カリブ地域

カリブ地域海洋プラスチックごみ対策アドバイザー業務

業務完了報告書

(Annex A)

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Technical Note.

Technical Project on Advisor for Marine Plastic Litter Management in the Caribbean Region

Technical Note No.1

Estimation of Future Waste Amount

JICA
Japan International Cooperation Agency

October 2023

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Estimation of Future Waste Amount

Prepared by Ikuo MORI, JICA Advisory Team
October 2023

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1 Objectives of this technical note

This technical note aims to provide readers with guidance on how to estimate the future waste amount, which is the first step when formulating a municipal solid waste management (MSWM) plan.

2 Estimation of future waste amount

2.1 First step: Estimation of current waste amount

a. Waste Generation Rate (kg/person/day)

Estimating the future amount of waste is a fundamental work for the preparation of a MSWM plan. The first step of this work is to obtain the current Waste Generation Rate (WGR), which is the amount of waste generated per person per day at present, expressed in kg/person/day. It is estimated by carrying out a Waste Amount Survey or by using weighbridge data if available.

There are basically three types of WGR as follows.

1. **WGR-household**

   = amount of waste generated by households / population

2. **WGR-ICIs (Institutional, Commercial and Industrial entities)**

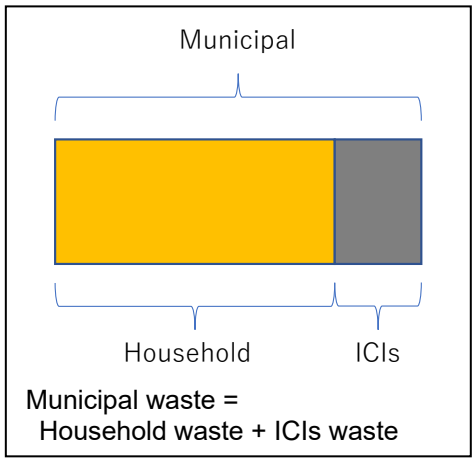
   = amount of waste generated by ICIs / population

3. **WGR-municipal**

   = (amount of waste generated by households + amount of waste generated by ICIs) / population

   = amount of municipal waste generated / population

The figure on the right schematises the relation between "household waste", "ICIs waste" and "municipal waste".



b. Waste Amount Survey

A Waste Amount Survey is usually carried out together with a Waste Composition Survey. Then, it is called a Waste Amount and Composition Survey (WACS). Even if weighbridge data is available, it is still recommended to carry out this survey. The survey provides a lot of information to improve management, prepare a waste minimization plan, etc.

The survey directly measures the amount of waste generated by each type of source, as shown in the table below. However, the survey can only measure a certain number of samples. The way waste generation sources are categorized should therefore be carefully considered. Samples should be taken from different categories so that they correctly represent the amount of waste generated by the entire city. Often, the approach used in developing countries for household waste is to divide citizens by income level. Indeed, in developing countries, the economic disparity among citizens is significant, and different income levels lead to different lifestyles and produce different amounts and compositions of waste.

Table 2-1: Categorization of Waste Generation Sources

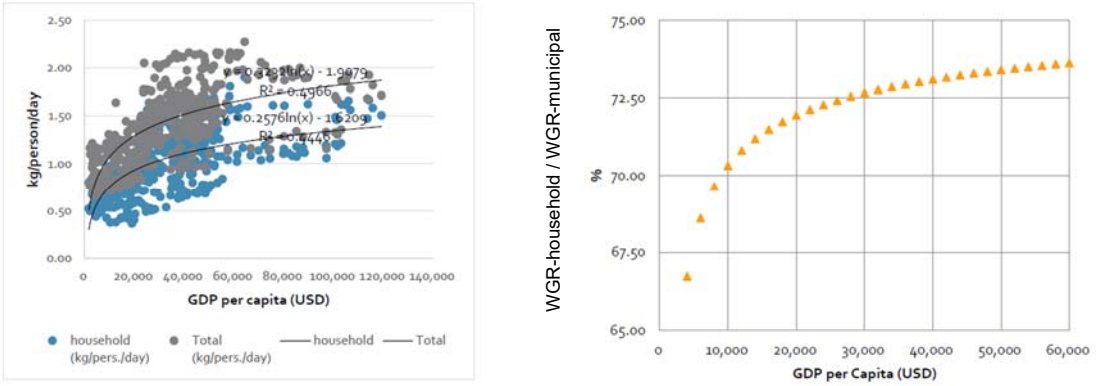
Waste generation source		Data for estimating the waste amount of the entire city
Household	High income	Population data by income level
	Middle income	
	Low income	
Other than household (Institutional, Commercial and Industrial entities)	Offices	Number of offices, number of shops, sales amount, number of beds, rooms, etc.
	Shops	
	Restaurants	
	Hotels	

Note: Industrial waste may be out of the scope. Hospital waste may be under the responsibility of the municipality. The target waste for the survey should be defined depending on the purpose of the plan.

The amount of waste generated by the entire city will be estimated based on the survey results obtained. Therefore, the existence of data should be confirmed when designing the survey. For example, if citizens are divided by economic strata, population data for each stratum is required. If various waste generation sources from institutional, commercial and industrial entities are set, it is also important to consider how the waste amount of the entire city can be inferred based on the survey results. It might be necessary to know the number of staff in each type of office in the city, the number of beds of all hotels, etc. However, such detailed data is usually lacking in developing countries. In order to solve this problem, historical data can be used to estimate waste amount from ICIs.

WACS provides various precious data. It is not so difficult to obtain representative data from households, however, as mentioned above, it is difficult to obtain representative data from ICIs as their waste varies a lot depending on the characteristics of their activities. Also, it is very expensive to take many samples to increase the reliability of the survey.

It is known that there is a correlation between WGR and GDP per capita. Also, there is a correlation between WGR-household and WGR-municipal (total). The figures below show such correlations.



Source: Prepared by JAT based on historical OECD countries data.

Figure 2-1: Correlation between WGRs and GDP per capita

Using the World Bank's definition, a developing country is roughly a country with a GDP per capita of less than USD 10,000. According to the figure above, the ratio of WGR-household to WGR-municipal in developing countries is approximately 70%. Therefore, WGR-ICIs and WGR-municipal can be roughly estimated from WGR-household obtained by the WACS as follows.

WGR-municipal = WGR-household obtained by WACS / 0.7

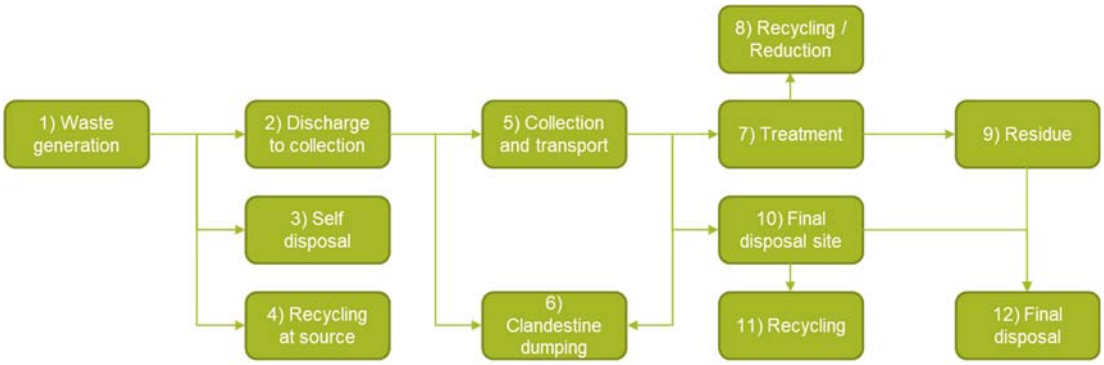
WGR-ICIs = WGR-municipal × 0.3

Consequently, it is recommended that the survey covers both household waste and ICIs waste if sufficient financial resource and data about ICIs are available. However, it is also possible to survey only household waste, and use the correlation to estimate the amount of ICIs waste.

c. Use of weighbridge data

If there is weighbridge data, it may be used to estimate the Waste Generation Rate. However, it is important to bear in mind that "amount of waste disposed of" is different from "amount of waste generated". For estimating the amount of waste generated (Waste Generation Rate), data or information about the amount of self-disposal, recycling, treatment, and clandestine dumping are indispensable.

The figure below represents a waste flow and shows the relation between generation and final disposal.



Note: Weighbridge data can provide the waste amount at 10) or 12) in the waste flow.

Figure 2-2: Typical Waste Flow

d. Estimation of the current waste amount

The various WGRs, such as WGR-household (low income), WGR-ICIs (office), and WGR-ICIs (hotel), have now been obtained. Those are then coupled with data on the sources of generation to estimate the total amount of waste generated throughout city.

Table 2-2: Estimation of Current Amount of Waste Generated (example)

Waste generation source		Waste generation rate (kg/person/day)	Population (person)	Total (kg/day)
Household	High income	1.2	10,000	12,000
	Middle income	1.0	30,000	30,000
	Low income	0.8	10,000	8,000
	Total	-	50,000	50,000
	WGR-household = 50,000 kg/day / 50,000 person = 1.0 kg/person/day			

Waste generation source		Waste generation rate*	Nos. of unit	Total (kg/day)
ICIs	Office	0.2 kg/employee/day	20,000	4,000
	Restaurant	1.0 kg/table/day	10,000	10,000
	Hotel	0.5 kg/bed/day	12,000	6,000
	Total	-	-	20,000
	WGR-ICIs = 20,000 kg/day / 50,000 person = 0.4 kg/person/day			

* Unit of generation rate is different for each generation source.

Amount of municipal waste generated: 50,000 + 20,000 = 70,000 kg/day
WGR-municipal = 70,000 kg/day / 50,000 person = 1.4 kg/person/day

2.2 Second step: Future waste amount

a. Change in WGR

When estimating future waste amount, it is necessary to consider changes in WGR in the future. Some factors may impact WGR such as people's consumption behaviour, development of a specific industrial sector (e.g. tourism sector), etc. Changes in such factors may be reflected in economic development, such as GDP per capita.

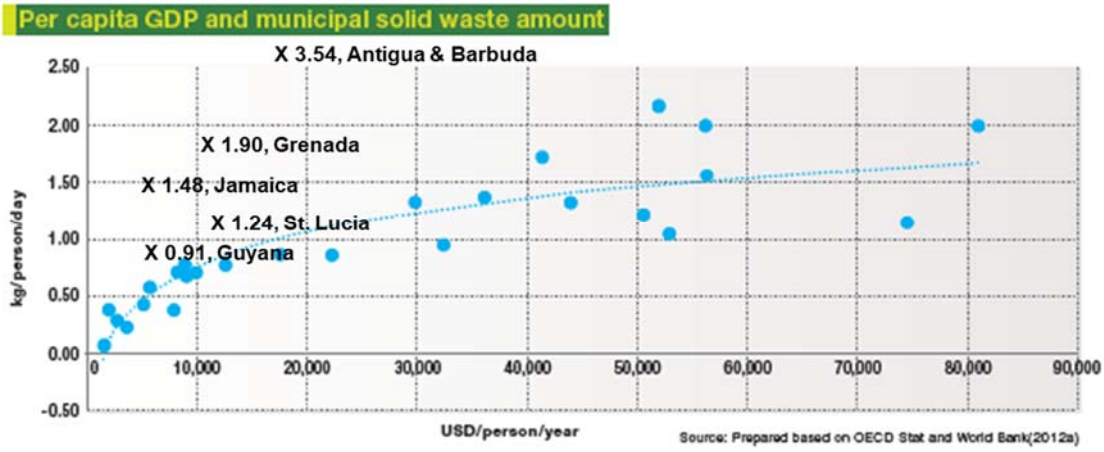
According to the figure below, it can be said that:

- If the GDP per capita of a country is less than 10,000 USD/person/year, it is very likely that the WGR-municipal will increase rapidly.
- If the GDP per capita of a country is more than 10,000 USD/person/year, the WGR-municipal tend to increase slowly or remain stable.

In many developing countries, the economic development of large cities is often much faster than that of other cities or rural areas. Lifestyle can also be very different. In such a case, it might be more appropriate to consider GRDP (Gross Regional Democratic Product) instead of the GDP of the whole country.

As for the five target countries (Antigua and Barbuda, Grenada, Guyana, Jamaica, Saint Lucia) of this marine plastic litter project, their WGR-municipal are relatively high considering their GDP per capita. This can be due to some reasons, such as Americanised lifestyle, large proportion of ICIs waste (e.g. waste from the tourism sector), etc.

Consequently, it is recommended that Grenada, Jamaica and Saint Lucia use the current WGR-municipal for planning. For Guyana, it might be better to take into consideration the projection of GDP per capita to determine the future WGR-municipal. For Antigua and Barbuda, it is recommended to carry out a WACS as the current WGR-municipal seems too high.



Source: Basics of Municipal Solid Waste Management in Africa, p.9 (https://unhabitat.org/african-clean-cities-publications)

Figure 2-3: Correlation between WGR-municipal and GDP per capita

b. Estimation of waste amount in the future

Once the future WGR-municipal has been determined, it is possible to obtain the future amount of waste generated as follows:

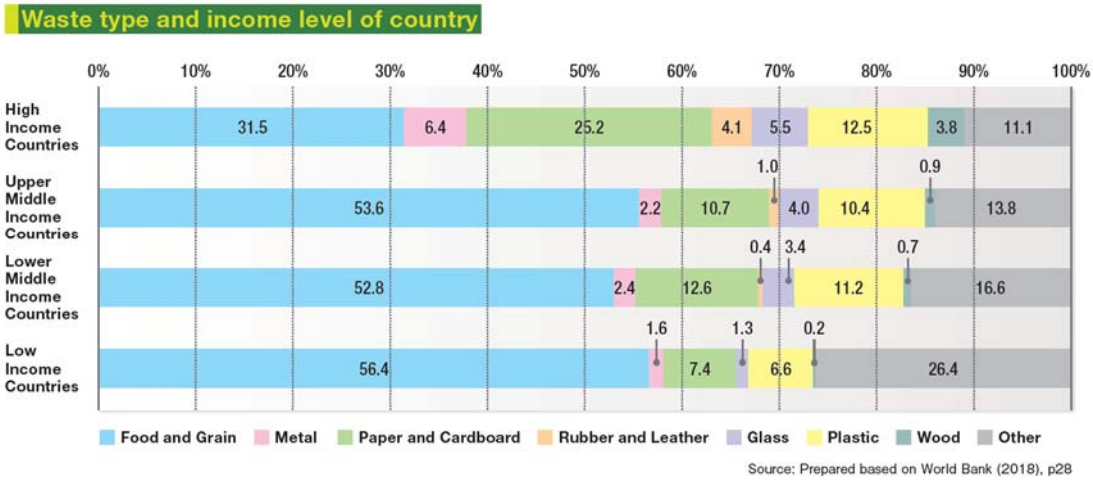
Waste amount generated = WGR-municipal × Population

Table 2-3: Estimation of Future Waste Amount (example)

Item	Unit	20xx	20xx	20xx
WGR-municipal	kg/person/day	0.8	1.0	1.2
Population	person	80,000	100,000	120,000
Waste amount	ton/day	64	100	144

3 Waste composition in the future

The question arises whether the composition of the waste will change in the future. The answer is “Yes”. The figure below shows typical waste composition by income level. The waste composition in high-income countries is very different from that in countries of other income levels, with a smaller share of food and grain and a larger proportion of paper and cardboard. The share of plastic is very similar except in low-income countries.



Low (USD 1,025 or less), Lower middle (USD 1,026-4,035), Upper middle (USD 4,036-12,475), High (USD 12,476 or more)

Source: Basics of Municipal Solid Waste Management in Africa, p.9 (https://unhabitat.org/african-clean-cities-publications)

Figure 3-1: Waste Composition and Income Level

In addition to income level, there are other factors which can cause changes in the composition of the waste, such as technology and policy. For example, technological development in the production of plastics has led to a huge consumption of plastics. On the other hand, policies banning single-use plastics can result in less plastic consumption.

Consequently, it is not recommended to factor in a change in waste composition when preparing a master plan which has a planning period of about 10 years. The reason for this is that it is impossible to predict whether or not the waste composition will change significantly over the course of a decade. However, if the introduction of some special treatment such as composting, biogas or incineration (Waste-to-Energy) is considered, it is recommended to analyse the waste composition of the target waste and evaluate the feasibility of introducing said technology.

Technical Project on Advisor for Marine Plastic Litter Management in the Caribbean Region

Technical Note No.2

Collection and Transport

Japan International Cooperation Agency

October 2023

Technical Project on Advisor for Marine Plastic Litter Management
in the Caribbean Region

Technical Note No.2

- Collection and Transport -

Prepared by Satoshi HIGASHINAKAGAWA, JICA Advisory Team
October 2023

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1 Collection and Transportation Plan

1.1 Objective

The preparation of a collection and transportation plan is necessary to consider a future collection and transportation system in the target area. The collection and transportation plan generally has two objectives. One is for planning collection and transportation to consider necessary equipment, and another is for setting collection route based on the available collection and transportation equipment.

The collection and transportation plan provides the necessary information to procure the necessary equipment and calculate the budget required for it. Also, during the planning process, optimal selecting and acquiring appropriate collection vehicles and containers are crucially considered for establish an efficient collection and transportation system.

The collection and transportation plan also aims to establish detailed collection and transportation routes based on existing collection and transportation equipment and personnel. Proper route planning allows for cost optimization and improved time efficiency. Well-planned collection routes and frequencies minimize waste accumulation and promote public health and environmental protection.

As mentioned above, the main objectives of collection and transportation plan are as follows.

- To plan the necessary equipment for collection and transportation
- To plan collection route with allocation of available resource

1.2 Understanding Current Situation

It is necessary to grasp current collection and transportation system by reviewing existing document and monitoring report including the information of operation and maintenance situation. The technical staff, skilled workers, etc related to collection and transportation seems to understand the situation. However, it is important to share the information of operation and maintenance situation to review, improve and monitor. The collected information is shown as follows.

1.2.1 Information on current collection and transportation service

- Information of current waste collection (collected waste quantity, collection rate (wt%), type of waste)
- Collection service level (coverage area (%), collection frequency, etc.)
- Type of collection (door to door collection, curb side collection, station collection, etc.)
- Collection area (collection routes, collection points, road condition, traffic condition, etc.)
- Type, capacity, number, operation rate, procured year, and etc. of collection vehicles

1.2.2 Operation status of collection vehicle

It is necessary to grasp the operation status of collection vehicle. Overall status can be understood by daily operation record of each collection vehicle including starting time, collection time (loading time), transportation time, unloading time, rest time, finishing time,

and etc. Sometimes, such recording is not implemented or is not sufficient. In that case, it is necessary to implement time and motion survey. The following item should be mainly measured during the time and motion survey.

- Preparation time of collection vehicle before starting collection
- Collection/loading time of solid waste at each collection point
- Transportation time between each collection point
- Transportation time between collection area and final disposal site
- Unloading time at final disposal site
- Checking and washing time of collection vehicle
- Resting and the other time
- Trip number and frequency of each collection vehicle
- Weight of solid waste for each trip of each collection vehicle

  etc

1.2.3 Maintenance status of equipment

It is necessary to grasp maintenance status of equipment.

- Operation rate of equipment
- Maintenance implementation body (direct maintenance in own workshop or outsourcing to private company)
- Maintenance period and frequency
- Availability of spare parts

1.2.4 Collection and transportation cost

Waste collection costs are important for understanding the adequacy of collection and transportation and for identifying problems. It is necessary to collect the following data for planning for budgeting.

- Vehicle prices (including information on vehicle type and year of purchase)
- Labour cost by job category
- Fuel consumption by vehicle type
- Unit cost of fuel
- Maintenance and management costs

1.3 Identification of Issues through Problem Analysis

1.3.1 Analysis of Problem

It is necessary to identify the issues and the points to be improved for future planning.

Based on the understanding of the current situation, it is important to identify the problems with a clear perspective.

- Is the sanitary environment sufficiently maintained?
- Is the collection service sufficiently provided?
- Are the waste containers appropriate?
- Is the type of collection equipment appropriate?
- Is the collection equipment in proper working condition?
- Is collection being carried out efficiently?
- Is the operation and management of collection (especially in the case of private contractors) appropriate?
- Is collection and transportation implemented systematically?
- Is the safety of workers secured?
- How about the level of cooperation of residents?

In the analysis, utilizing tree of cause and effect can be understandable, and main issues can be identified. The tree will be effective tool to discuss with relevant and wide range of stakeholders as well as experts.

1.3.2 Identification of Issues

Through the analysis of problems, issue will be identified. As described above, tree method which presents cause-effect relationship is one of effective tools for the identification. Examples of issues are follows.

- Improvement of discharge manner of waste discharger
- Improvement of collection method
- Shortage of collection vehicle
- Necessity for capacity development of maintenance worker

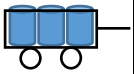
1.4 Consideration of Suitable Options for Collection and Transportation

It is necessary to consider the technical options of collection and transportation system for target area. Suitable options depend on the type of the target waste for the collection, the characteristics or condition of collection area or road, distance between collection area and the target facility which will receive the waste, etc. The example of technical options for collection and transportation including primary collection, secondary transportation and separate collection are follows.

