enforcement power by amending the law, (2) introducing responsibility to a waste discharger for illegal dumping, (3) strengthening monitoring and (4) governmental support to clean up illegal dumping sites and improper disposal sites.

5 Reduce, Reuse and Recycle—3R

Based on the "Fundamental Law for Establishing a Sound Material-Cycle Society," the first phase of the Fundamental Plan for Establishing a Sound Material-Cycle Society approved by the Cabinet in 2003, three targets on resource productivity, cyclical use rate and final disposal amount were set. The Waste Management Law was also amended for the reinforcement of measures for recycling.

By applying the concept of extended producer's responsibility (EPR), recycling laws for specific products or waste type were enacted as follows and the legislative framework is shown in Fig. 5.

- Containers and Packaging Recycling Law (1995): for PET bottles, glass bottles, and plastic or paper containers and packaging.
- Home Appliance Recycling Law (1998): for TV Sets, air conditioners, refrigerators, freezers and washing machines (flat-screen TV sets and home driers are added in 2009).
- Construction Material Recycling Law (2000): for waste materials from designated construction and civil works.
- Food Recycling Law (2000): for food waste from manufacturers, wholesalers, retailers, and restaurants.
- End of Life Vehicles Recycling Law (2002): for end of life vehicle (Fig. 6).

Resource recovery by the local communities and municipalities amounted to 9.4 million tons and was 21 % of the amount of treated, disposed and voluntarily collected waste in FY2010. These figures increased from year to year (Ministry of the Environment 2012).

Fig. 5 Legislative framework to establish a sound material-cycle society. *Source* Ministry of the environment 2012

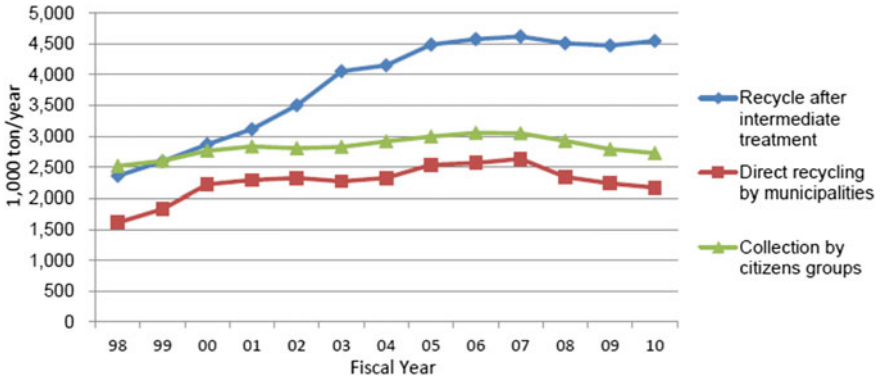

Fig. 6 Trend of resource recovery from MSW. *Source* Ministry of the environment (2012)

6 Current MSW Policy and Future Development

6.1 Current Management System

The Waste Management Law mainly sets the overall waste management system. Table 1 shows regulatory framework on MSW by Waste Management Law. Figure 7 shows the structure of the Waste Management Law including the definition, responsibility, planning, licensing, standards and penalty.

6.2 Establishing a 3R Society

MSW policy has shifted from proper treatment and disposal of MSW by developing MSW facilities to establishing a 3R society. The background of this movement is: (1) increase in the amount of solid waste, (2) difficulty in siting of final disposal (development of treatment by incineration), (3) limited capacity of remaining landfill site, (4) frequent illegal dumping of waste and (5) public attention to toxic substances such as dioxins arising in the course of waste management. The policy shift brought such moves as (1) bringing valuable goods in waste to managed material flow, (2) pursuing waste discharger responsibility, (3) applying extended producer's responsibility on recycling measures and (4) collaboration of the central and local governments to involve stakeholders.

In order to establish a 3R Society, the Government of Japan intends, among other initiatives, to further develop laws and regulations for waste management and recycling; to promote a 'slower', less consumption-oriented lifestyle by enhancing environmental education and learning and providing adequate information; and to accelerate the production of environmentally friendly goods and

Table 1 Regulatory framework on MSW by waste management law

Activity	Regulation
(Discharger)	
Consignment of treatment/disposal	Consignment standard
(Contractor)	
Status of contractor	Municipality's permit to those meeting conditions on capability of the applicant and the needs of the municipality
(Collection and transportation)	
Collection and transportation by contractor	Standards on collection and transportation
(Treatment/disposal facilities)	
Installation or change of facilities	Permit to those meeting conditions on environmental impact study, technical standards and capability of the applicant Information disclosure
Operation of facilities	Technical standard Information disclosure Closure of landfill site
(Export)	
Export of MSW	Confirmation by the Minister whether the exporter meets conditions

services through the incorporation of Design for the Environment (and systems for the lease or rental of items).