1.4.1 Primary collection by manual equipment

Primary collection by manual equipment is collection at each waste generation and transportation from each generation source to transfer station. Typical options of the collection methods are shown in the following table.

Table 1: Examples of Alternative Measures for Primary Collection by Manual Equipment

Number of Case	Explanation of Case	Positive feature	Negative feature
Case PC – 1	Door to door collection with direct waste collection by hand cart or rikshaw van directly 	- Easy to discharge from house	- Waste handling is difficult after collection
Case PC – 2	Door to door collection by putting waste into bins in hand cart or rikshaw van 	- Easy to handle after collection	- Need to put bin in the hand cart or rickshaw van
Case PC – 3	Door to door collection Putting waste packed by packing material such as plastic bag into hand cart or rikshaw van directly 	- Easy to handle after collection	- Need to pack the waste before discharge

Source: JAT

1.4.2 Secondary Transportation / direct transportation without transfer by mechanical equipment

Secondary transportation is transportation from a transfer station to a treatment or disposal facility, which is necessary in case of long distance from collection area to a treatment or disposal facility. If the distance between them is short enough, direct transportation could be implemented for waste collection and transportation without transfer from primary collection to a treatment or disposal facility.

Table 2: Examples of Alternative Measures by Mechanical Equipment

Number of Case	Explanation of Case	Positive feature	Negative feature
Case ST-1	Transportation by compactor vehicle after the compaction of receiving waste in the vehicle 	- Possible to reduce volume of waste by compacting for effective transportation of waste	- Basically, not suitable for separate collection because the waste is compacted together
Case ST-2	Transportation by dump truck after the receiving waste in some transfer stations by manual or equipment 	- Possible to collect various types of waste simultaneously - Lower purchase cost than compactor vehicle	- Not transport waste effectively

Source: JAT

1.4.3 Separate Collection

Separate collection is necessary if a recycling system or an intermediate treatment system that can receive a specific type of waste is introduced. There are some options including daily differentiated collection, collection by collection vehicle designed especially for separate collection. The examples of options are follows.

Table 3: Examples of Alternative Measures for Separate Collection

Number of Case	Explanation of Case	Positive feature	Negative feature
Case SC-1	Daily differentiated collection for specific type of waste 	- Separate each type of waste for daily scheduling	- Necessary to storage the waste at source for a few days - Educate waste dischargers for collection date
Case SC-2	Separate containers or area for each collection vehicle  Source: Shinmeiwa Ltd.	- Collect various type of waste simultaneously	- Initial cost is relatively high

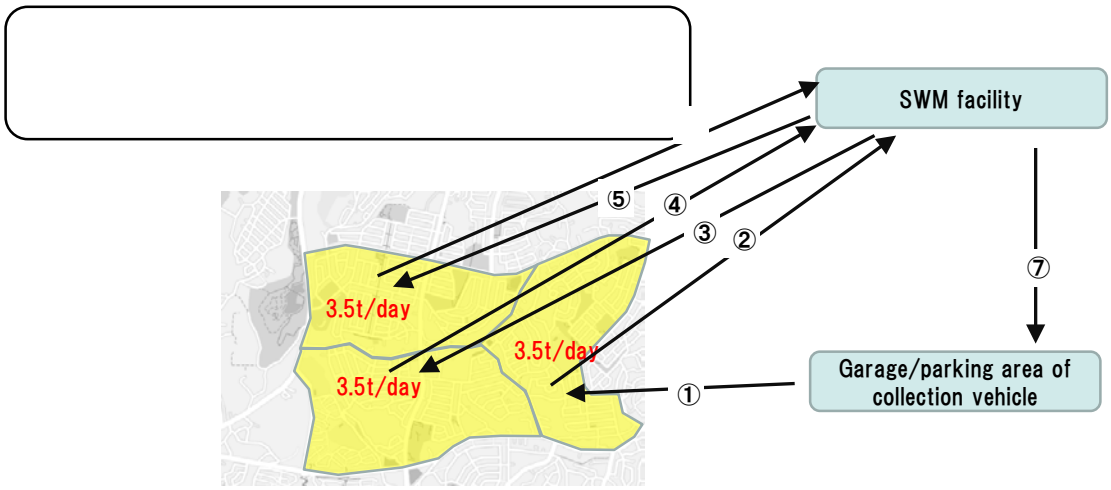
Source: JAT

1.5 Collection and Transportation Planning

The collection and transportation plan should be developed based on the information such as waste collection amount and characteristics, collection area.

(1) Basic plan of collection and transportation

Basic plan of collection and transportation should be prepared based on collection area and the location of SWM facility. The image of collection and transportation to SWM facility is shown as following figure.



Source: JAT

Figure 1: Image of collection and transportation to SWM facility

1) Confirm all the target areas for collection and transportation

   The all the target areas for collection and transportation should be set and confirmed because it is necessary to estimate the amount and characteristics of waste generated in all the target area.

2) Calculate approximate waste quantity in all the target area

   It is necessary to calculate approximate waste quantity for each type of waste and, if segregation system is introduced, each type of separated waste described in separation rule for the separate collection should be compatible to type of receivable waste in the treatment facility. For example, combustible waste for incinerator and plastic / metal for sorting facility of recyclable material should be separated.

3) Select the type of waste collection and transportation system with consideration of area characteristics

   As described in 1.4 consideration of suitable options for collection and transportation, there are many technical options for primary collection and secondary transportation. The type of waste collection and transportation system should be selected for each area with consideration of area characteristic such as road width, population density, etc. For example, road width will affect the size of collection vehicles for secondary transportation and possibilities of setting container.

4) Set the collection and transportation schedule like collection date and collection and transportation time. It is necessary to prepare the collection route map and timetable which describe collection points and time.

5) Divide the target collection area into areas where the waste amount that each collection vehicle can collect in one trip is generated as shown in Figure 1. For example, if the collection capacity of one trip for the collection vehicle is 3.5 tons, the target collection area is divided into areas where the waste in each area can be collected up to 3.5 tons. The number of divided collection areas becomes the trip number.

6) Calculate collection and transportation time for each trip

7) Calculate possible trip number per day for each vehicle to collect target waste (if necessary, considering separate collection or special collection, etc)

8) Set collection frequency of target waste in each collection area (if necessary, considering separate collection)

9) Calculate necessary number of collection vehicles by dividing total necessary number of trips by the possible trip number per day with consideration of the total working time of collection and transportation

10) Allocate each collection vehicle to target area with consideration of approximate trip time from each trip area to the treatment and disposal facility

11) Adjust collection and transportation time by time fluctuation factor at collection points or on road condition, etc

12) Adjust target waste quantity by quantity factor due to daily and seasonal fluctuation, etc

For example, there is not so much waste in winter due to lack of fruits and vegetable, but it is much more waste in summer than in winter which cause the increase of trip numbers of collection vehicle in summer.

13) Prepare the map including collection points and route since the target area of each trip by a certain collection vehicle can be clearly understood.

(2) Detail Plan

As the detail plan, the routing and scheduling of the collection and transportation are necessary. In addition to planning, monitoring is necessary during implementation stage, based on the monitoring result, the plan including the collection and transportation route and their schedule should be updated. The image of monitoring sheet for scheduled collection is shown as following table.

Table 4: Image of Monitoring Sheet for Scheduled Collection

Area	Point No.	Number of household, business establishment	Estimated collected waste amount [kg/day]	Planned arrival time	Actual time	Remark
Area A	1	10	9	9:00	9:00	
Area A	2	7	6.3	9:02	9:03	
Area A	3	8	7.2	9:05	9:06	
Area A	4	7	6.3	9:07	9:08	
Area B	5	7	6.3	9:10	9:12	
・・・	・・・	・・・	・・・	・・・	・・・	・・・
・・・	・・・	・・・	・・・	・・・	・・・	・・・

Source: JAT

2 Waste Transfer

2.1 Objective

Generally, solid waste is collected by collection vehicles and directly delivered to treatment or disposal facilities, such as composting facilities or final disposal sites. However, if the waste collection area is far from the waste treatment/disposal facility, the time spent for transportation will be very long. In this situation, it is possible to improve the transportation time by installing a "waste transfer station" at where waste is transferred from small collection vehicles to large transportation vehicles.

To improve the transportation efficiency, it is better that waste transfer station should be developed near the collection area and the capacity of waste transportation vehicle should be large. The transfer to larger transport vehicles at waste transfer facilities also has the advantage of improving transport efficiency per vehicle, easing traffic volume, and reducing carbon dioxide emissions by reducing fuel consumption of transport vehicles. In the case of wide-area collection and disposal system where facilities are shared among municipalities, waste transfer facilities can be established in the location near the collection area of municipalities, and the waste transferred in the waste transfer facilities and loaded into large capacity vehicles could be effectively transported to the treatment and disposal facilities comparing small capacity vehicle. The main purpose of waste transfer system are follows.

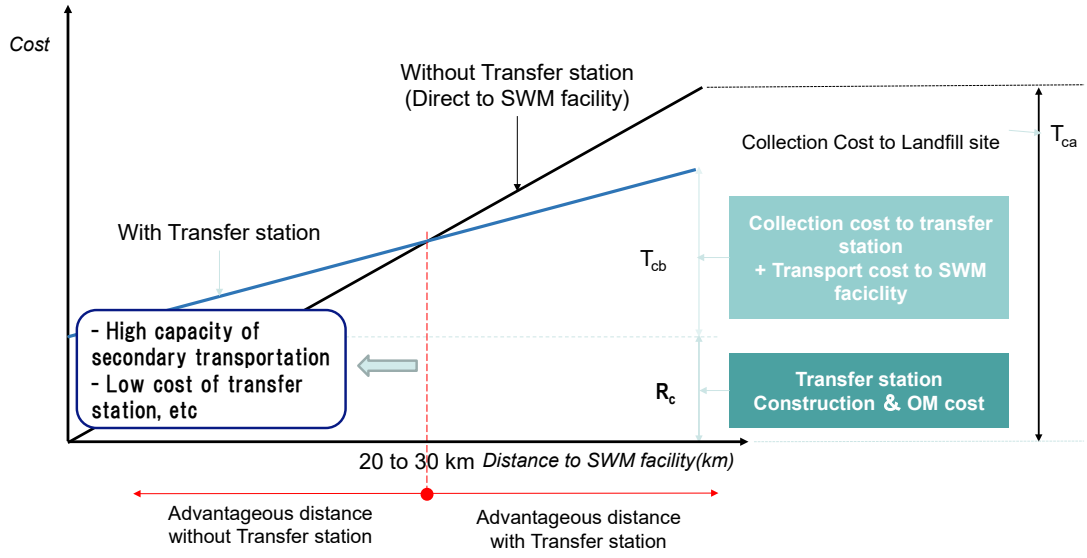
- Increase of the transportation efficiency
- Reduction of transportation cost
- Mitigation the traffic congestion by waste collection and transportation
- Reduction of greenhouse gas emission in aspect of the reduction of the number of trip of transportation vehicles

2.2 Consideration of Waste Transfer

In general, the collection and transportation mainly include waste collection in collection area and transportation to treatment and disposal facilities from collection area. The key point to reduce the time for collection and transportation is to improve transportation efficiency as well as collection efficiency including loading waste and route selection within collection area. When the distance from collection area to the treatment and disposal facilities is long, the transportation efficiency should be improved by transferring from small collection vehicles to large vehicles.

In case of considering waste transfer system, it is necessary to consider not only transport efficiency but also cost effectiveness. The construction, operation and maintenance cost of waste transfer system (waste transfer station + secondary transportation vehicles) should be smaller than the cost of collection with direct transportation.

As shown in the figure, the total cost of collection and transportation with transfer station (Tcb) is lower than the total cost of collection and transportation (Tca) in the case of direct transportation (Tca > Tcb), then the introduction of a transfer station will be economically effective. Though it depends on the target countries, the introduction of the system is worth considering when the transport distance exceeds around 20 to 30 km.



Source: Waste collection –theory and implementation p145, Maruzen (2011)

Figure 2: Image of Comparison of Cost based on the Distance to SWM facility in the Cases of “With Transfer Station” and “Without Transfer Station”

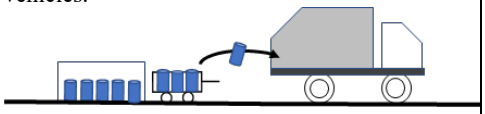
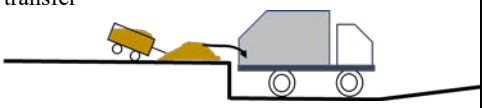
2.3 Type of Transfer Station

Transfer system mainly involve loading from small vehicles to large vehicles. They range from small scale using manual methods to large one using automatic methods. The main methods for small scale waste transfer station are shown in Table 2.1. The main methods for large scale transfer station are Open Top Transfer trailers/containers Type Transfer Station, Compactor Container method, and Dust drum method, each of which is shown in Table 2.2.

2.3.1 Small Scale Waste Transfer station

There are some types of small scale waste transfer station. Each type of waste transfer station is shown as follows.

Table 5: Examples of Alternative Cases for Small Scale Waste Transfer Station

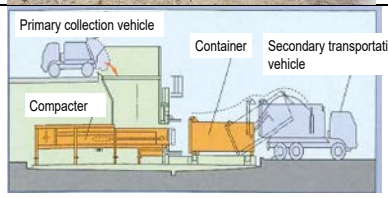
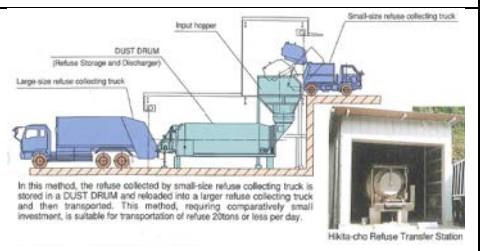
Number of Case	Explanation of Case	Positive feature	Negative feature
Case TS -1	Utilize waste bin not unloading at transfer stations but directly transferring into collection vehicles. 	- Need waste bin only	- Need cooperation of primary collector
Case TS -2	Utilize the platform with slope for smooth transfer 	- No significant change of current primary collection method	- Need construction work of ramp for primary collector
Case TS -3	Mechanical loading of container in rickshaw van by utilizing hydraulic power of refuse collection vehicle. The container of rickshaw van is fucked in the arm in compactor vehicle to load it up and reverse it like the pictures 	- Not necessary of unloading onto the ground - Not necessary of loading manually	- Need of maintenance of mechanical parts in primary collection vehicle
Case TS -4	Utilize heavy equipment to transfer from rikshaw van to secondary transportation vehicle like dump truck 	- Not necessary of loading manually	- Need of heavy equipment - Scattering the waste in the site

Source: JAT

2.3.2 Large scale transfer station

There are some types of large scale waste transfer station. Each type of waste transfer station is shown as follows.

Table 6: Examples of Alternative Measures for Large Scale Waste Transfer Station

Type of transfer method	Main features	Image of the method
Open Top Transfer trailers/containers Type Transfer Station	Waste can be unloaded directly into the "open top" of the trailer or can be unloaded on the tipping floor to allow for materials recovery and waste inspection before being pushed into the trailer or container. This is a simple technology that does not rely on sophisticated equipment such as compactor or baler	
Compactor-Container Method	This method produces high efficiency of secondary transport due to the waste compaction at waste transfer station. Waste scattering or environmental problem does not occur due to closed system during waste transfer and compaction process.	
Dust Drum Method	Transfer station like 20 tons or less per day is possible. The waste collected by small-size refuse collection vehicle is stored in a dust drum and reloaded into a larger refuse collection vehicle for secondary transportation.	

Source: JAT

In addition to the above waste transfer by large transportation vehicles, there are also cases of waste transfer from collection vehicles to ships or railroads, etc. For example, in Tokyo, non-combustible waste is delivered to the Nakaho non-combustible Waste Disposal Centre or the Keihinjima Non combustible Waste Disposal Centre, but since both facilities are located on the waterfront, some wards have set up a transfer station and have been transferring the waste into a barge for secondary transportation. In case of Kawasaki City, they use railway for waste transfer. Photographs of secondary transportation by barge and railway after waste transfer at the transfer station are shown below.

3 Preventive Maintenance of Collection Vehicles

The maintenance of collection vehicles is divided into daily check and periodic inspection such as monthly or yearly ones for maintenance, which is either directly managed by the municipality or outsourced to the private sector.

The maintenance of collection vehicles requires a wide variety of tools, machines, spare parts, measuring instruments, maintenance workshop which has maintenance area, storage space and personnel to handle these tools. If the number of collection vehicles is small and there is a private maintenance workshop nearby, large-scale maintenance may be outsourced to the private sector. However, it is important for the responsible organization of operation and maintenance that owns the vehicles to conduct daily checking, monitoring, and maintenance, including cleaning and daily inspections of the vehicles themselves. This will ensure that the vehicles are properly maintained and managed, allowing them to be used for a long period of time.

3.1 Operation Record

The operation record is necessary to identify the condition of collection vehicle and to consider the maintenance plan. Drivers should enter the vehicle number, working hours, and results of vehicle inspections as daily driving report. Drivers should also enter details of actual or perceived problems experienced when using the vehicle, and report to the staff in charge of vehicle management after work is completed. Staff in charge of vehicle management will take the necessary measures based on this report. An example of operation record is shown as follow.

Table 7: Example of Operation Record

Item	Contents
Vehicle type	Enter the type of vehicles such as compactor or dump truck, etc.
Loading capacity	Enter the vehicle's loading capacity (ton).
Registration number	Enter the registration number of vehicle
Name of the vehicle manufacturer	Enter the manufacture of vehicle
Starting time for each date	Enter the starting time
Ending time for each date	Enter the ending time
Operation hour (hr.) for each date	Enter the operation hour for each date
Operation distance [km/day] for each date	Enter the operation distance for each date, which will be reference for maintenance schedule preparation
Loading weight (ton) for each trip	Enter the loading weight for each trip which will be reference for maintenance schedule

Source: JAT

3.2 Daily Check

Before starting the operation, it is necessary to check the collection vehicles. The details of the checking points are based on the operation and maintenance manual provided by the manufacturers. However, it will be better to have separate checking lists for the operators, such as drivers and collectors. An example of the check items is shown as follows.

Table 8: Example of Daily Check Item

Item	Contents
Foot brakes	Check the condition of the brake pedal and brake response.
Parking brake	Check the condition of the lever for the parking brake
Amount of brake oil	Check the amount of brake oil in the reserve tank.
Amount of engine oil	Check that the amount of engine oil is within the appropriate range on the oil gauge.
Headlights and turn signals	Turn on the headlights and turn signals to check the working condition
Fan belt	Check the tension of the fan belt and look for signs of damage.
Tires	Check the air pressure, wear and tear, and signs of damage to tires.
Coolant	Check the amount of coolant in the reserve tank and that there is no leakage.
Rear and side view mirror	Check how objects are reflected in the rear and side view mirror and adjust the mirror position if necessary
License plates	Check that the license plates on the front and/or back of the vehicle are not damaged or loose.
Remarks	-

Source: JAT

3.3 Maintenance Record

It is necessary to implement maintenance periodically such as monthly or yearly. Therefore, previous maintenance record should be especially kept for next maintenance at least and desirably kept for a certain period like 5 years or 10 years. The example of the items of maintenance record is shown as follows.

Table 9: Example of Maintenance Record

Item	Contents
Name of the vehicle manufacturer	Enter the manufacture of vehicle
Registration number	Enter registration number
Purchase date	Describe the purchase date for considering the routine repairment
Loading capacity	Describe loading capacity as reference
Maintenance date	Describe the previous maintenance date for planning maintenance date
Details of maintenance work	Describe the detail maintenance work for next maintenance work
Next Maintenance Time	Describe next maintenance time as a plan
Maintenance costs	Describe the maintenance cost as reference
Name of responsible organization and person of the maintenance	Describe the name of responsible organization and person

Source: JAT

4 Public Area Cleansing

4.1 General

The street sweeping is necessary activities in SWM, especially for the areas which has the issues of public awareness and/or collection system. Many cities spend between 30 to 50 percent of their solid waste budgets on street cleaning.

It is a service for which a wide variety of tools, equipment and methods, both manual and mechanical, are available, and it is one in which there is often great scope for financial saving by the introduction of more efficient methods. This is an area in which public relations are very important. Much of the work arises directly from shortcomings in public behaviour, such as throwing litter on the streets and open spaces.

In some areas, however, a high proportion of street waste arises from deficiencies in the waste collection service, leading residents to dispose of domestic and shop wastes in the streets. The cost of removing wastes which have been scattered on the streets is very much higher than the cost of collecting similar wastes which have been placed in containers such as domestic wastes bins or litter containers. Thus, street cleaning policies should have the following objectives:

- Provision of clean condition of roads and public spaces for households and business establishment,

- Reduction of waste scattering by environmental education and public awareness raising,

- Optimisation of systems which achieve high labour productivity by using effective tools and equipment.

4.2 Type of Waste

For the purpose of solid waste management all street wastes fall into three main categories:

(1) Natural Wastes

These include dust in unpaved areas, and decaying vegetation such as fallen leaves, blossoms and seeds which originate from trees and plants in the city. Natural wastes cannot be avoided, but may be controlled by such measures as the careful selection of the types of tree planted in the city.

(2) Road Traffic Wastes

Motor vehicles deposit oil and mud. In addition, there is sometimes accidental spillage of a vehicle's load. Animals drawn vehicles deposit excrement on the road surface. At large construction sites, mud is often carried away by motor vehicles and deposited on adjacent roads; this can cause danger to other traffic in wet weather.

(3) Behavioural Wastes

The main source of wastes is litter thrown by pedestrians and household waste or shop-wastes swept or thrown out of private premises instead of being placed in the suitable container. Behavioural wastes are largely avoidable provided an appropriate waste collection service is in operation and waste bins on the sidewalk along the road are provided for the use of pedestrians. But success requires a continuing programme of public education and awareness backed up by legislation and rapid enforcement measures.

4.3 Plan of CLEANING OF STREET AND PUBLIC PLACES

Streets usually consist of a paved road for cars and motorbikes and sidewalks for pedestrians on both sides. The sidewalks are slightly raised and separated from the paved road by the drainage channel. The channel is the lowest part of the road structure and serves as a drainage channel during rainfall. There, at regular intervals, gutters are provided to channel surface water to the main drainage system.

Highway surfaces rarely need to be swept because the flow of traffic by motor vehicles carries dust and dirt away from the pavement and concentrates it in the side channels.

Thus, there are usually two areas for street sweeping: sidewalks and waterways. The debris on the sidewalks is primarily light debris and dust, while the waterways usually contain a higher percentage of sludge, which has a higher density.

Sidewalks tend to be large areas where waste is scattered, while waterways are narrower strips and tend to be heavier with more waste. While these principles apply to most urban streets, the

amount of waste generated varies in proportion to the level of human activity, and the required cleaning frequency can range from several times a day to once or twice a week.

Daily cleaning frequency is essential when there are residents living near a public road. Isolated areas or roads with few residents in the vicinity do not require daily cleaning though the periodical cleansing is necessary. A street cleaning schedule should be developed, prioritizing which streets need daily cleaning and which need periodic cleaning.

Daily cleaning of public streets, avenues, paths, and side streets should be performed on a daily basis when there is residential or commercial activity on one or both sides of the street, as well as on streets in daily use, including Sundays and holidays.

A list of the lengths and widths of such streets and avenues must be prepared and a program for daily cleaning must be developed by the local government, taking into account the established standards. Unoccupied streets and avenues that do not require daily cleaning may be divided into separate groups and cleaned every other day, twice a week, once a week or occasionally, depending on the need, as the urban municipality deems appropriate. Similarly, a timetable for regular cleaning should be developed to ensure that Open space is kept clean and not turned into a waste dumping area.

Table 10: Example of Sweeping Plan

Area	Type of area	Frequency
Area 1	City center shopping	Daily
Area 2	Market areas Daily	Daily
Area 3	City center and minor streets	Daily
Area 4	Sub-urban shopping streets	Daily
Area 5	Residential streets (high & low income)	Daily
Area 6	Roads and streets having no households/establishments	Once a week
Area 7	Sub-urban main streets	Twice a week
Area 8	Open Space	Occasionally, when required.

Source: JAT

4.4 Cleaning Method

4.4.1 Manual Cleaning

Basically, manual cleaning is utilized in developing countries and useful for narrow road and/or rural bumpy road. Even though manual cleaning method is applied, use of appropriate tool and/or equipment play an important role in improving the efficiency of the work force. Equipment used for manual street sweepings are brooms, shovels, and transportation equipment are handcart, rickshaw van and containers, etc. Presently most of the tools utilized by the sanitation workers are inefficient and outdated and need to be replaced by new tools and equipment. The pictures of the situation of manual cleaning are shown as follows.

	
Sweeping by Cleaning Staff	Collection of Swept Waste by Primary Collection Vehicle (Rickshaw Van)

4.4.2 Mechanical Cleaning

Road sweepers for mechanical cleaning are suitable for cleaning main roads where wide vehicle can pass by and are not suitable for cleaning narrow roads such as in residential areas. In addition, while they can remove small debris such as sand, large debris such as empty cans must be picked up by people because they can cause breakdowns road sweeper. Therefore, depending on the situation, prior removal of debris by hand is necessary. In addition, road sweepers operate in the middle of the night, and the speed of road sweepers is 40 to 50 km/hr. Traveling at that speed on an main road causes a great deal of inconvenience to other drivers. If there is a lot of traffic, it may cause a traffic jam, so it is chosen to utilize the midnight hours when there is less traffic. There are two types of dust collection methods used by street sweepers. One is the "brush type," which collects waste or dust by scraping it up with brushes, and another is the "vacuum circulation type," which collects waste or dust by suction. The pictures of two types of road sweepers are shown as follows.

	
Three wheels brushing type road sweeper	Vacuum circulation type road sweeper

Technical Project on Advisor for Marine Plastic Litter Management in the Caribbean Region

Technical Note No.3

Material Recycling and Composting

JICA
Japan International Cooperation Agency

October 2023

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- Material Recycling and Composting -

Prepared by Yukihisa SAKATA, JICA Advisory Team
October 2023

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1 Material Recycling

1.1 Objective

The purpose of material recycling is to conserve resources, reduce landfilled waste amount, and minimize the environmental impacts.

Firstly, material recycling plays an important role in conserving resources, as it allows for the recovery and reuse of materials from discarded products. By implementing recycling processes, recyclable materials like metals, plastics, paper, and glass can be extracted and reprocessed to produce new goods. This reduces the dependence on raw material extraction and preserves natural resources for future generations.

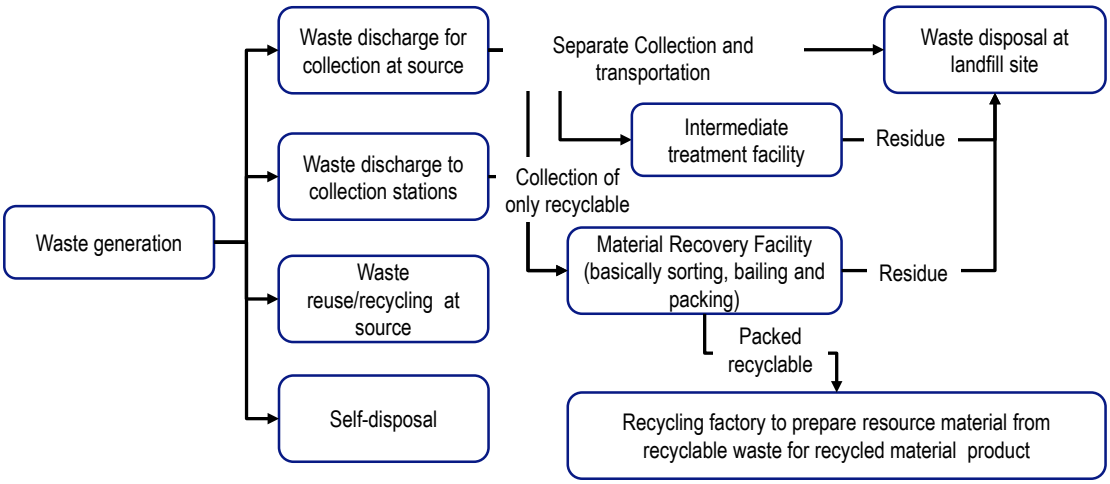
Secondly, an objective of material recycling is to reduce waste disposal amount to be landfilled. Recycling diverts materials away from disposal sites and put into productive use, thereby extending the lifespan of landfills and reducing the need for new waste landfill sites.

Material recycling also mitigates the environmental impact associated with raw material extraction and manufacturing processes. These activities are often energy-intensive and emit greenhouse gases, contributing to climate change.

On the other hand, recycling process also cause environmental impacts such as air and water pollution from extracting, processing, and disposing of raw materials but the recycling process could include suitable environmental pollution control system to mitigate the pollutions.

1.2 General Waste Flow of Inorganic waste

To consider the recycling system, it is firstly important to prepare the current waste flow of inorganic waste including recyclable and residue from waste generation, collection and transportation, intermediate treatment, material recovery facility, final disposal, etc. An example of waste flow is shown as following figure.



Source: JAT

Figure 1: Example of Waste Flow of Inorganic Waste

1.3 Current Situation and issues in Caribbean Country

The current recycling situation in the Caribbean countries presents several challenges. While there are some companies engaged in recycling activities, the total volume of recyclable separated from the waste generated is not substantial. Most of these companies simply package the recyclable and export it to other countries due to limited recycling facilities and infrastructure locally.

The recyclable generated in the region is higher expenditures for transportation and recycling more than sale price. The sale price of recyclable is often unpredictable and tends to fluctuate, leading to difficulties in covering the transportation costs constantly associated with the proper packaging of recyclable materials. As a result, the financial viability of recycling initiatives is uncertain, hindering their growth and sustainability.

For example, some of the recyclable is stored in each recycling company after compaction and packing for waiting for the better condition of the recycling market. The following pictures show storage condition of recyclable in the facility in Recycling Partner of Jamaica.

Storage Area in Recycling Partner of Jamaica (No.1)

Storage Area in Recycling Partner of Jamaica (No.2)

Source: JAT

1.4 Existing Recycling Technology

Recyclable waste includes metal, plastics, paper and glass, etc. In case of recycling of waste plastics, there are three types of recycles such as material recycle, chemical recycle and thermal recycle (energy recovery).

Material recycling involves physically processing the waste plastics by crushing and melting them, converting them back into plastic products such as PET bottles and containers.

Chemical recycling, on the other hand, employs advanced processes to break down the waste plastics. This enables the conversion of the plastics into raw materials that can be used to produce not only new plastic products but also a wide range of other chemical compounds and materials.

Thermal recycling involves incinerating the waste plastics, which generates energy during the combustion process. This energy can then be harnessed and utilized for various purposes, such as electricity generation or heating. While this method can be beneficial for energy recovery, it is essential to ensure that the incineration process is carried out with proper environmental controls to minimize harmful emissions.

Table 1: Classification of Recycling Methods of Plastic Waste

Classification	Method of recycle	Final product
Material Recycle	Reutilization as plastic material and/or plastic product	PET bottle, plastic sheet, moulded product, plastic film, fibre, etc
Chemical Recycle	Resource material and/or monomer	PET bottle after monomer
	Reducing agent and fuel for blast furnace	Blast furnace gas for power generation
	Chemical resource for coke furnace	Cokes, cokes furnace gas for reducing agent
Thermal Recycle	Fuel for cement factory Waste to energy, Refuse Derived Paper and Plastics Densified Fuel (RPF) or Refused Derived Fuel (RDF)	Thermal energy and energy for power generation

Source: Japan Containers and Packaging Recycling Association (JCPRA)

In case of material recycle of PET bottle, after sorting and removing impurities from the recyclable plastic waste, the sorted PET bottle is baled using a baling machine and temporarily stored. It is then crushed and washed to produce flakes. After that, the flake is melted and granulated in a granulator to create pellets.

These recycled raw materials, which include flakes and pellets, are utilized to produce plastic product through melting process including moulding. The materials are melted down again in these plants to manufacture products such as underlays, weed prevention sheets, work clothes, detergent bottles, and more. This recycling process facilitates the transformation of waste plastics into resource for plastic products, contributing to a more environmentally friendly and circular economy approach.

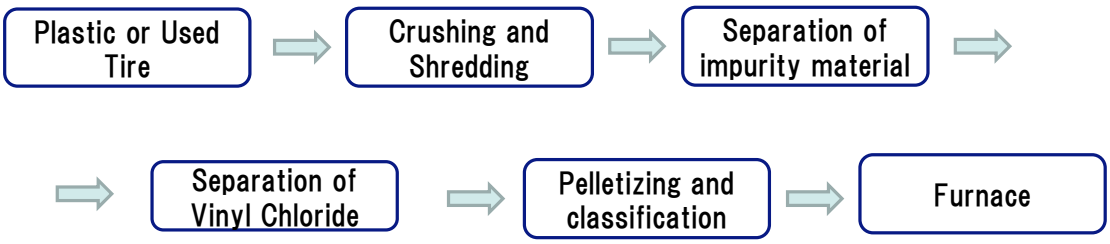
The flow from collection to flake and pellet production for plastic waste recycling is shown in the following figure.

Source: Japan Containers and Packaging Recycling Association (JCPRA)

Figure 2: Flow from Collection to Flake and/or Pellet Production for Plastic Waste Recycling

In case of the other mixed plastic, various plastics are sometimes collected as mixed together, such as polyethylene used in plastic containers and bags other than PET bottles, polystyrene in food trays and cushion materials. The mixing of multiple plastic types complicates the sorting and cleaning processes, making material recycling challenging.

Additionally, certain food packaging is composed of various materials combined and it is difficult to clearly separate each sort of material. Because plastic have high lower calorific value, it is often processed into fuel, known as Refuse-derived Fuel (RDF), by blending them with materials like paper, adjusting the calorific value. For waste tires, material recycling is also challenging, and the mainstream practices involve converting them into solid fuel or using them in cement plants. On the other hand, plastic such as Polyvinyl Chloride (PVC) includes chloric components to be removed by specific gravity separation because the specific gravity of PVC is higher than the other plastics such as Polyethylene, Polypropylene and Polystyrene before their going to the furnace in cement processing as following figure.



Source: JAT

Figure 3: Example of Flow of Thermal Recycle Plastic including Vinyl Chloride

1.5 Transboundary Issues (Basel Convention)

The Basel Convention, formally known as the "Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal," is an international treaty that establishes a framework and procedures for the regulation of certain hazardous waste movements across borders and their disposal.

During the 14th Conference of the Parties to the Basel Convention (COP14), which took place from April 29th to May 10th, 2019, a resolution was adopted to amend the annex of the Basel Convention concerning the transboundary movement and disposal of hazardous waste (hereinafter referred to as "the Basel Convention") to include plastic waste as a new regulated category. The amendment to the annex became effective on January 1, 2021, and as of that date, prior consent from the importing country is required when exporting plastic waste falling under the scope of regulation in the Basel Convention.

The regulated plastic waste includes not only hazardous plastic waste but also plastic waste that requires special consideration. However, the specific criteria for determining which plastics fall under the category of waste requiring special consideration are subject to interpretation by each contracting party to the convention.

In case of Japan, the specific act regarding Basel Convention has been amended based on above amendment. The purpose of this is to enable appropriate judgment on whether a particular plastic waste is subject to regulation under the Basel Convention and the Act on the Control of Specific Hazardous Wastes and Other Wastes (Act No. 108 of 1992) that guarantees the Basel Convention when exporting plastic waste.

Source: Ministry of Environment in Japan

Figure 4: Regulated Plastic (mixed colour) and Not Regulated Plastic (single coloured plastic)

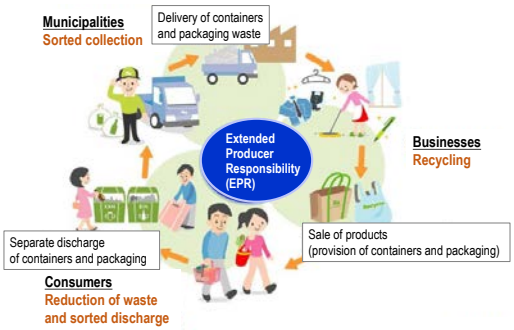
In case of Japan, for example, pellets and single colour flakes are exemption of special consideration. However, if mixed colour plastic is processed into flakes, it is difficult to visually distinguish contamination and foreign substances. Therefore, the exemption is not applied for the mixed coloured plastic flakes. On the other hand, if plastic waste generated during the manufacturing process is directly processed or adjusted into flakes or pellets, it is less likely to have contamination and foreign substances adhering to it during that process. Therefore, if it can be confirmed from transaction documents that the plastic waste originated from the manufacturing process, it will be exempted from special consideration in the regulation.

In case of CARICOM, it will be necessary to establish the criteria to satisfy Basel Convention in each country or to prepare to establish a practical and suitable agreement between CARICOM, OECS or relevant countries regarding recycling network in the Caribbean Region.

1.6 Introduction of Recycling System of Packaging and Container Waste in Japan

The recycling system is governed by the Containers and Packaging Recycling Law, which was enacted in 1995 and has been amended to strengthen recycling targets and expand the scope of covered materials. Under this law, businesses that handle packaging and containers are required to take responsibility for their waste management by participating in designated recycling organizations and setting up their recycling systems.

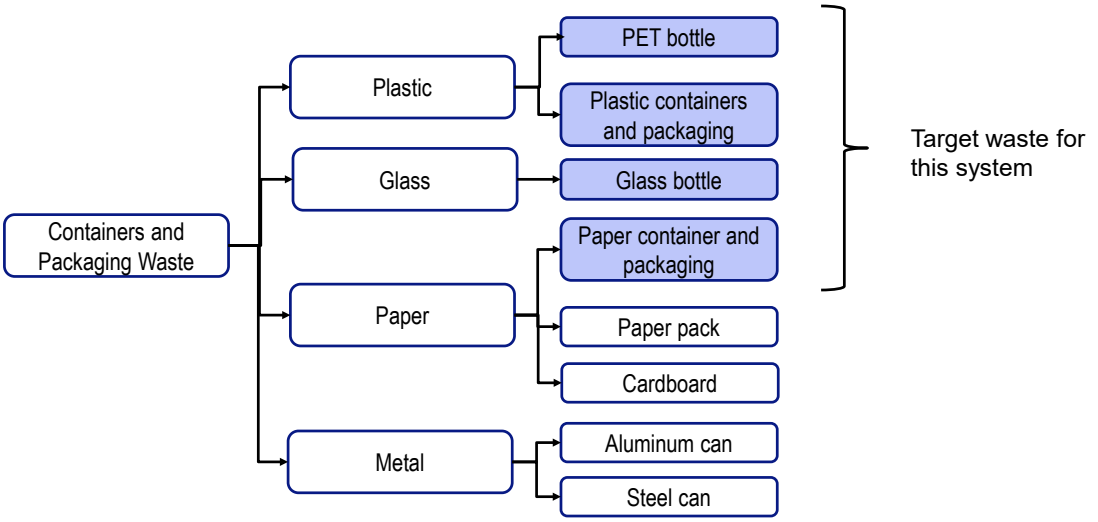
Consumers play a crucial role by separating packaging and container waste at source into specified categories, such as plastic bottles, aluminium cans, glass bottles, and paper packaging, before collection service of them. Local municipalities provide separate collection and sorting facilities, and the business entities are responsible for recycling the collected recyclable in recycling facilities.



Source: Japan Containers and Packaging Recycling Association (JCPRA)

Figure 5: Each Roles of the Stakeholders related to Plastic Recycling

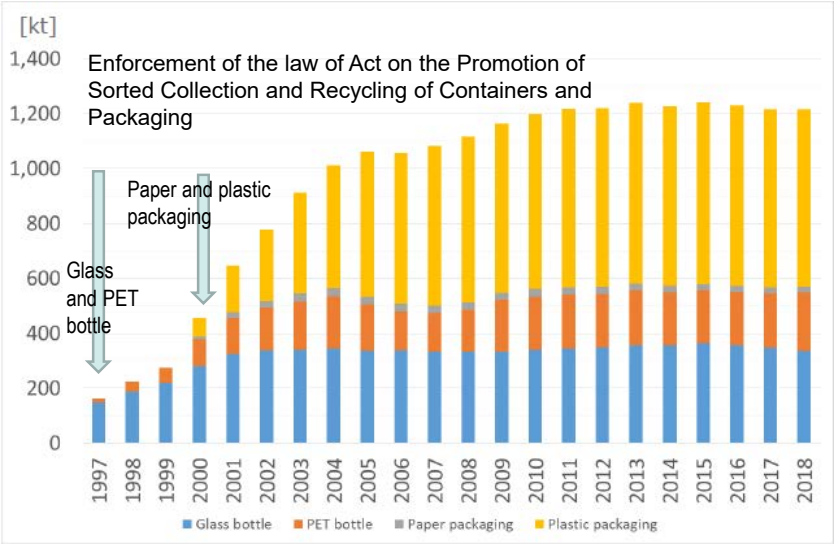
The collected packaging and container waste is sorted and processed at recycling plants to remove any impurities and prepare the materials for recycling. Depending on the type of waste, the recycling system governed by the Containers and Packaging Recycling Law" is applied. The type of waste which this system applies is shown in the following figure.



Source: Japan Containers and Packaging Recycling Association (JCPRA)

Figure 6: Type of waste which the system applies stipulated in Containers and Packaging Recycling Law

Recycled materials are then reintroduced into the production cycle, reducing the need for raw materials and conserving natural resources. By promoting the use of recycled materials, the recycling system contributes to energy conservation, greenhouse gas emission reduction, and waste reduction, supporting Japan's sustainability goals. Since 1997, the recycling of glass and PET bottles has increased, and the recycling of plastic and paper packaging has also seen an increase since 2000. Overall, Japan's recycling system for packaging and container waste might be able to serve as an effective model for other countries aiming to address the challenges of waste management and build circular economy.