As a result, resource productivity and cyclical use rate in the Fundamental Plan for Establishing a Sound Material-Cycle Society has gradually risen and the final disposal amount has greatly dropped. But the reduction of waste generation has not progressed. Although there is a high public consensus about the need to reduce waste generation, there is a discrepancy between this awareness and actual behavior by citizens. The national and local governments, businesses, and the public should continue to coordinate their efforts to establish a Sound Material-Cycle Society. Also, there is an economic risk in the recycling system, as commodity prices fluctuate, sometimes double or and at other times half the price, all within a short period.

Apart from municipalities' separate collection of recyclables, resources retrieval groups in local communities and other voluntary measures play an important role in recycling. To establish an optimum recycling need in the society, it is essential to fully recognize the deficiencies and drawbacks of existing methods. A more efficient system must be worked out through close cooperation among the administrative authorities, citizens and producers, each with a definite assigned responsibility (Tanaka 1999).

Also, as solid waste and recyclables circulate beyond national borders, the Japanese government have called for 3R Initiatives at the international and regional fora (see Sect. 1.2).

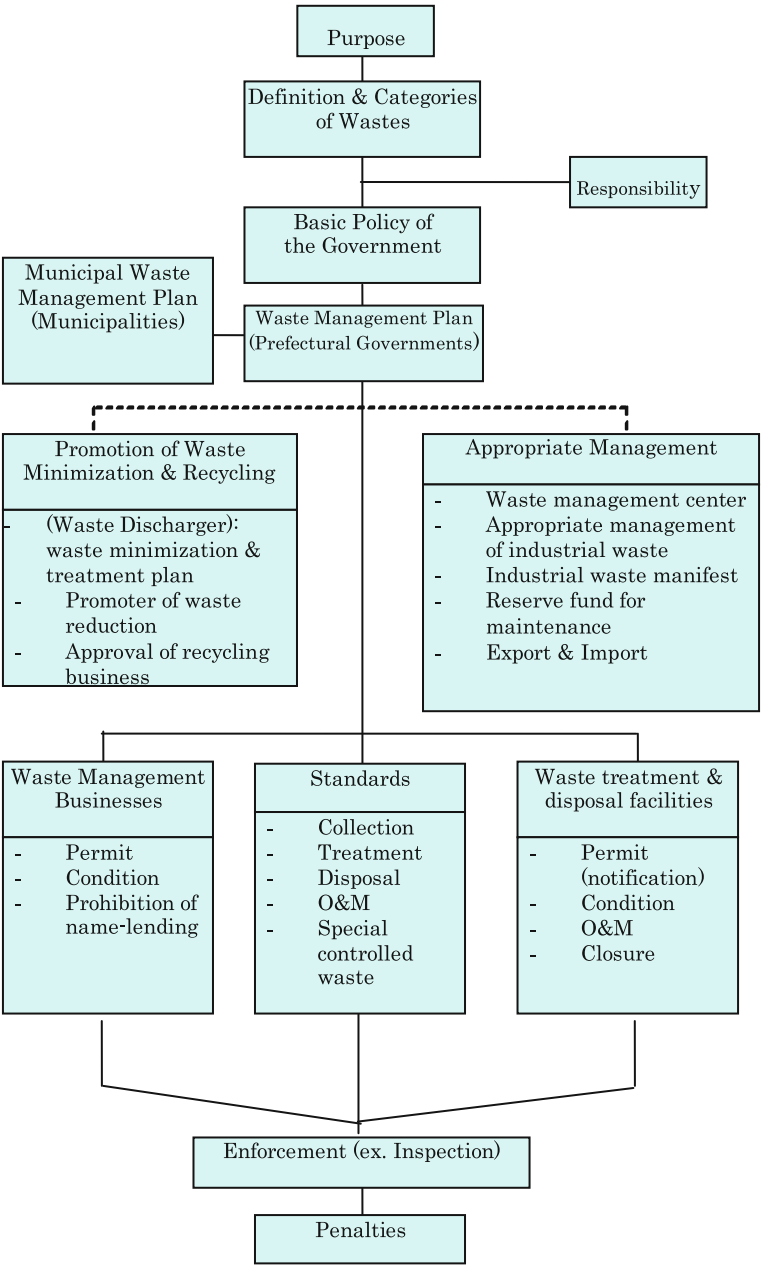

Fig. 7 Structure of waste management law

6.3 EPR Approach

New public policy called "Extended Producer Responsibility" (EPR) was studied at OECD as a major means for constructing a successful life-cycle waste management system. EPR entails still wider responsibility including liability for the management of a product after consumption. EPR is based on a new strategy for promoting the internalization of all environmental and other "external" costs related to the entire life-cycle of a product.