Source: Japan Containers and Packaging Recycling Association (JCPRA)

Figure 7: Historical Trend of Recyclable Packaging and Container Waste in Japan

2 Composting

2.1 Objective

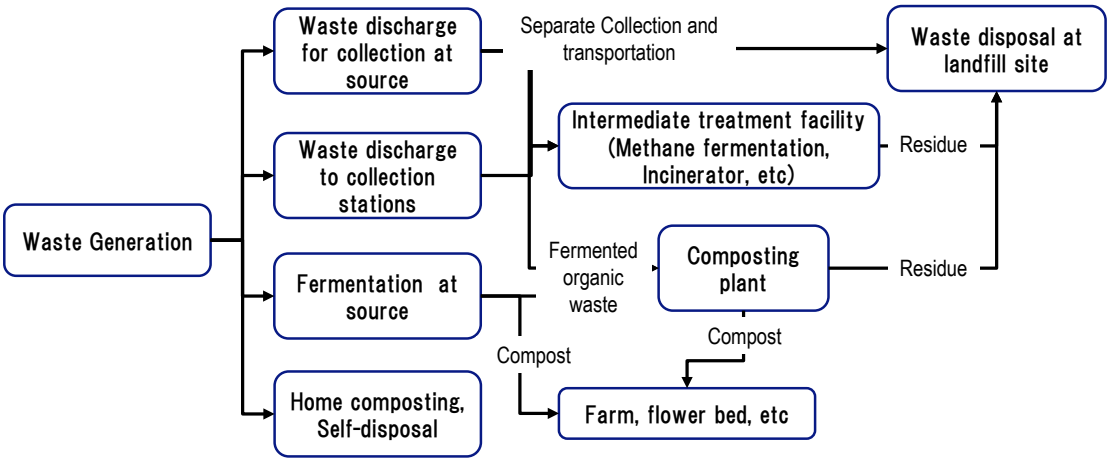
The purpose of composting are volume reduction of organic waste and resource circulation by returning organic waste to the natural cycle. The specific objectives are as follows:

- Waste Reduction: Composting organic waste reduces the amount of waste sent to landfills, thereby decreasing the overall waste generation.
- Resource Recycling: Product produced of the composting process from organic waste could be used for fertilizer or soil conditioner in agricultural fields and gardens.

To achieve these objectives, individuals, businesses, and local governments promote composting to ensure proper disposal and recycling of organic waste.

2.2 General Waste Flow of Organic Waste

To consider the handling procedure of organic waste, it is firstly important to prepare the current waste flow of recyclable waste as well as understanding waste characterization and compost demand. An example of waste flow is shown as following figure.



Source: JAT

Figure 8: Example of Waste Flow of Organic Waste

2.3 Current Situation of Organic Waste in Caribbean Country

Currently, the composting situation in the Caribbean countries varies widely, with some countries making some progress in promoting composting practices, while others face challenges in implementation. Several Caribbean countries have recognized the importance of composting for waste management and sustainable agriculture.

In countries where composting is well-established, there is a growing emphasis on waste reduction, resource recovery, and environmental protection. Composting for kitchen waste and/or garden waste have been launched to encourage citizens to separate the wastes from their household waste and participate in composting activities.

However, Caribbean nations are still struggling to implement effective composting programs. Limited resources, lack of infrastructure, and insufficient awareness among the population hinder the widespread adoption of composting practices. Additionally, some countries face challenges in handling composting in urban areas with high population density.

To address these challenges and promote sustainable waste management, regional collaborations and partnerships are being fostered among Caribbean countries. Exchange of best practices, capacity building, and technical assistance are being provided to help these nations develop successful composting strategies.

Despite the disparities in the current composting status, there is a growing recognition of organic waste reduction to be landfilled in the Caribbean region. Continued efforts to strengthen composting practices can contribute to mitigating waste disposal issues.

2.4 Composting

2.4.1 Type of Composting

In waste management, composting is one of the means of "reduction and recycling of organic waste. In order to promote the reduction and recycling of organic waste, it is important to use the compost after the production, and it is necessary to produce compost that is effective for agriculture and horticulture, etc., which are the destinations of compost utilization. There are large and small scales for composting as follows.

(1) Type of Large-Scale Compost

As a large-scale composting facility, it is classified into two types: piling method and mixing method. Regarding the piling method, the structure is simple, with composting materials covered by a roof for rain protection and separated by partitions. Mixing is done using equipment like a wheel loader. Due to the slower reaction rate of this type of composting, some compost sheds have added ventilation functionality to the floor area. However, this method has the drawback of easily dispersing unpleasant odors outside, making it less suitable for locations near residential areas. Nonetheless, it is a cost-effective approach as it requires minimal mechanical equipment.

As for the mixing method, there are two types: open-air mixing method and sealed mixing method.

In the open-air mixing method, composting materials are mixed and supplied with oxygen using automated machinery. Some systems have ventilation functionality, while others do not. Various types of machines are used for mixing, including rotary, scoop, crane, screw-auger, and self-propelled systems.

In the sealed mixing method, there are two types: vertical and horizontal. Both types require a relatively small installation area, and some facilities also have heating capabilities. The vertical type consists of an insulated cylindrical fermentation tank placed vertically. Composting materials are input from the top and mixed using internal stirring blades. The composted material is then extracted from the bottom of the reaction tank. Though the first fermentation period is relatively short, secondary fermentation is essential. The horizontal type is also known as the rotary drum method. It involves a cylindrical fermentation tank with insulation.

(2) Type of Small-Scale Compost

There are some types of home composting process such as cardboard composting, inground composting and bio reactor.

Cardboard composting is a method of reducing and composting kitchen waste from households by placing it in a cardboard box along, which is a type of aerobic composter. This feature allows

it to be used even in apartment buildings or places without a garden. The advantages of the cardboard composter include the affordability and easy availability of the cardboard box used as a container, as well as its effectiveness in providing insulation and allowing excess moisture to be released from the walls. These features make it a cost-effective and functional option for composting.

Inground composting is a method of composting where kitchen waste is buried in the ground for decomposition. This process allows the microorganisms in the soil to break down the organic matter and turn it into compost. Inground composting is a simple method as it doesn't require special composting bins or structures, and it helps minimize odors and pests associated with traditional compost piles.

An electric kitchen waste processing machine, also called a bioreactor, uses electrically generated warm air to dry and compost kitchen waste. It can be installed indoors, and compost can be rapidly produced through the decomposition of kitchen waste. However, the main disadvantage is high cost of the machine itself. Additionally, it consumes electricity, leading to higher energy costs, and it generates noise during operation.

Table 2: Comparison of Main Home Composting Methods

Name	Setting location	Temperature measurement	Time	Advantage	Disadvantage
Cardboard Composting	Indoor （to prevent rainfall)	Necessary	Around 3 month	Low cost and easy to handle	Everyday care like mixing or temperature control
In-ground composting)	Outdoor	Not necessary	Around 3 month	Easy to prepare large amount of compost	Necessity of filling place of organic waste
Bio reactor	Indoor	Not Necessary	Around one week to two weeks	A little labor	Necessary of initial and operation cost

Source: JET

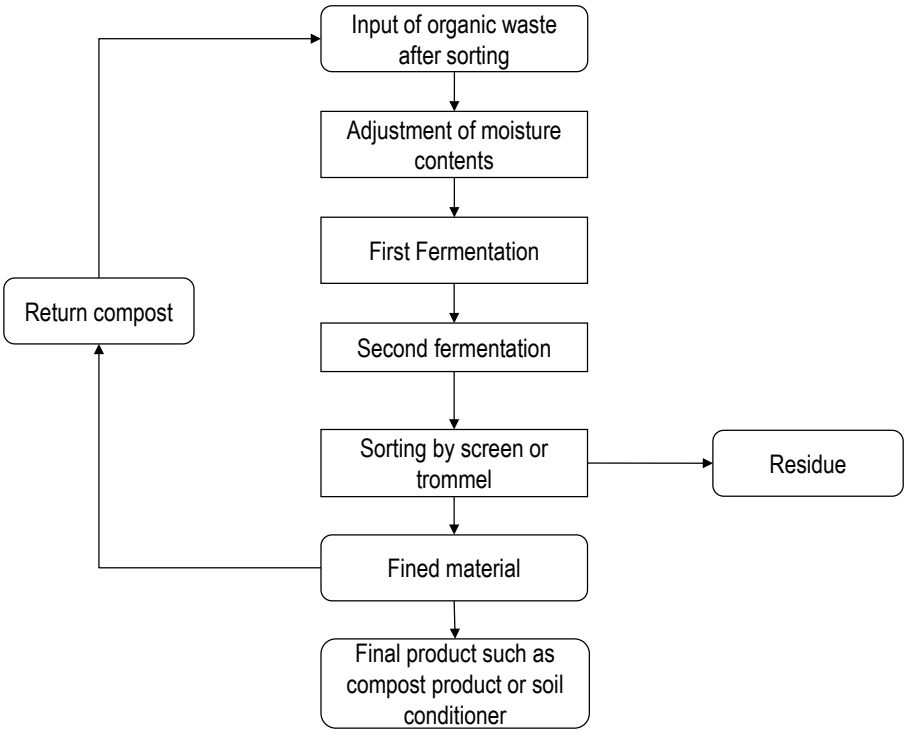
2.4.2 Composting Process

The organic waste (food waste, branches, leaves, etc.) brought into the composting facility is sorted to remove impurities and inappropriate materials such as plastics. It is then crushed and shredded to facilitate decomposition, and adjusting materials are mixed in for moisture regulation before conducting fermentation in the fermentation area.

The composting process can be broadly divided into two stages: "primary fermentation" and "secondary fermentation." In the primary fermentation stage, easily decomposable organic matter in the waste, such as carbohydrates and sugars (organic matter easily broken down by microorganisms), is decomposed by microorganisms, which use it as an energy source and multiply. The heat generated during the decomposition of this easily decomposable organic matter can raise the temperature inside the waste layer, reaching temperatures of 60 to 80°C. During the first half of primary fermentation, microorganisms capable of living and multiplying in high-temperature conditions become overwhelmingly abundant compared to other bacteria. Later on, as easily decomposable organic matter like carbohydrates is fully decomposed, the temperature inside the waste layer begins to decrease. Primary fermentation is completed in a few weeks.

In the secondary fermentation stage, toughly decomposing organic matter like cellulose and lignin is decomposed. Secondary fermentation, also known as the "maturation process" of compost, is a process where the remaining organic matter from primary fermentation is slowly decomposed for long time at temperatures of around 30 to 40°C. Afterwards, the compost is screened for particle size adjustment and transformed into the final product. The compost produced during this stage contains a wide range of useful microorganisms, making it suitable for reuse as "returning compost" to facilitate further composting of organic waste.

The typical composting process are shown in the following figure.



Source: JET

Figure 9: Typical Composting Process

2.5 Cases in Japan

2.5.1 Home compost

Home compost is implemented in some cities in Japan though it is difficult to implement continuously due to the individual effort of citizens and incentive for the activities. However, some cities make effort to continue the promotion of home compost. Two examples are described as follows.

(1) Case in Kitakyushu City

In Kitakyushu City, the efforts of home compost are being made to reduce waste and promote resource utilization by encouraging composting of kitchen waste at households and collecting the processed materials. The composting from kitchen waste has been conducted by using composting containers (cardboard-style, Takakura-style, etc.) or electric kitchen waste processing machines is accepted if it has undergone primary fermentation and is adequately dried before being placed in poly bags. Kitakyushu City has also introduced a point system for participating in eco-friendly activities, where individuals who bring compost receive 4 points.

Furthermore, the city holds workshops on utilizing kitchen waste composting containers for composting kitchen waste. These workshops introduce the purpose and methods of composting kitchen waste to achieve waste reduction and resource utilization. Participants also engage in practical exercises, such as making composting containers and learning how to compost kitchen waste, providing them with valuable environmental knowledge. In addition, Kitakyushu City introduces eco point system that Kitakyushu City provides eco goods through eco point which they can exchange with the compost product made by the participants.

	
The status of training courses for home composting.	The production status of cardboard composters.

Source: JAT

(2) Case in Sapporo City

For composting kitchen waste at home but have no use for the compost, Sapporo City provides a collection service for kitchen waste compost. The collected compost undergoes secondary processing and is utilized in local farms within the city. Only the compost produced from either a cardboard composter or an electric kitchen waste processing machine produced under aerobic conditions, can be utilized. The compost material must be adequately processed and fully dried without any odor or presence of flies. As a token of appreciation, Sapporo City will present participants with a vegetable exchange voucher when they bring in their compost.

2.5.2 Community Compost

Community compost is implemented in some cities in Japan. It is also difficult to continue the composting from organic waste due to the cooperation of citizen in community base. However, they make effort to implement composting as community basis.

(1) Case in Shibushi City

In case of Shibushi city, organic waste from household is composted in organic factory which contracts with the city. Firstly, residents have to separate the organic waste for compost in their kitchen, and after draining the water using a net or bucket for water drainage, each resident discharges the waste to special bucket for organic waste. The city collects the organic waste 3 times a week and bring to recycling center to conduct composting. The compost after composting process is utilized by farmers and garden of flower shop.

	
The discharge status due to emptying organic waste buckets	In the composting process, a wheel loader is used for transporting and mixing organic waste

Source: Shibushi City

(2) Case in Minato City

The community compost project from kitchen waste generated at each household is conducted. The objective of this project is to convert kitchen waste into compost to reduce the waste and utilize it as compost. The participants of this project are around 30 households, office and school in Minato Ward in Metropolitan Tokyo, and they are registered beforehand. The participants conduct composting from the kitchen waste generated in the households, offices or schools. After first fermentation, they bring the composted material to a park where the compost container is set at the park. Minato ward collaborates with private food recycling company and publishing company for this activity. After the production of compost, it is utilized for tree planting in public space.

	
Signboard and Containers for maturation of composting material collected	A container for maturation of composting material collected

Source: JAT

Technical Project on Advisor for Marine Plastic Litter Management in the Caribbean Region

Technical Note No.4

Intermediate Municipal Solid Waste Treatment

JICA
Japan International Cooperation Agency

October 2023

Technical Project on Advisor for Marine Plastic Litter Management
in the Caribbean Region

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- Intermediate Municipal Solid Waste Treatment -

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October 2023

Table of Contents

Tables

Figures

1 Objectives of this technical note

There are a variety of technologies for the intermediate treatment and recycling of waste in order to minimise the amount of waste sent to landfill and to utilise materials. This technical note aims to provide the reader with knowledge of these technologies, which are widely used in Japan.

2 Role of intermediate treatment in the waste stream

In Japan, the waste generated is not disposed of directly in landfills, but is incinerated, sorted and otherwise processed, collectively referred to as “intermediate treatment.” Intermediate treatment has the effect of reducing the volume of waste itself and sorting out what can and cannot be recycled.

In many developing countries we often see the waste stream as shown in the figure below. Self-disposal (burial, incineration or animal feed) makes up a significant proportion and recycling, which relies mainly on the informal sector, makes up a certain proportion. We can see one MRF (Materials Recovery Facility). However, it is not fully operational because a separate collection system is not well established.

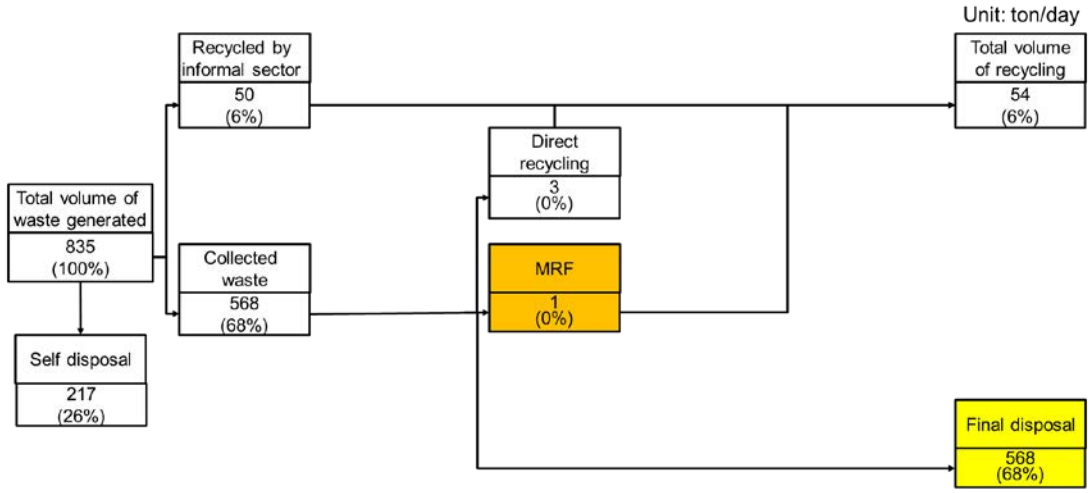


Figure 1: Current waste stream

The figure below shows the waste stream of the example above in 30 years. In this case, a WTE (Waste-to-Energy) plant is installed and the capacity of the MRF has increased. By introducing intermediate treatment, the recycling rate becomes higher and the disposal rate becomes lower than before.

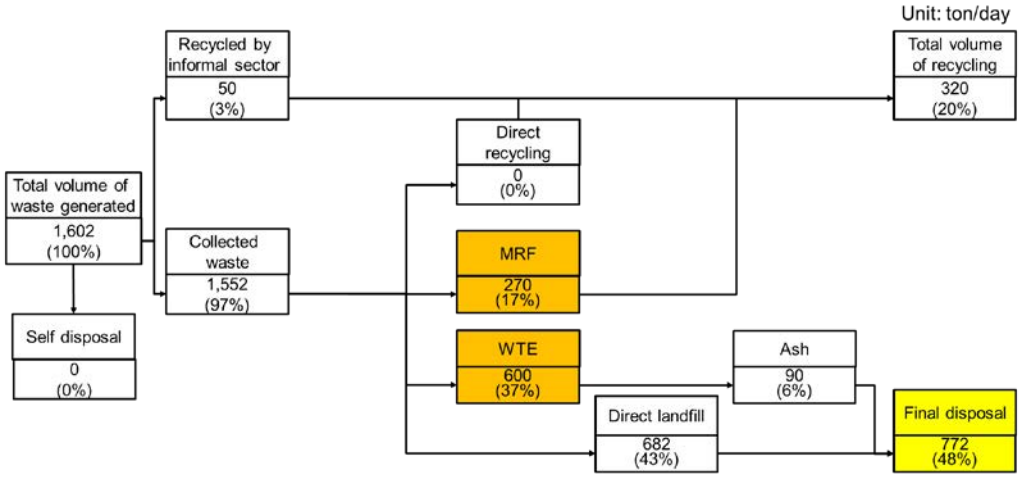
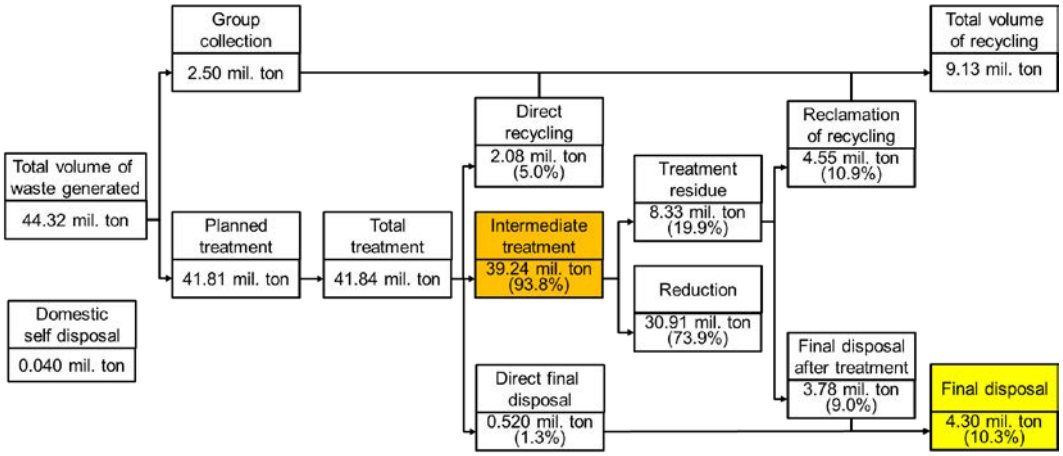


Figure 2: Waste stream in 30 years

The figure below shows the waste stream in Japan. The intermediate treatment rate is 93.8% of the total waste treated in Japan, and the final disposal rate is about 10%. It shows that the introduction of intermediate treatment lowers the final disposal rate. In Japan, as well as in many Caribbean countries, land for final disposal is limited and crucial. That is why intermediate technology has been well developed in Japan.



Source: Waste management in Japan, FY2014 edition, Ministry of the Environment, Japan, 2016

Figure 3: Waste stream in Japan

3 Types of intermediate treatment technology

There are different types of intermediate treatment technology. This chapter presents representative intermediate waste treatment technologies.

3.1 Basic technologies

Basic technologies are used in a treatment/recycling plant with other technologies.

a. Incineration

The purpose of incineration is to reduce the volume of waste by burning it to ashes.

b. Shredding / Crushing

The purpose is to reduce the volume of waste.

c. Sorting

Sorting is to sort waste according to type and purpose.

d. Stabilization

Some waste, such as acid and alkali waste, are harmful to the human body and the environment in their original state. Stabilization is a process of neutralizing such waste and returning it to a stabilized state.

3.2 Treatment/recycling method for each type of waste

To treat recyclables or waste, market demand has to be considered, and the final shape/package of the processed waste is very important. The table below shows where and how each category of waste is used in the market.

For example, organic waste is supposed to be a major component of residential waste, however, it may not be suitable for mass processing and many trials for kitchen waste composting have been suspended before commercial operation.

Table 1: Recycling method for each type of waste

Component	Potential final product	Common current state	Observation
Organic	Compost / animal food / mulching material	Only project basis	Organic waste is a major part of municipal solid waste, therefore, it should be reduced with the most concern.
Paper / Cardboards	Paper / carboards /fuel	A market exists in other countries?	Paper without contamination should be sorted.
Glass	Civil work material	For bottles, a market exists?	Only glass bottles should be sorted.
Metal	Metal	For aluminum, a market exists in other countries?	Should be sorted even if contaminated.
Plastic	Plastic / Fuel(RDF/SPF)	A market exists for selected plastics in some countries	Should be recycled but there is limitation of material recycling due to its quality as raw material.
Other	Other	Dumped in a dumpsite	All for landfilling

3.3 IWMF (Integrated Waste Management Facility)

In European countries, it is often seen that various kinds of waste are treated at one place. It is called “Integrated Waste Management Facility” and has several intermediate treatment functions that can make a series of cascade processing for one category of waste. This technology has been developed:

- To separate recyclable materials that are later sold/handed over to private sector companies or used in public works to save virgin materials,
- To reduce the amount of waste going to landfill, especially organic waste, thereby increasing landfill lifetime,
- To reduce organic waste that contributes to methane gas emission at landfills,
- To reduce organic waste that causes accidental fire hazards, and
- To create many job opportunities around the facilities

The figure below shows a typical illustration of an IWMF.

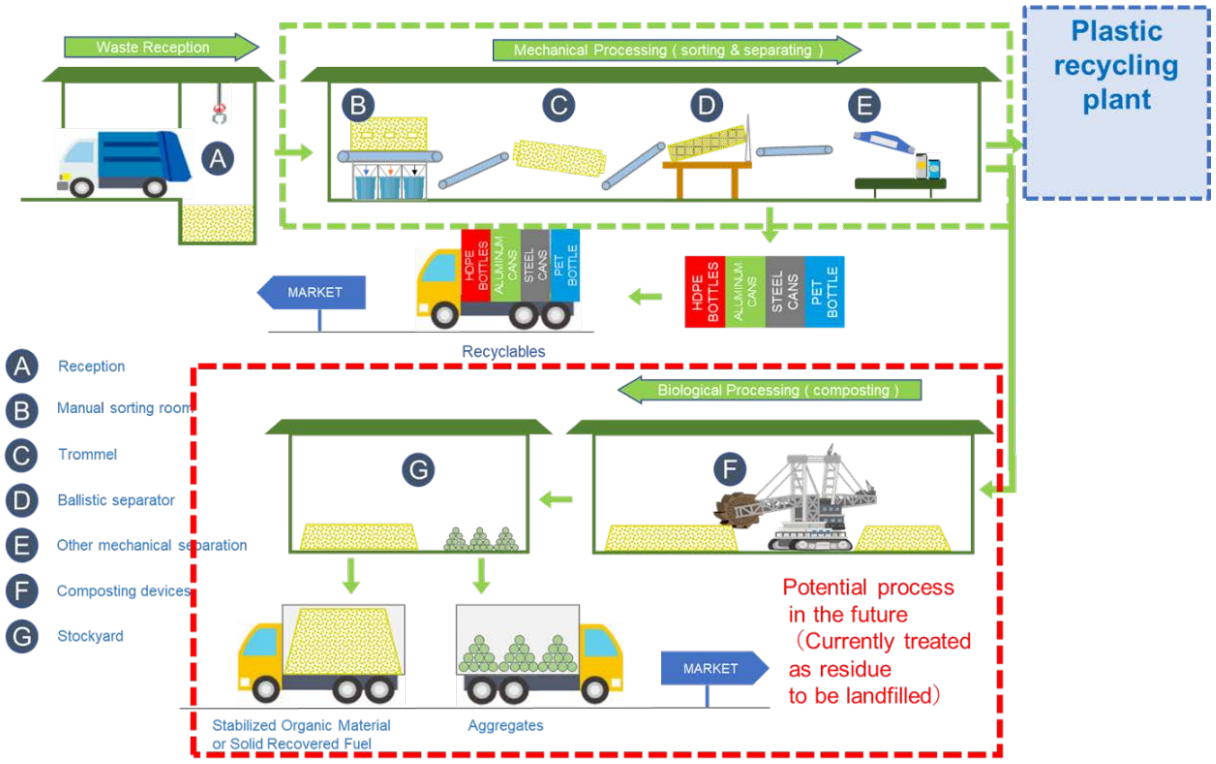


Figure 4: Example of IWMF

3.4 Sorting plant

In this section, a series of recycling processes are presented from “Reception” to "Stockyard".

3.4.1 Reception

Incoming waste/recyclables are delivered to a reception facility. It has a flat concrete floor for waste tipping.

Figure 5: Reception facility

3.4.2 Manual sorting

This figure shows an example of manual sorting system with a single-line and long conveyor. This type of sorting system is often recommended if workers can be easily recruited.

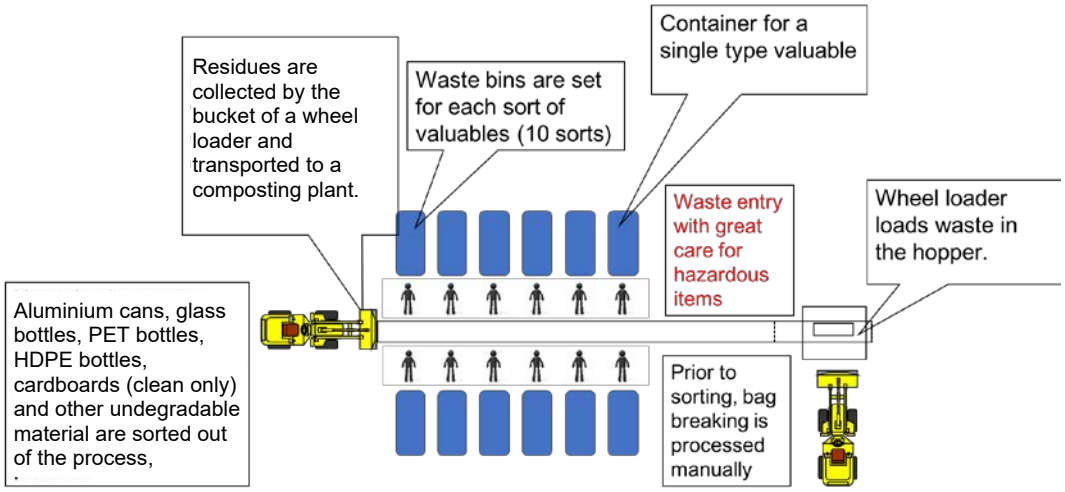


Figure 6: Manual sorting

3.4.3 Trommel screening

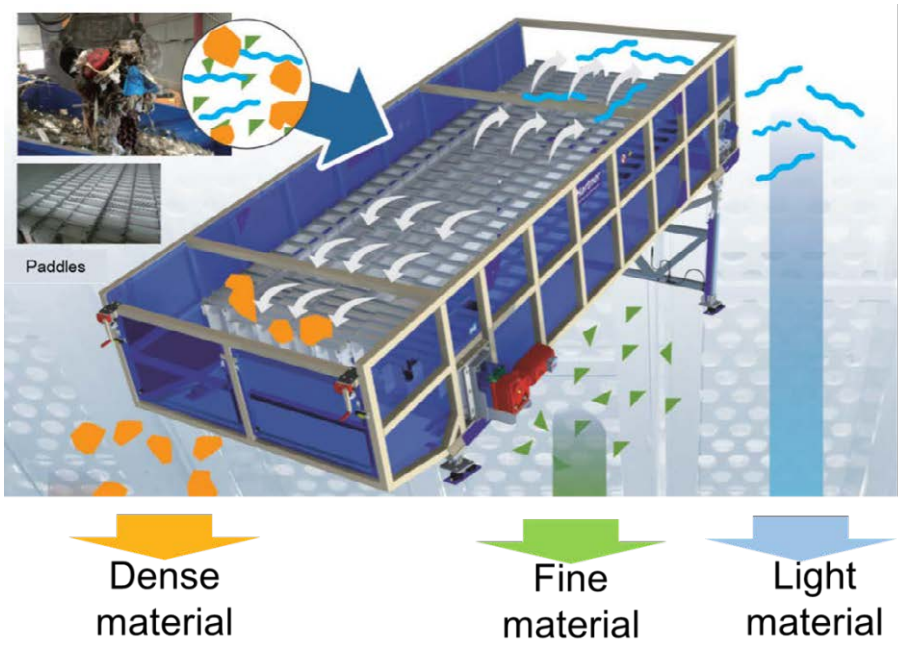
Trommel screens are often used in recycling plants. A trommel rotates at the speed of 30 to 60 min^{-1}. Bulky waste is eliminated, and the remaining waste is untangled and sorted.

Source: Yamaura Co., Ltd. Homepage, https://eng.yamaura.co.jp/products/search/structure

Figure 7: Trommel screening

3.4.4 Ballistic separator

A ballistic separator has integrated functions for sorting. It consists of fans, vibrators, and screens. Plastic bags and papers are sorted by the air blown by the fans. Mixed waste is divided into 3 types of fragments according to their specific gravity.



Source: Ballistic Separator HV40-338 pamphlet, BRT Hartner

Figure 8: Ballistic separator

3.4.5 Baling

Balers (compression packaging machines) produce bales from wastepaper and waste plastics through a process of volume reduction and compression using a hydraulic press, followed by binding with wire or PP bands during discharge process. The baled products are transported and become resources through material and chemical recycling.

Figure 9: Vertical type baler and baled plastics

3.4.6 Storehouse

All the sorted items are put into sacks and stocked in a roofed storehouse.

Figure 10: Storehouse

3.4.7 Equipment combination options

The table below shows a combination of equipment for recycling. The arrangement depends on the shape, volume, quality, etc. of the targeted recyclables.

Table 2: Equipment combination options

Equipment	Mandatory (M) or optional (O)	Cost	Remarks
Manual sorting system	M	-	
Trommel screening	O	●	Similar function to a ballistic separator
Ballistic separator	O	●●●	Similar function to a trommel screen. For RDF production, it is necessary.
Baler	M	-	
Stockyard	M	-	

●: Very low, ●●: Low, ●●●: High, ●●●●: Very high

3.4.8 Optional Sorting Method: Optical sorter

Optical sorters are developed and improved year after year. This device allows easy separation of specified materials. YouTube videos describing this equipment can be watched on the following website: https://vdrs.com/tomra-optical-sorting/

3.5 Composting plant

3.5.1 Need for a composting plant

If the organic waste collected is landfilled as is in a dumpsite, organic matters will decompose over time, however, the speed of the decomposition is slow. In many cities, this is the main cause of the shorter lifespan of landfills.

Moreover, remaining organic waste produces GHG such as methane, which reinforce the greenhouse effect.

Organic waste recycling experiments have been conducted in many places, however, in many cases composting has been abandoned. The Tokyo Metropolitan Government stopped composting in the 1970s. When mass composting was first developed in Tokyo, the technology was not suitable for all household waste. Nowadays, however, some composting plants with a certain amount of organic waste are in operation in Japan. With the use and selection of appropriate technology, composting can be a good treatment method in Caribbean countries.

Through composting, organic waste can be changed into recyclable products. Even if the compost produced cannot be sold, the composting process can reduce the volume of organic waste by at least 20 to 30% of its original volume and the material can be easily managed and used as mulch or cover material at the landfill.

3.5.2 Composting method comparison

The table on the next page shows a comparison of various composting methods. Standard windrow, passively aerated windrow, forced aerated windrow and mechanical composting system are introduced respectively. The selection of the composting method should be based

on the targeted volume and quality of composting products. It is also important to consider the pros and cons of each method.

Table 3: Composting method comparison

Type	Image		Method	O&M	Investment Cost	O&M cost	Building Space	Time of compost process	Advantage	Disadvantage
Windrow Compositing			Aerobic Mechanical /Manual	Moderate	Low	✓Manual : low ✓Mechanical: Moderate	Large	Long	✓ Simple method ✓ Small and large amount of bio-degradable waste can be treated ✓ Investment cost is low	✓ Environmental issue is easily happened ✓ Success of operation depends on the capacity of supervisor ✓ Time of compost process is the longest
Passively Aerated Windrow			Aerobic Mechanical /Manual	Moderate	Low	✓Manual : low ✓Mechanical: Moderate	Large	Moderate	✓ Simple method ✓ Small and large amount of bio-degradable waste can be treated ✓ Investment cost is low	✓ Environmental issue is easily happened ✓ Success of operation depends on the capacity of supervisor
Forced Aerated Windrow			Aerobic Mechanical	Easy	Moderate	Moderate	Moderate	Short	✓ Small and large amount of bio-degradable waste can be treated ✓ Environmental issue can be mitigated ✓ Time of compost process is short	✓ Electricity charge is required
In Vessel / Mechanical Composting			Aerobic Mechanical	Operation: easy Maintenance : not easy	High	High	Small	Short	✓ Environmental issue can be mitigated ✓ Easy operation ✓ Time of compost process is short	✓ Small amount cannot be treated. ✓ Electricity charge is required

3.5.3 Example of forced aerated composting process

a. Process 1: Reception and feeding returned compost

Flat concrete floor for tipping of residues (raw material) and consecutively supplying returned compost.

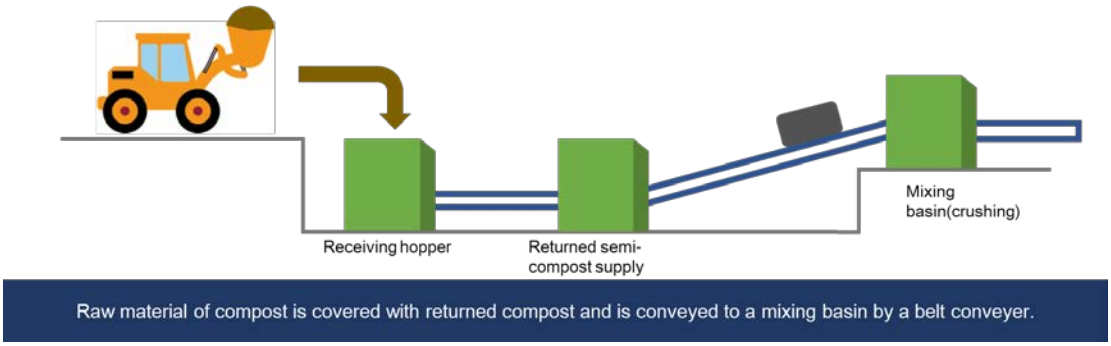


Figure 11: Reception and feeding equipment

b. Process 2: Mixing basin

The crusher (screw conveyor) mixes the raw material and the returned compost into a granulate at this process for enhancing fermentation.

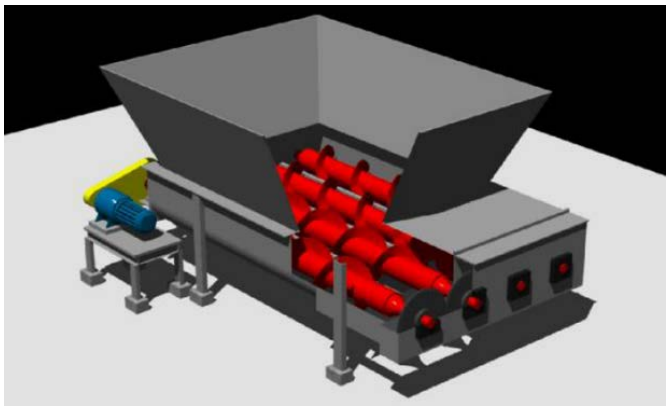


Figure 12: Crusher (Screw Conveyor)

c. Process 3: Semi-product storage

The mixed materials are stored in the semi-product storage. Then, the semi-product is moved to reactors.

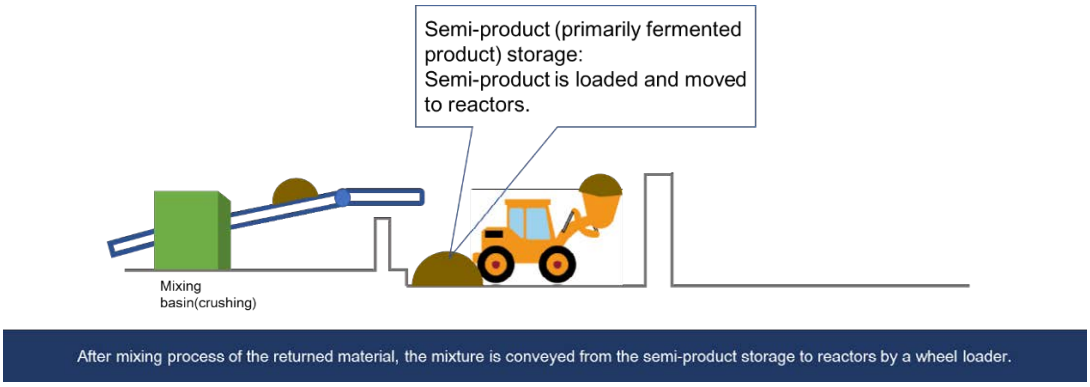


Figure 13: Semi-product Storage

d. Process 4: Reactor

The grained material (semi-product) is fermented aerobically.

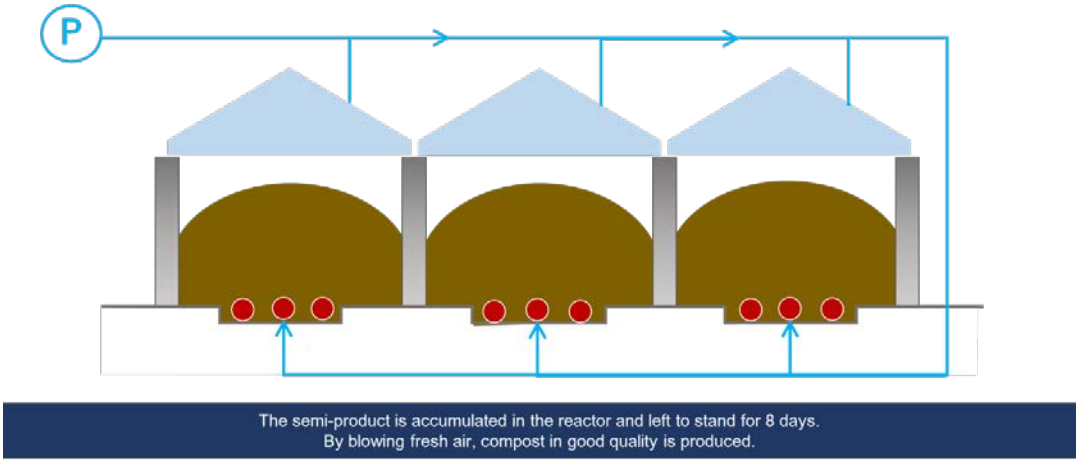


Figure 14: Reactor

e. Process 5: Classification and storage

Compost is sorted by particle size using a classifier. This prepares the products for sale.

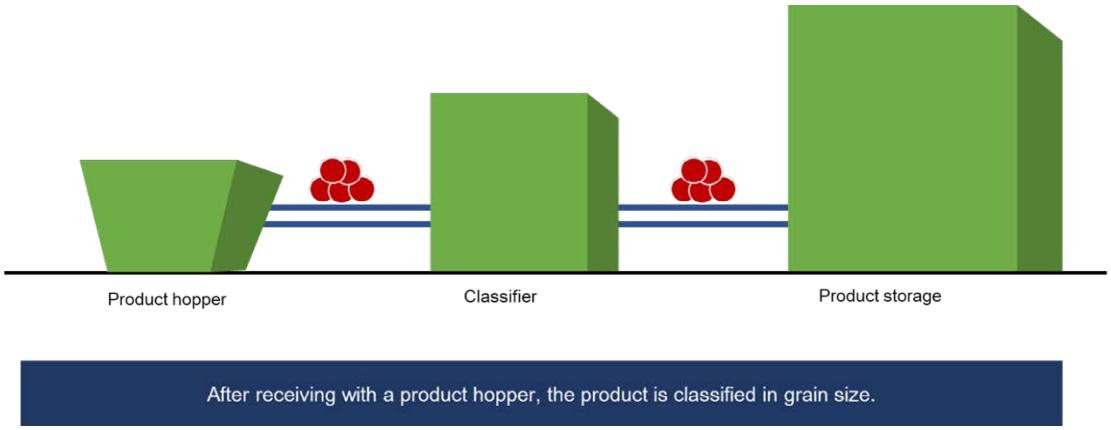


Figure 15: Classifier and packager

f. Process 6: Shipping

A packing device is used for an effective shipping.