Firstly, Japan introduced the EPR policy on waste management with the promulgation of the Containers and Packaging Recycling Law in 1995. The aim of this law is to introduce a recycling system under which, specified business entities (manufacturers, retailers, wholesalers and importers) have a responsibility to recycle containers and packaging, while municipalities have the responsibility for the sorted collection of those items. A government-designated organization provides actual recycling operation on behalf of specified business entities which pay recycling fees to the organization.

Home Appliance Recycling Law promulgated in 1998 provides a collection and recycling system. Home appliance retailers take charge of collecting used home appliances and home appliance manufacturers take charge of recycling used appliances. Consumers who discharge home appliances shall pay for the recycling cost. Association for Electric Home Appliances operates the home appliance recycling coupon system, which is convenient for paying and collecting recycling fees. Recycling fees may be paid and collected via retailers or by postal transfer [Ministry of Economy, Trade and Industry 2008].

6.4 Cost of MSW Management

Total expenditure on MSW management by municipalities was 1,863 billion Yen and 14,600 Yen/capita in FY2006. The total cost of municipalities started decreasing after FY2001 [Ministry of the Environment 2008]. Because solid waste management cost shares a substantial portion of the budget for municipalities, reducing cost with keeping service level is a big challenge especially for local governments. Municipalities have reduced solid waste management cost by reducing construction and reform cost of their facilities. Also, municipalities try to keep operation and maintenance cost by commissioning these works to the private sector in order to reduce personnel expenses. Finance in many municipalities is very tight and most municipalities need further reduction of their expenditure. Waste reduction is also necessary from this viewpoint.

Recycling also incurs expenditure. According estimates for 2003, as a result of The Containers and Packaging Recycling Law, the net increase of expenditure in all municipalities was 38 billion Yen. That is, cost reduction in incineration and landfilling was subtracted from 300 billion Yen of additional collection and

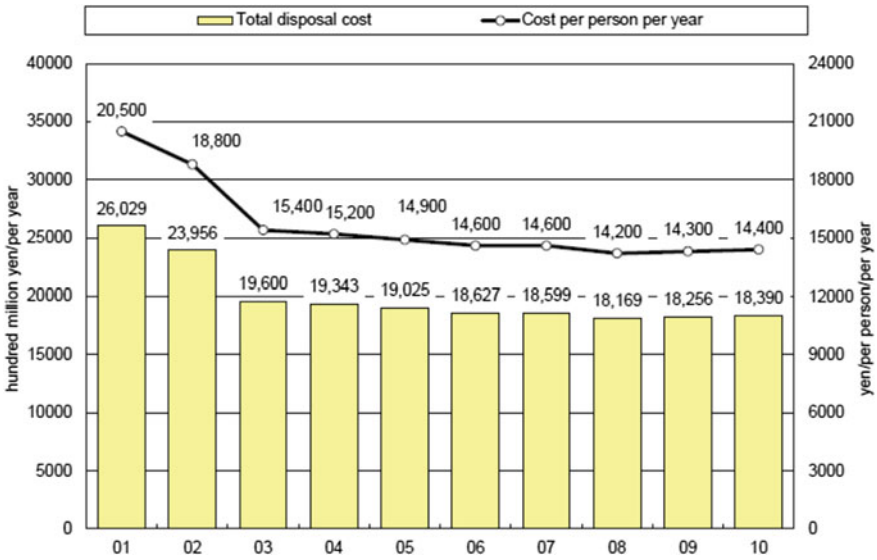

Fig. 8 Total disposal cost and cost per person per year for MSW. *Source* Ministry of the environment (2012)

storage cost for recycling. On the other hand, business entities of containers and packaging bore the cost of 40 billion Yen in FY2003, 48 billion Yen in FY2006 and 38 billion Yen in FY2011 for the recycling of merchandise (Ministry of the Environment 2008). The Japan Containers and Packaging Recycling Association, 2012, http://www.jcpra.or.jp/archive/cycledata/total_fee_detail.html (Fig. 8).

7 Case Study-Management of Disaster Waste Generated by Great East Japan Earthquake

On March 11, 2011, Iwate and Miyagi Prefectures suffered badly from the Great East Japan Earthquake, and large quantity of disaster waste was generated by the earthquake and tsunami. Japanese government decided to conduct wide area disposal of disaster waste, and ask for cooperation of the local governments in non-disaster area. The radiation level of disaster waste is very low, but some people express concern about radioactive contamination and it causes a delay of wide area disposal plan (Table 2).

The total waste generated by the Great East Japan Earthquake in Iwate, Miyagi and Fukushima Prefectures is estimated at about 25 million tons (as of April 5, 2011) Ministry of the Environment (2001). Although proper disposal of disaster waste is essential to restore disaster-stricken areas, the amount far exceeds the processing capacities of existing and specially built emergency waste disposal facilities.