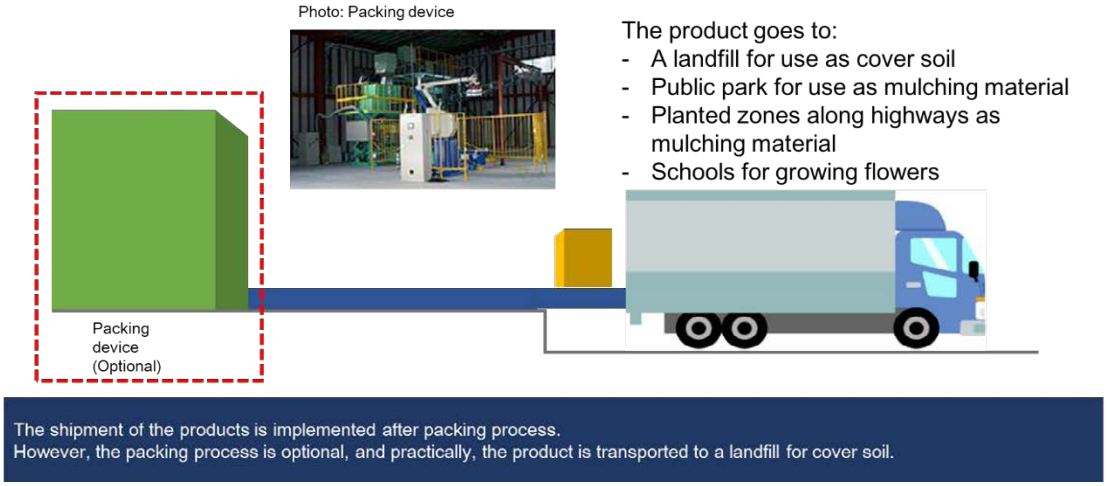


Figure 16: Packing and Shipping

3.6 Plastic recycling

There are three main methods for plastic recycling: material recycling, chemical recycling, and thermal recycling. Since material recycling is the most common method in the Caribbean countries, the RDF method is presented here as a potential new market targeting companies using a boiler system (e.g. cement plant).

3.6.1 RDF (Refuse Derived Fuel) production

The diagram on the next page shows the general process flow for RDF production. RDF is made from waste that can be incinerated. The final product of RDF varies in terms of density. Some RDF can be called fluff, other is pelletized. Fluff RDF is introduced here. In Japan, RDF

is sometimes made from all combustible waste, including kitchen waste and other wet waste, and therefore, chemical drying is part of the standard treatment process.

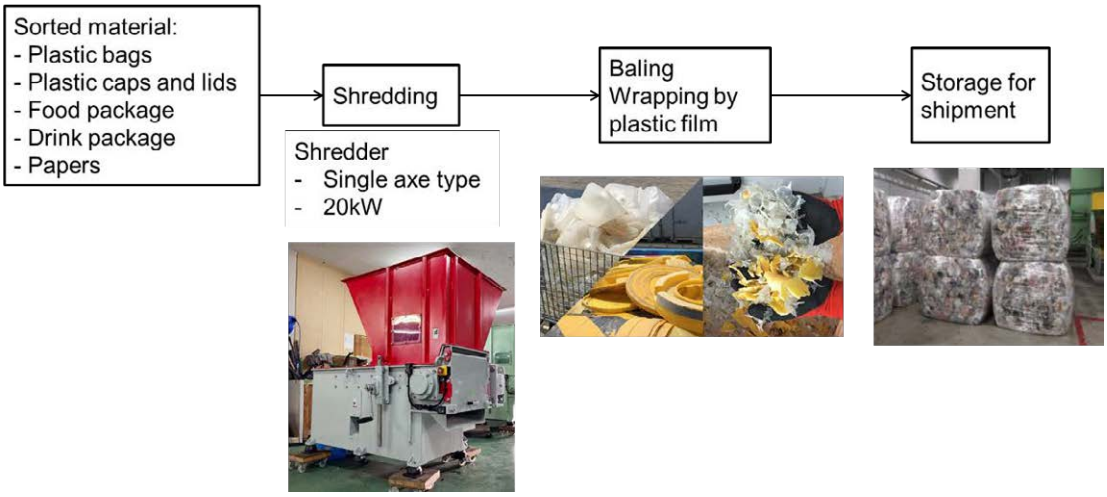


Figure 17: RDF production

3.6.2 Necessary staff and equipment (example)

The table below shows an example of necessary staff and equipment for operating an intermediate treatment plant. The number of workers is key to reduce operation cost.

Table 4: Necessary staff and equipment (example)

Capacity	90 tons/day	30 tons/day
Recycling plant (Sorting mainly)	Receptionist :2 Sorting worker: 40 Loader operator: 2 Forklift operator:4 Worker: 10 Engineer: 3 Wheel loader: 2 Forklift:4	Receptionist :2 Sorting worker: 16 Loader operator: 2 Forklift operator:2 Worker: 10 Engineer: 3 Wheel loader: 2 Forklift:2
Compost plant	Loader operator: 2 Worker: 10 Engineer: 2 Wheel loader: 2	Loader operator: 2 Worker: 6 Engineer: 1 Wheel loader: 2
RDF production	Loader operator: 1 Worker: 6 Wheel loader: 1 Forklift: 1	-

3.7 Waste-to-Energy (WTE) Technology

3.7.1 Types of waste-to-Energy Technology

Waste-to-Energy technology is often equated with waste incineration with power generation. There are four main categories of WTE technologies that are known as successful developed technologies. In this section, these four technologies are introduced.

3.7.1.1 Landfill Gas Recovery Technology

The figure below shows a diagram of landfill gas recovery technology. The methane generated in the landfill layers is trapped, undergoes desulfurization and is burnt in a gas engine to produce electricity.

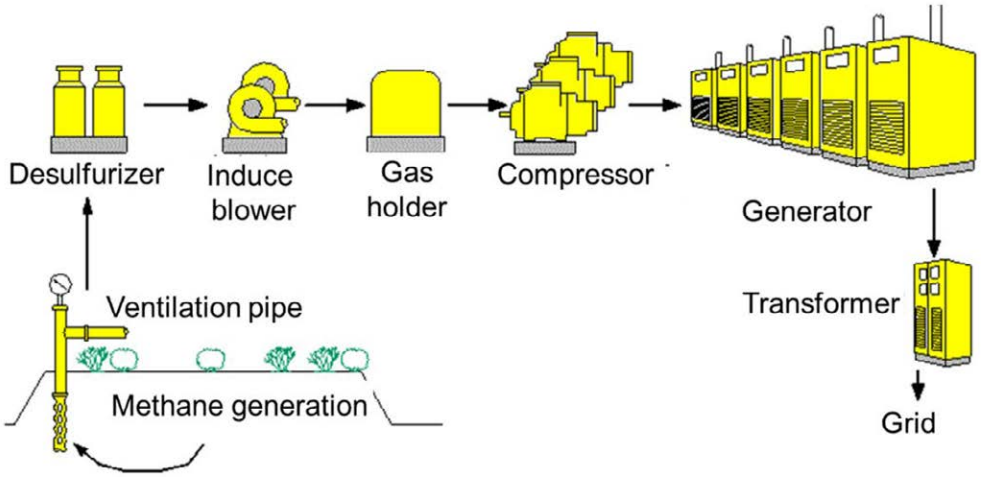
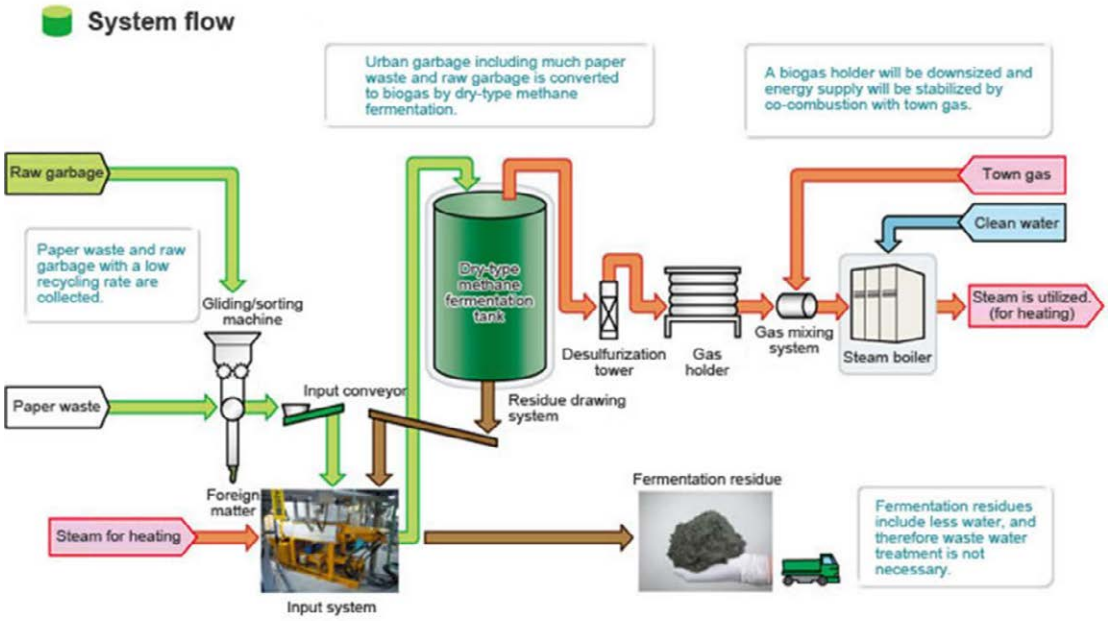


Figure 18: Landfill Gas Recovery Technology

3.7.1.2 Bio-gasification Technology (Organic waste methane fermentation)

The figure below shows a diagram of typical bio-gasification technology. Raw garbage in a fermentation tank is transformed into methane to be used as fuel for a boiler. Power generation is also the main use of the methane produced by this technology.



Source: Tokyo gas Homepage

Figure 19: Bio-gasification Technology

3.7.1.3 Waste Incineration Technology

The figure below shows a typical diagram of waste incineration technology. Recovered heat from waste incineration produces high temperature and high pressure steam, and the steam turbine generates electricity by rotating turbine blades.

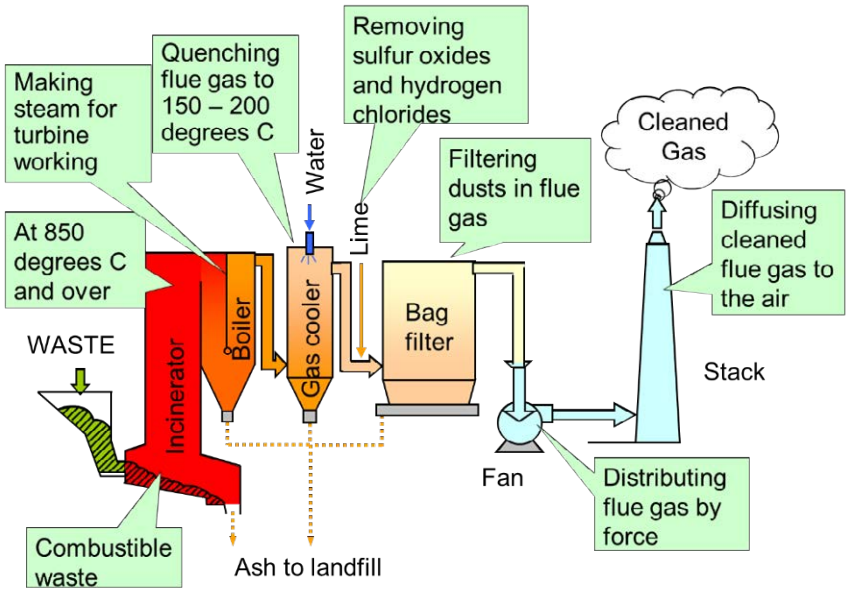


Figure 20: Waste Incineration Technology

3.7.1.4 Gasification Technology

The figure below shows the waste gasification technology. Using pyrolysis reaction, flammable gas is produced, and electricity is generated with gas engines. This system also produces liquid fuel.

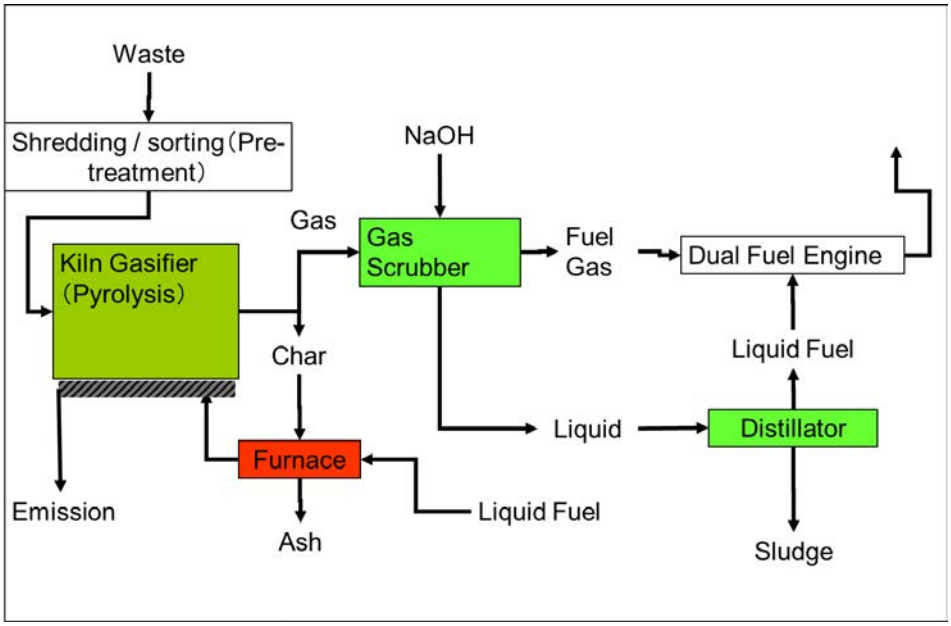


Figure 21: Gasification Technology

3.7.2 Issues to be considered in selecting waste-to-energy technology

3.7.2.1 Waste component

The table below shows the waste components that can be processed with each method. When selecting an intermediate technology, it is important to consider how the target waste should be processed in the overall waste stream. The presence of plastics is decisive in the choice of a sustainable waste management method. If landfill gas power generation technology is selected, the plastics will remain as they are in the waste layer. In the case of organic waste methane fermentation technology, the plastics must be treated in some way. The two remaining technologies can thermally treat plastics.

Table 5: Waste-to-Energy Technology and Waste Component

Method	Availability for Component		
	Organic matter	Plastics	Inorganic matter
Landfill gas power generation	○	×	Acceptable
Organic waste methane Fermentation	○	×	×
Incineration with power generation	○	○	A few amount can be accepted.
Gasification with power generation	○	○	A few amount can be accepted.

○: processable, ×: non-processable

3.7.2.2 Power Generation Rate

The table below shows a comparison of power generation rates per ton of waste for each technology. The power generation rate is important for continuous operation in terms of power sales. Generally, the life-cycle cost (LCC) is calculated to compare the technologies. A typical WTE project costs consist of investment for the plant installation and other preparatory events like official permit or environmental studies, and operation and maintenance. On the other hand, revenues are mainly obtained from tipping fee and power sales at the operation stage. Therefore, the entire project life cost and revenue balance shall be considered in the comparison.

Table 6: Power Generation Rate (Example)

Method	Organic matter (60%)	Plastics & Others (40%)	Total kWh/t-waste
Landfill gas power generation	**100kWh/t-waste**		**100**
Organic waste methane Fermentation	**200kWh/t**	**0**	**120**
Incineration with power generation	**350kWh/t-waste**		**350**
Gasification with power generation	**350kWh/t-waste**		**350**

3.7.2.3 WTE selection criteria

The table below shows an example of WTE technical natures. This section talks about criteria for selecting WTE technology.

Table 7: WTE Technical Comparison (Example)

Method	Experience for 500t-MSW/d up	Additional Fuel	Initial Cost	Power Sales	Volume Reduction Rate
Landfill gas	+++	-	+++	+	+ 50%
Methane Fermentation	+	+	++	++	+ 60%
Incinera-tion	+++	+++	+	+++	+++ 95%
Gasifica-tion	+	+	+	+++	+++ 95%

+++: Excellent ++: Good +: Fair -: Not necessary

a. Experience

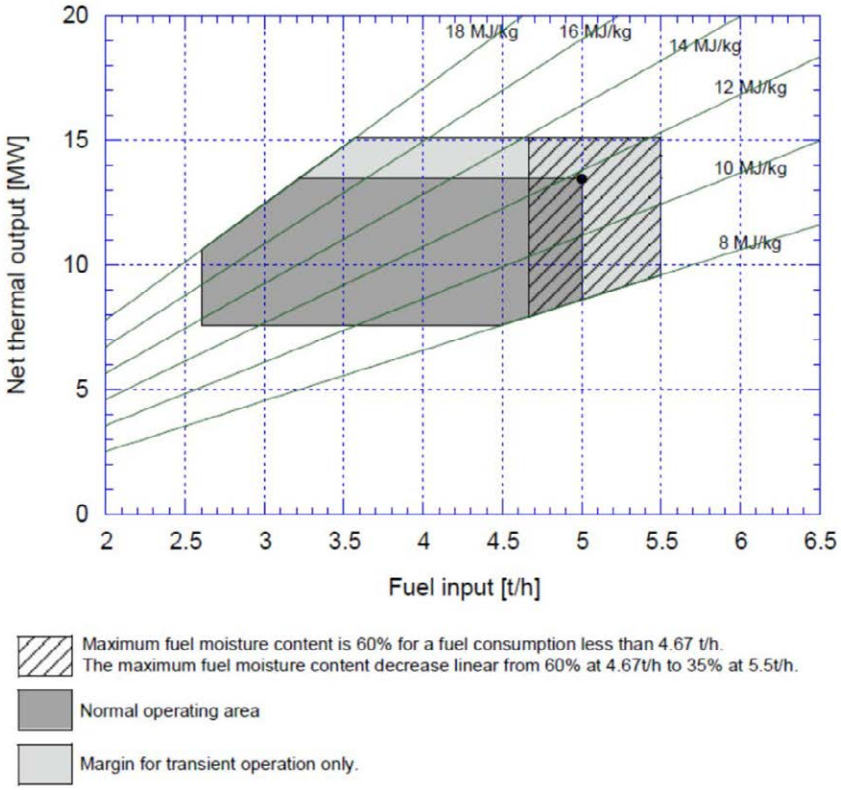
Waste treatment is “experiential engineering.” The number of MSW treatment plants in operation with a certain capacity is critical. For example, in Japan, over 500 incineration plants are in operation. For methane fermentation, there are over 100 plants. However, the number of bio-gasification plants in operation for more than 10 years is still low. As for gasification, over 50 plants are in operation. In recent years, there has been no procurement of gasification plants in the Japanese market.

b. Additional fuel

Additional fuel consumption is also to be considered. If the waste calorific value ranges between 1,000 and 1,400 kcal/kg-MSW (approx. 4 to 6 MJ/kg), some treatment technologies need additional fuel. Besides, the gasification technology would need constant addition of

additional fuel to operate with the solid waste generated which has a certain portion of moisture (see the diagram below).

Municipal solid waste in the Caribbean consists of 50% organic waste with high moisture content. Such waste requires additional fuel for gasification technology, which can significantly increase operating costs.



Source: Energos

Figure 22: Diagram representing the relationship between fuel consumption rate and heat generation for the gasification process

c. Volume reduction

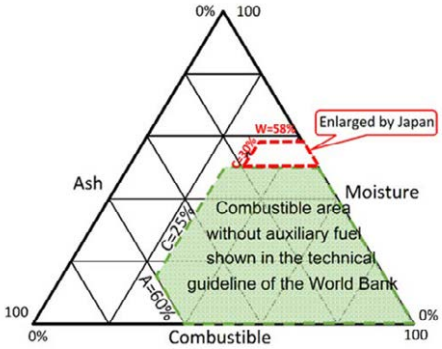
The volume reduction rate is important when you face the lack of remaining capacity of the landfill. In the Caribbean, this may be a high priority.

d. Ability to respond to waste fluctuations

A Waste-to-Energy plant needs the necessary mechanical functions and equipment to respond to fluctuations in waste characteristics in the short and long term.

The figure on the next page shows the relationship between the three components (moisture, ash, and combustible) of waste when you consider introduction of the incineration technology. The green area shows the properties required for the waste to be incinerated without any additional fuel and thus be considered combustible according to the World Bank guidelines. Waste with high moisture content in the red frame can also be incinerated without auxiliary fuel using Japanese technologies.

If the target waste has a lower calorific value than the waste in Japan or Europe, it should be confirmed whether it is in the green, red or white area. This assessment is essential in countries where kitchen waste accounts for a large share of municipal waste.



LHV=180×combustible-25×moisture

Source: Municipal Solid Waste Incineration, p.12, The World Bank, 1999

Figure 23: Relationship between the 3 components (moisture, ash, and combustible) in incineration of waste

3.8 Hazardous waste facility

Although it is not an intermediate treatment technology, hazardous waste treatment is addressed here. Hazardous waste facilities must isolate the waste from the surroundings, and they must meet certain requirements for proper operation (see the pictures below).

Figure 24: Hazardous waste

[Requirements]

- *Municipal waste brought to landfill includes a small amount of hazardous waste.*
- *In order to manage landfilling safely, hazardous waste shall be sorted and separated from other municipal waste.*

A hazardous waste pit is illustrated below. It needs an liquid embankment made of concrete so that spilt liquid hazard waste can remains inside the embankment.

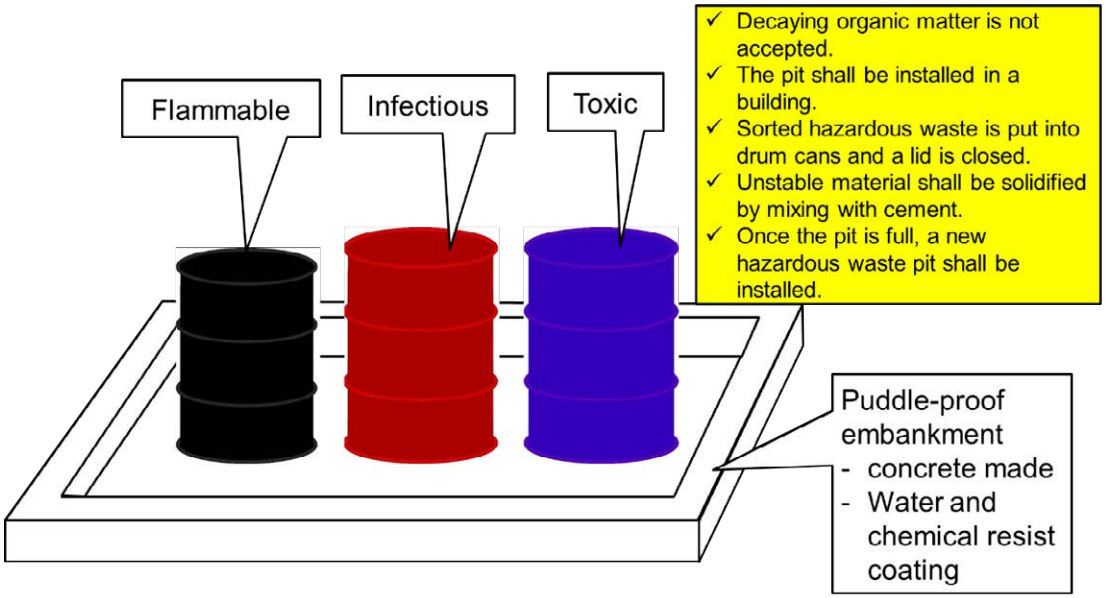


Figure 25: Hazardous waste pit

4 Discussion

The main intermediate treatment technologies have been introduced in the above two chapters. For an appropriate choice of the most suitable technology, the following should be clarified:

- Objective of the introduction of the technology
- Capacity of the plant
- Characterization of the target waste
- How to use the process output, what is the market for the output

Technical Project on Advisor for Marine Plastic Litter Management in the Caribbean Region

Technical Note No.5

Final Disposal of Municipal Solid Waste

JICA
Japan International Cooperation Agency

October 2023

Technical Project on Advisor for Marine Plastic Litter Management
in the Caribbean Region

Technical Note No.5

- Final Disposal of Solid Waste -

Prepared by Yukihisa SAKATA, JICA Advisory Team
October 2023

Table of Contents

Tables

Figures

1 Objective of this technical note

This technical note aims to provide the readers with information on the final disposal of municipal waste.

2 Plan and design of final disposal

2.1 Landfill design process

When designing a landfill, several tasks must be carried out following an appropriate process.

The figure below outlines the typical process for a landfill project. When designing a landfill, all elements relating to the project must be considered holistically.

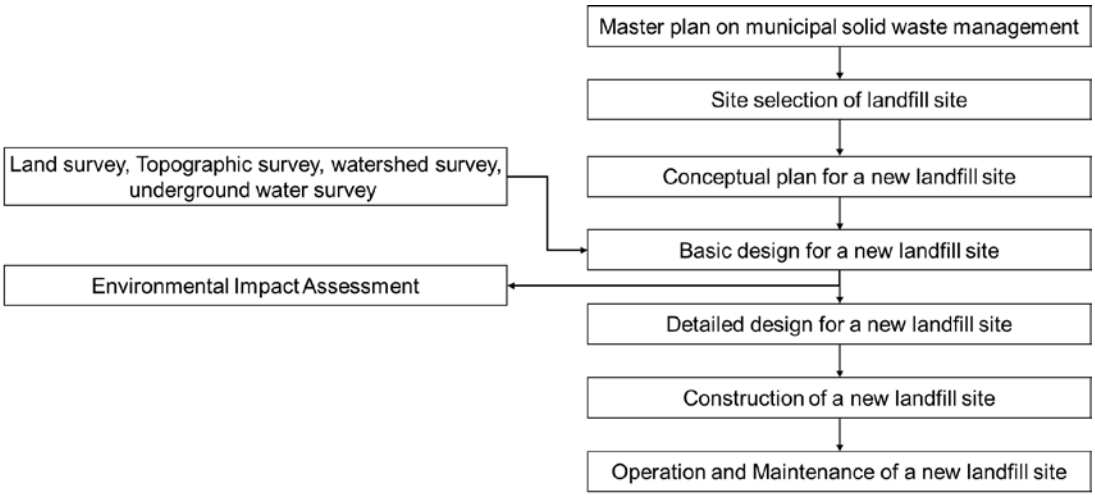


Figure 1: Landfill project process

2.2 Design items

Both the basic design and the detailed design consist of the items listed below. However, this figure only shows the basic items, so other items may need to be taken into account in case a project has specific features.

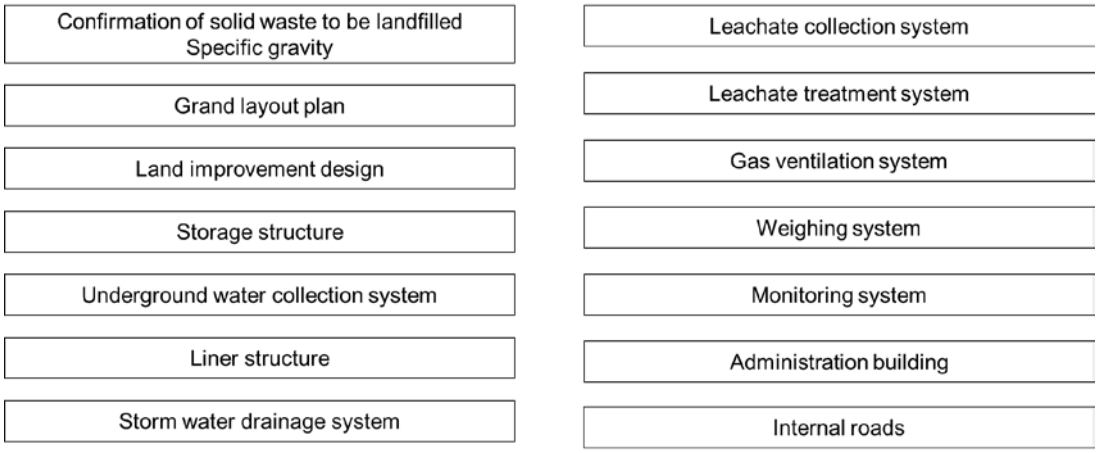


Figure 2: Items of the design

2.3 List of basic design documents and drawings

General basic design documents are listed in the table below. A set of design documents not only consists of design drawings but also include calculation reports.

Table 1: Design document list (example)

item	name
Basic Design Drawings	Land use plan (after land development)
	Land use plan (after landfilling)
	Main section
	Storm water and drainage layout plan
	Standard section drawings of storm water and drainage
	Leachate collection layout plan
	Leachate collection equipment standard drawing
	Gas ventilation standard structure drawing
	Underground drainage layout plan
	Underground drainage standard section plan
	Drainage basin map
	Balancing reservoir standard structure
	Standard road section drawing
Flow rate calculation report	Discharge flow rate calculation
	Balancing reservoir capacity calculation
	Design of leachate collection pipe diameter
Stability calculation for landslide	Stability calculation for landslide
	Result of the calculation
Quantity calculation report	Quantity calculation report

3 Semi-aerobic landfill

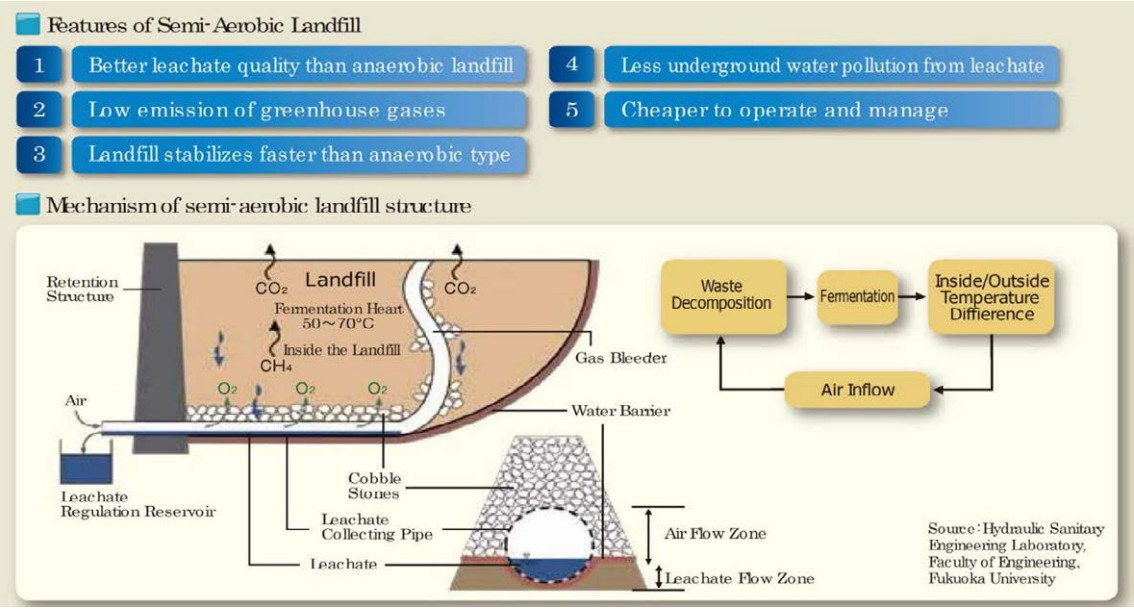
In landfills in many Asian cities, waste is dumped and burned in the open. Japan used to be the same; however, joint research by Fukuoka University and Fukuoka City in the 1970s developed and implemented a semi-aerobic landfill structure that is sanitary and environmentally friendly compared with the conventional (anaerobic) landfill.

Compared to anaerobic landfill, the semi-aerobic landfill technology quickly stabilizes sites once they have fulfilled their role as landfill, enabling them to be used for parks and open space for sports and leisure. This technology was accredited as CDM methodology by the UN CDM Executive Board.

Leachate collection pipes are set up at the bottom of the landfill to remove the leachate from the landfill layers, so that it does not remain where the waste is stored. Natural air is brought in from the open pit to the landfill layers through the leachate collection pipes, which promotes aerobic decomposition of the waste. This enables early stabilization of waste and prevents the generation of methane and other greenhouse gases, making it an effective technology to prevent global warming.

Generally, the air present in an aerobic atmosphere transforms the carbon contained in organic matter into carbon dioxide, ammonium into nitrogen through nitrification and denitrification, and sulfur into sulfur ions, which reduces the generation of foul odours and flammable gas. Moreover, an aerobic atmosphere increases the activity of microorganisms that decompose waste, accelerating the stabilization process.

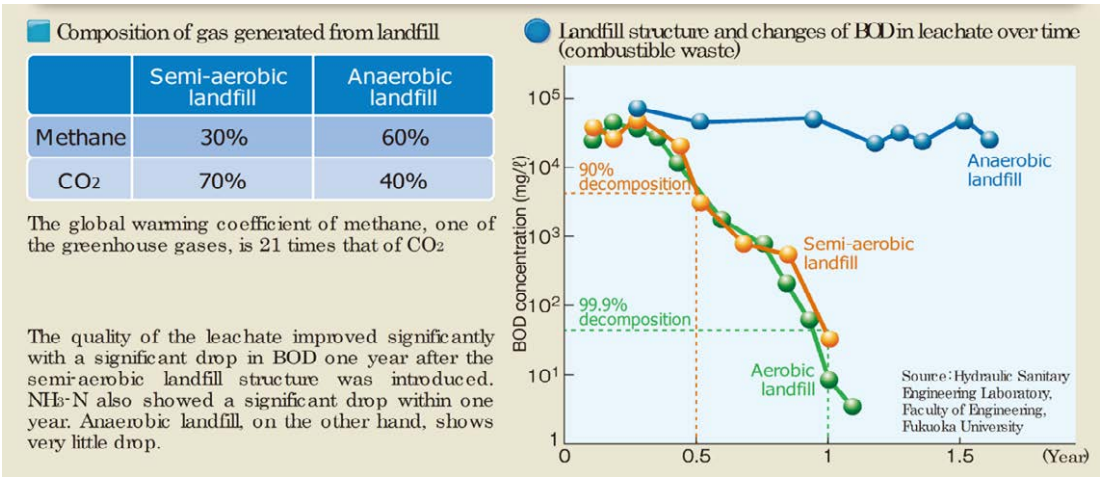
In contrast, in an anaerobic atmosphere, where oxygen is not present, organic matter turns into volatile organic acids, such as acetic acid, and then into methane or carbon dioxide, while nitrogen and sulfur are transformed into ammonia, amine, hydrogen sulfide, and mercaptan, which emit foul odours and negatively affect the living environment of the surrounding area.



Source: Hydraulic Sanitary Engineering Laboratory, Faculty of Engineering, Fukuoka University

Figure 3: Mechanism of semi-aerobic landfill

The figure below shows a comparison between semi-aerobic and anaerobic landfills. It can be easily seen that semi-aerobic landfills contribute more to the preservation of the environment than anaerobic landfills in terms of contaminant control.



Source: Hydraulic Sanitary Engineering Laboratory, Faculty of Engineering, Fukuoka University

Figure 4: Comparison of semi-aerobic landfill and anaerobic landfill

The table below shows another comparison of semi-aerobic and anaerobic landfills. A semi-aerobic landfill would be strongly recommended from an environmental point of view. However, the capacity of the leachate treatment facility is greater than that of an anaerobic landfill, which might be more expensive.

Table 2: Comparison of Landfilling methods

	Semi-Aerobic	Anaerobic
Lead time for land use after closure	Short 5-10 years	Long 10-20years
Generated gas	CO_2, H_2O	CH_4, H_2S
Odor	Less	More
Capacity of leachate treatment facility	Big	Small

Source: Estimation by JAT

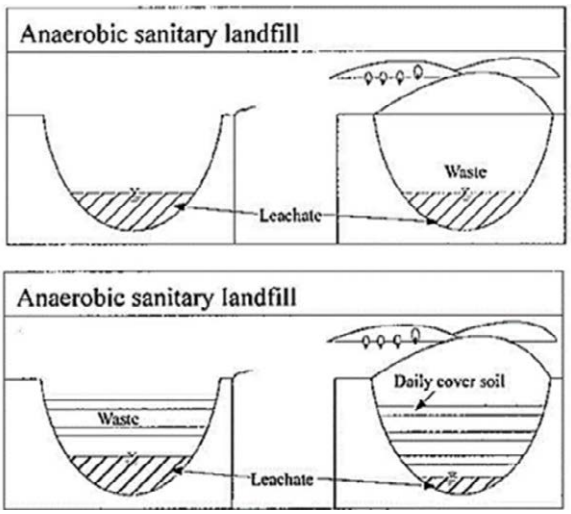
4 Waste management in Japan

Nowadays, technology for solid waste management in Japan is well-developed. However, most Japanese people remember the devastating situation with solid waste management in Japan, which they experienced just 50 years ago.

4.1 History of landfill disposal

Until the 1950s, even in Japan, anaerobic landfill was the most common landfill method. Moreover, landfilling of solid waste was carried out without any soil cover or water treatment. Solid waste was just dumped into pits that were excavated at the ground level or in a valley. In the figure below, the top image shows a typical landfill. Subsequently, although it was still anaerobic landfilling, each waste layer was covered with soil. The bottom image in the figure below shows a somewhat advanced type of landfill.

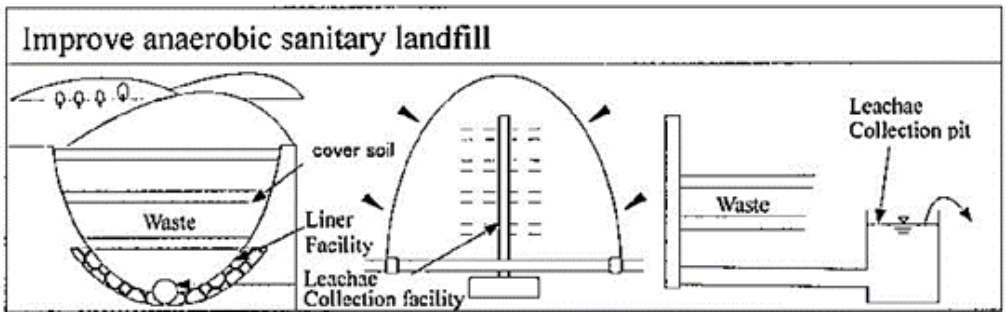
Neither of these two landfill types had a leachate collection system, therefore, the atmosphere in the waste layers was probably in poor condition for decomposition throughout their service life.



Source: T. Shimaoka et al., Characteristic and Mechanism of Semi-Aerobic Landfill on Stabilization of Solid Waste, Environmental Science, 2003

Figure 5: Initial types of solid waste landfills in Japan

In the next stage, an improved type of anaerobic landfill was developed (see figure below). It had a leachate collection pipe system, and the waste layer had an anaerobic atmosphere due to the high humidity.



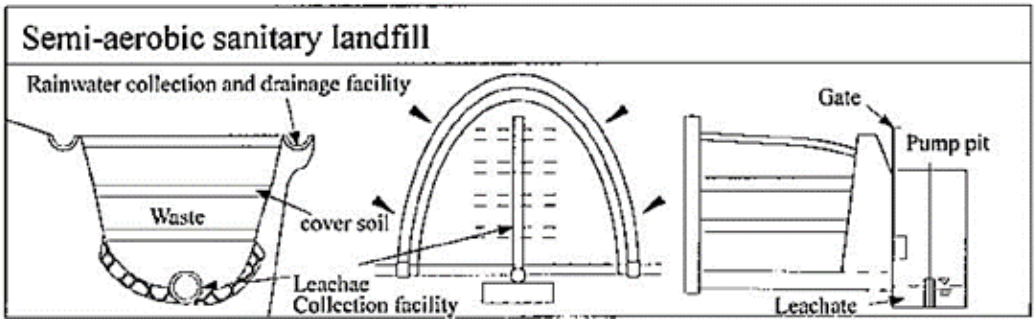
Source: T. Shimaoka et al., Characteristic and Mechanism of Semi-Aerobic Landfill on Stabilization of Solid Waste, Environmental Science, 2003

Figure 6: Improved anaerobic sanitary landfill

Then, the semi-aerobic landfill method was developed, and this new landfill structure was introduced in many projects in Japan instead of the conventional landfill method.

One of the features of the semi-aerobic method was the installation of leachate collection pipes of sufficient diameter and open to the air.

The moisture content in the landfill layers is lower, and the oxygen supplied through the leachate collection pipes keeps the landfill aerobic. The figure below shows features of a semi-aerobic landfill.