Table 2 Total quantity of disaster waste generated by earthquake and tsunami in Iwate and Miyagi Prefectures, and its portions which washed out to the sea and needs to be disposed of in land (4)

Classification of the waste	Concrete waste (x1, 000 t)	Combustible waste (x1, 000 t)	Total (x1, 000 t)
Iwate prefecture (Total waste generated)	3,746	2,236	5,982
(Washed out to the sea)	1,124	671	1,795
(Needs to be disposed of)	2,622	1,565	4,187
Miyagi prefecture (Total waste generated)	11,963	3,980	15,943
(Washed out to the sea)	837	279	1,116
(Needs to be disposed of)	11,126	3,701	14,827
Total of 2 prefecture (Total waste generated)	15,709	6,216	21,925
(Washed out to the sea)	1,961	950	2,911
(Needs to be disposed of)	13,748	5,266	19,014

Thus, the national government of Japan is seeking the cooperation of local governments nationwide to receive, process and dispose of disaster waste. (Processing and disposal of surplus waste in non-disaster areas due to insufficient waste processing/disposal capacity in the disaster area is called "wide area disposal.") Waste subject to wide area disposal is the portion of disaster waste generated in Iwate and Miyagi Prefectures for which the local municipalities seek cooperation for wide area disposal. This portion of waste consists of combustible materials (e.g., wood waste) and non-combustible materials (e.g., concrete waste). Local governments nationwide have incineration facilities to process combustible waste, which have been built with government subsidies. Many local governments have managed to reduce waste by promoting "3Rs (Reduce, Reuse, Recycle)" in recent years, hence their waste processing facilities are believed to have surplus capacities. However, even local governments that were willing to accept disaster waste when the national government began requesting their cooperation for wide area disposal have taken virtually no action to do so. Although local governments wish to cooperate to restore disaster areas, they have been unable to accept disaster waste, mainly due to concern over radioactive contamination expressed by some residents.

7.1 Quantities and Physical Composition of Disaster Waste

The estimated amount of disaster waste generated in the three disaster-stricken prefectures in the Tohoku region is approximately 21 million tons, which excludes approximately 4.1 million tons of the waste that was washed out to sea. Since it has been decided that 1.7 million tons of disaster waste generated in Fukushima Prefecture would be processed and disposed of in the same prefecture, the remaining 19 million tons or so are subject to wide area disposal. Of this waste, around

14 million tons is concrete waste, plus 5 million tons of combustible materials e.g. wood. Most of this waste has been moved to temporary storage sites, but is still awaiting processing and disposal. Only 6–7 % had been disposed of as of March 2012 (Ministry of the Environment 2012).

Concrete waste is supposed to be crushed and reused as a building material for reconstruction purposes. Conversely, combustible materials e.g. remnants of destroyed houses are fire hazards, which can also decay and produce unpleasant odors. Therefore, they should be incinerated as soon as possible for public health. Better still, the heat produced from incinerating such waste should be exploited for power generation if possible. However, local waste processing facilities have capacity limits. It will not be easy to obtain public understanding to construct waste processing facilities for short-term use. Of the 4.2 million tons of waste in Iwate Prefecture, the local government seeks cooperation for the wide area disposal of 1.2 million tons. Of the 15 million tons of waste in Miyagi Prefecture, the local government is requesting the wide area disposal of 1.27 million tons generated in the Ishinomaki district.

7.2 Master Plan for Disaster Waste

In May 2011, the national government announced the guidelines (master plan) for disaster waste management (Tanaka 1999). This master plan targets the complete transfer of disaster waste to temporary storage sites by around the end of March 2012, and calls for the completion of intermediate processing and final disposal of waste two years later, by the end of March 2014. In Iwate and Miyagi, a total of 31 temporary incinerators were constructed (Photo 1) (Ministry of Enviroment Homepage 2013). The master plan sets forth the following basic rules for waste processing and disposal: (1) Waste shall be sorted and separated as much as possible at the disaster areas. (2) Recyclable materials shall be recycled and reused as much as possible. (3) Non-recyclable combustible materials shall be incinerated, and the ashes subject to landfill disposal. (4) Non-combustible materials that cannot be recycled or reused subject to landfill disposal.

7.3 Risk Management of Radioactive Material in Disaster Waste

Only disaster waste with no or low-level radioactive cesium is eligible for wide area disposal. In the case of combustible waste, this includes materials with a radioactive cesium level under 240–480 Bq/kg. This standard was set to ensure that the radioactive cesium level in incinerated ashes remains below 8,000 Bq/kg and that the radiation exposure to landfill workers, who are most affected by

Photo1 Disposal facility for disaster waste (Ishinomaki-city, Miyagi prefecture)

radioactive contamination during landfill disposal work, is lower than 1 mSv per year. Also, it is evaluated that influence among residents living near the disposal site is lower than 0.01 mSv per year with the worst-case scenario.

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