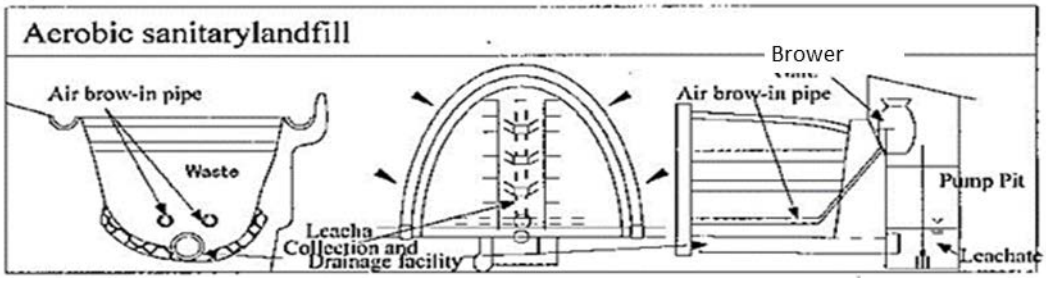


Source: T. Shimaoka et al., Characteristic and Mechanism of Semi-Aerobic Landfill on Stabilization of Solid Waste, Environmental Science, 2003

Figure 7: Semi-aerobic landfill

Besides these landfill types, aerobic landfill has also been developed in Japan. It had a system of air blowing pipes that could artificially push air from the outside into the landfill layers, thus it could remain the waste inside under aerobic conditions. However, this type of landfill was not very popular in Japan due to the continuous power consumption for air blower operation.

The figure below shows the features of an aerobic landfill.



Source: T. Shimaoka et al., Characteristic and Mechanism of Semi-Aerobic Landfill on Stabilization of Solid Waste, Environmental Science, 2003

Figure 8: Aerobic landfill

As described above, the history of landfill method in Japan is a series of trial and error, and more landfilling methods have been investigated.

Meanwhile, urbanization often had detrimental effects, not only on the environment but also on daily life in areas near landfills. The pictures on the next page show the situation in the Tokyo Metropolitan area #8 landfill and Yumenoshima landfill in the 1960s.

Source: Clean Authority of Tokyo homepage, https://www.union.tokyo23-seisou.lg.jp/shiro/nakattara/02.html

Figure 9: Tokyo Metropolitan area #8 landfill in the 1960s

Source: Clean Authority of Tokyo homepage, https://www.union.tokyo23-seisou.lg.jp/shiro/nakattara/02.html

Figure 10: Tokyo Metropolitan area landfill at “Yumenoshima” (1964)

4.2 Legal framework for solid waste management

The table below shows landfill-related legislations in Japan. The Waste Disposal Law is a major law for solid waste management. Considering the tragic background with many landfill-related problems, the Technical Standards for Landfill entered into effect in 1977 to preserve public health and the daily life of Japanese residents.

Table 3: Landfill-related legislations in Japan

Year	Laws and regulations
1890	Filth Cleansing Law
1954	Public Cleansing Law
1970	Waste Disposal Law
1976	Amendment to Waste Disposal Law
1977	Technical Standards for Landfill
1979	Guidelines for Landfills
1988	Amendment to Guidelines for Landfill
1991	Amendment to Waste Disposal Law
1997	Amendment to Waste Disposal Law
1998	Amendment to Technical Standards for Landfill
2001	Directions for Landfill Planning and Construction

The figure below shows the waste category chart and responsibilities of municipalities and business operators.

In Japan, under the Waste Disposal Law, waste is divided into two types, namely municipal waste and industrial waste, and the breakdown of each type is shown in the figure below. In the field of solid waste management, the term usually used globally is “municipal solid waste”. Under the Japanese law, it is called “general waste” but it has the same definition.

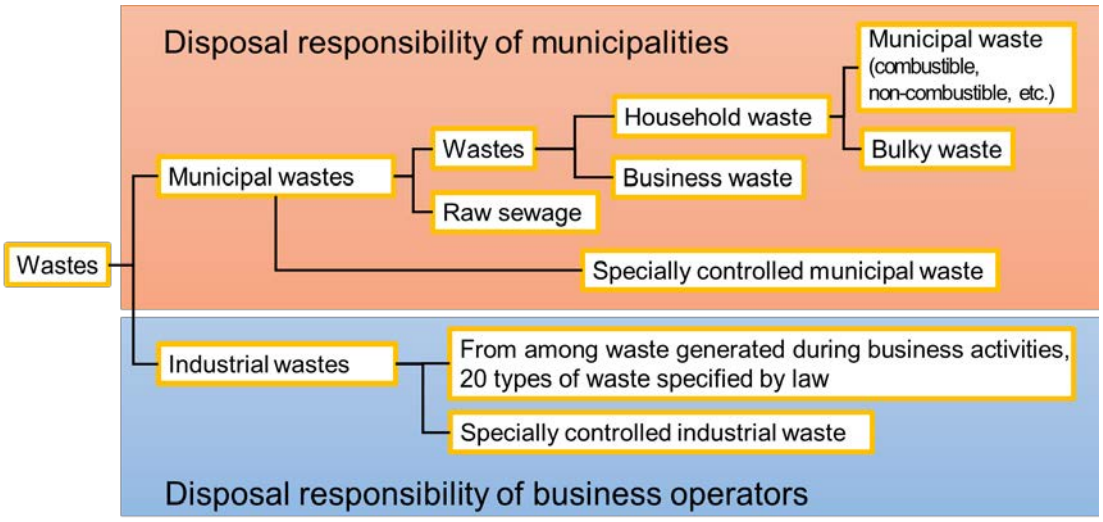


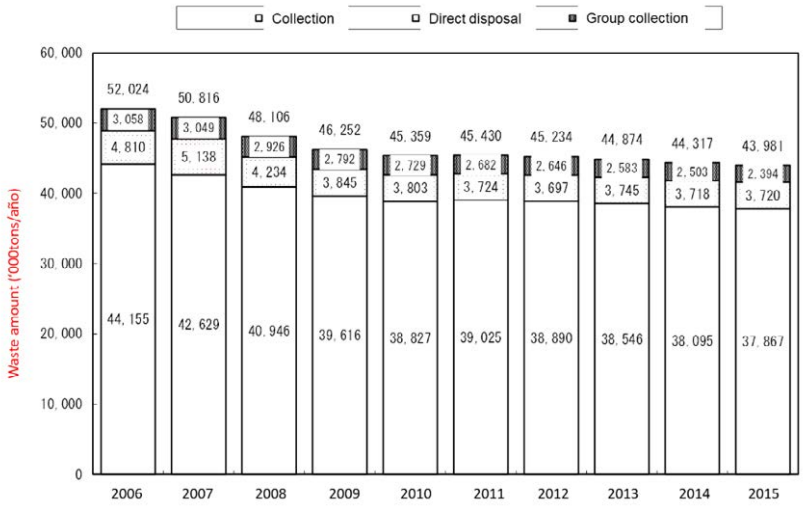
Figure 11: Definition of waste in the Japanese Waste Disposal Law

4.3 Generation and characteristic of waste in Japan

4.3.1 Waste generation

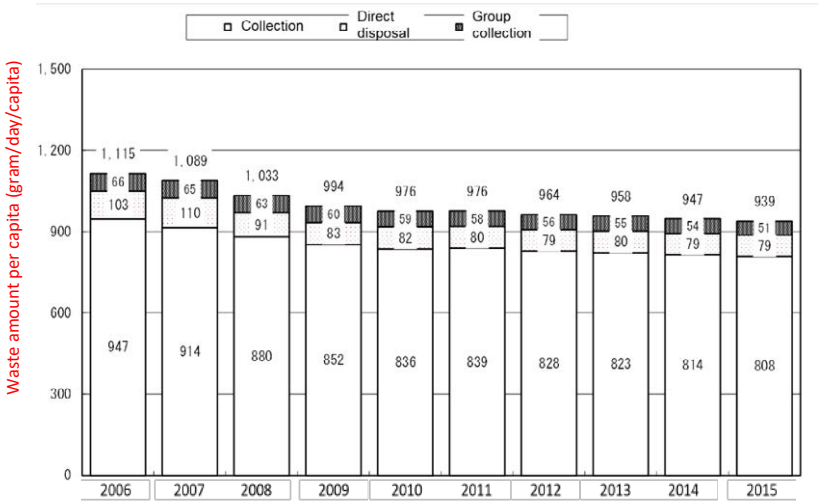
The figures below show the amount of waste generated in Japan. As the graph shows, the generated amount decreases year by year, and as for the treatment method, direct disposal only accounts for 10% of the total amount. This indicates that most of the waste collected is incinerated or recycled.

The waste generation rate per capita is also gradually decreasing and has managed to fall below 1.0 kg/day/capita.



Source: Solid Waste Management in Japan, FY2015 Edition, Ministry of the Environment, Japan, 2017

Figure 12: Amount of waste generated in Japan

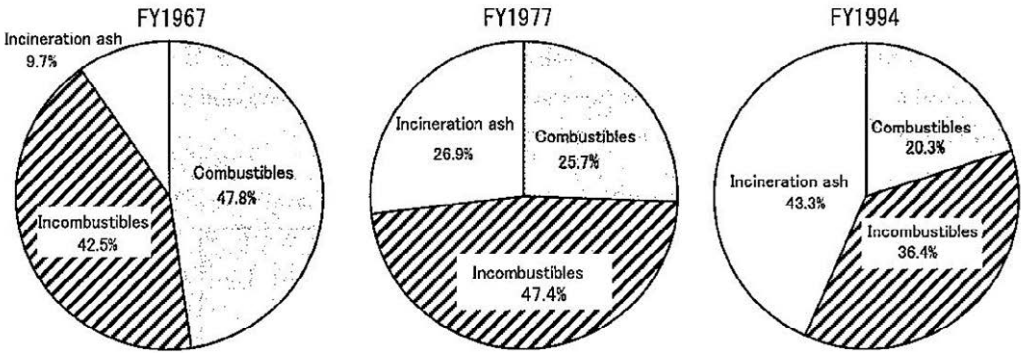


Source: Solid Waste Management in Japan, FY2015 Edition, Ministry of the Environment, Japan, 2017

Figure 13: Waste amount per capita in Japan

4.3.2 Waste characteristic

The percentage of direct landfilling has decreased from 42% in 1976 to 24.6% in 1986 and 12.8% in 1994. Meanwhile, the percentage of direct incineration has increased from 56.8% in 1976 to 71.8% in 1986 and 77.3% in 1994, indicating that the composition of the MSW landfilled is shifting towards incineration residue and incombustibles.



Source: Solid Waste Management in Japan, FY2015 Edition, Ministry of the Environment, Japan, 2017

Figure 14: Waste composition profile in Japan

5 Landfill facility

5.1 Necessary facilities for landfill

A landfill consists of the facilities listed below:

a. Storage facility (structures)

b. Landfill waterproofing systems (structures)

c. Leachate treatment facility

d. Groundwater collection/drainage facility

e. Leachate collection/drainage facility

f. Rainwater collection/drainage facility

g. Disaster prevention facility

h. Waste reception and weighing facility

i. Internal roads

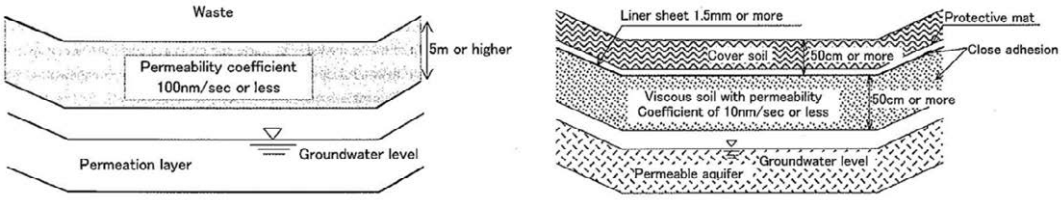
j. Monitoring facility

All items are to be designed in consideration of the other items.

5.2 Liner structure

5.2.1 Regulations for the landfill liner structure

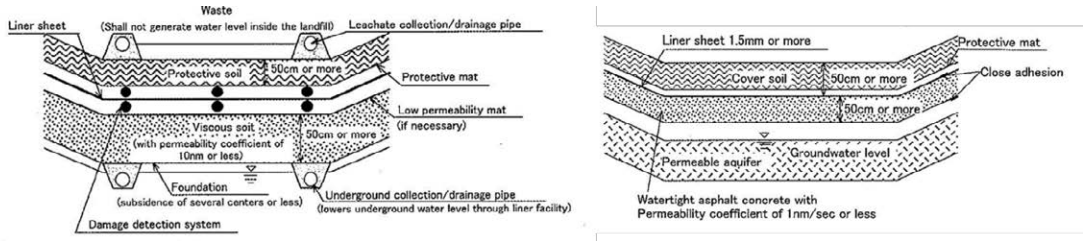
The function of the landfill liner is to isolate the waste landfilled from the environment, especially from the natural ground where groundwater may flow. There are regulations regarding the structure of the landfill liners and the figures below show examples of acceptable liners under the Japanese regulation. If the target site has a natural clay layer and this type of liner is acceptable under the regulation, as shown in Figure 15 on the left, this option should be considered in order to reduce the installation cost since the artificial material for the liner could be saved. In the Japanese regulation, an acceptable clay liner must be more than 5m thick and its permeability must be less than 100 nm/sec.



Source: Landfills in Japan, p48, LSA, NPO, 2006

Figure 15: Examples of acceptable liner structure (1)

Other good examples are shown in the figures below.



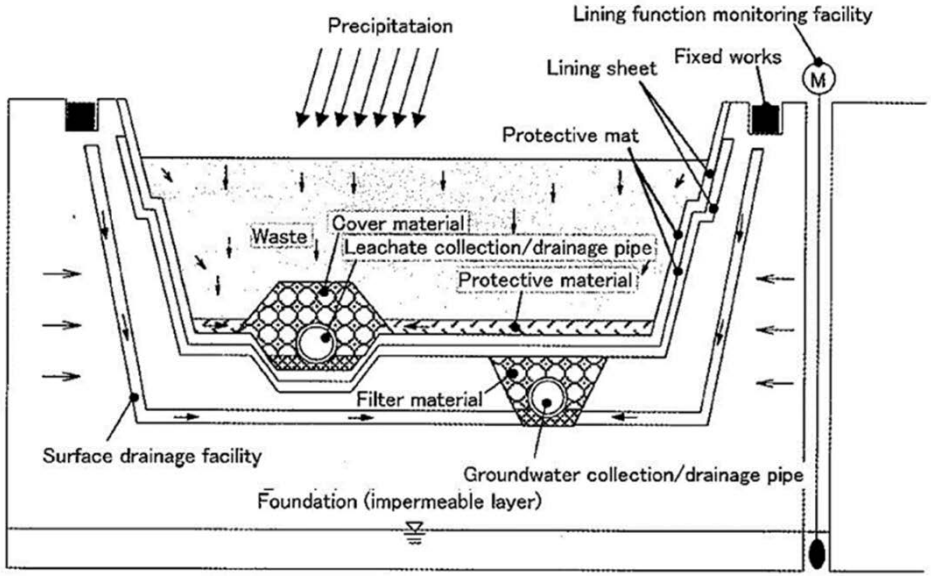
Source: Landfills in Japan, p54, LSA, NPO, 2006

Figure 16: Examples of acceptable liner structure (2)

The figure below shows a detailed overview of the liner structure. Precipitation on the landfill area eventually becomes leachate penetrating through the landfilled waste, and all the leachate must be collected inside the layers by leachate collection pipes.

For the purpose of liner protection, all the groundwater should be collected and drained smoothly using a groundwater collection system.

To check if the liner is functioning, a monitoring well is installed to control the quality of the groundwater flowing under the landfill.



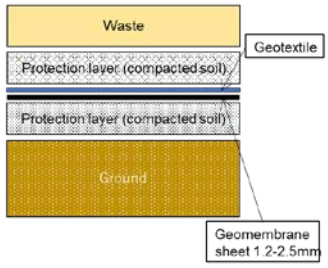
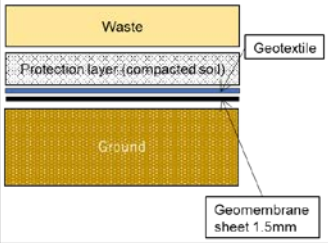
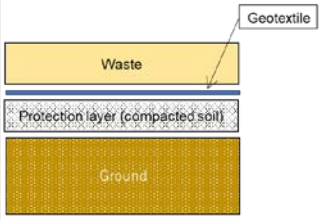
Source: Landfills in Japan, p55, LSA, NPO, 2006

Figure 17: Comprehensive overview of landfill liner

5.2.2 Comparison of various liner structure types

The table below shows a comparison of different types of liner structure. The cost depends not only on the type of liner, but also on the geographical location of the project and methods of material procurement. The unit cost of installation per square meter varies according to the type of liner, as indicated on the bottom line.

Table 4: Liner structure comparison by type

	Standard	Simple	Natural clay layer exists
Type of liner structure			
Unit cost of liner structure	Unit cost XXUSD/m² (100%)	Unit cost XXUSD/m² (70%)	Unit cost XXUSD/m² (50%)

5.3 Gas ventilation unit

In order to enhance the stability of the waste layer, gas ventilation is important for the passage of incoming air and outgoing gas generated by the waste layer.

A gas ventilation unit consists of a perforated pipe, a protective layer made of gravel and a wired mesh for fixing the gravel. If there is no protective layer, the perforated pipe could come into direct contact with the landfilled waste, which could block the air flow.

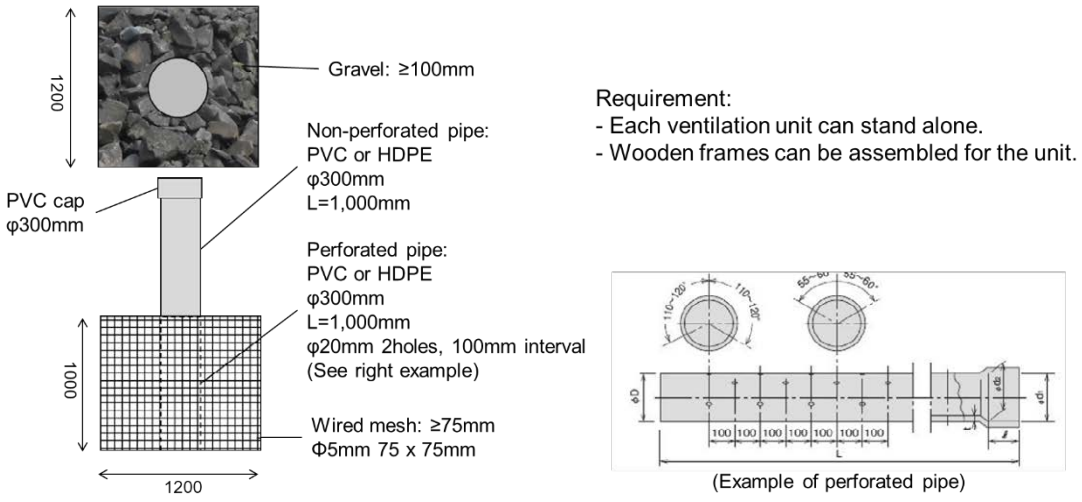


Figure 18: Gas ventilation unit

The figure on the next page shows a concrete example of the installation of gas ventilation units.

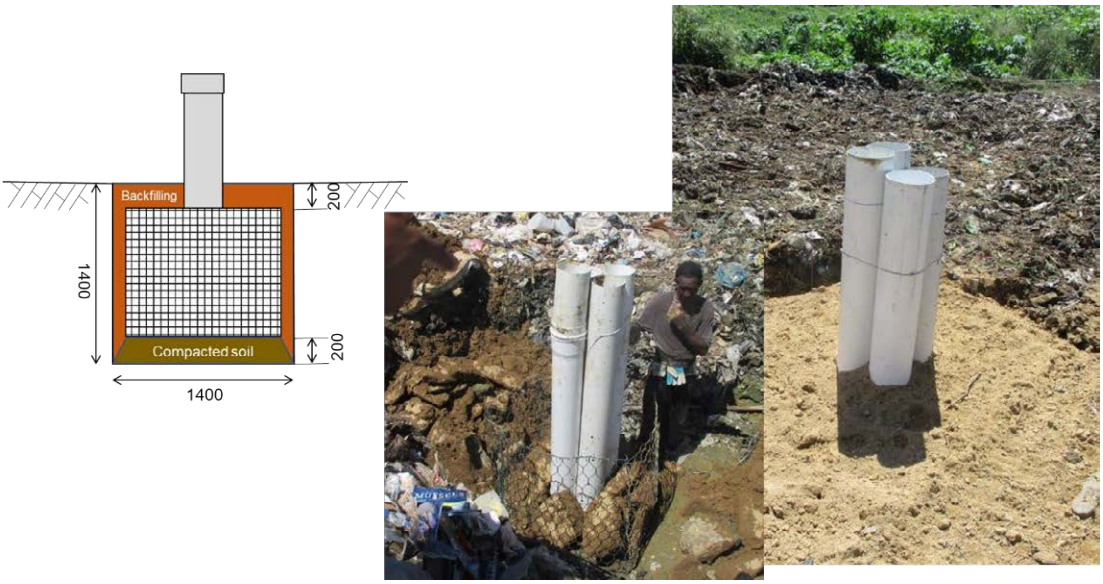


Figure 19: Installation of gas ventilation units

6 Operation and Maintenance of the landfill

Operation and maintenance are as important as the construction of the landfill. This chapter presents some practical examples of operation and maintenance.

6.1 Maintaining a dumping area

For maintaining the dumping area, it is recommended to cover the area with hardcore like gravel as this would facilitate the passage of all incoming waste vehicles.

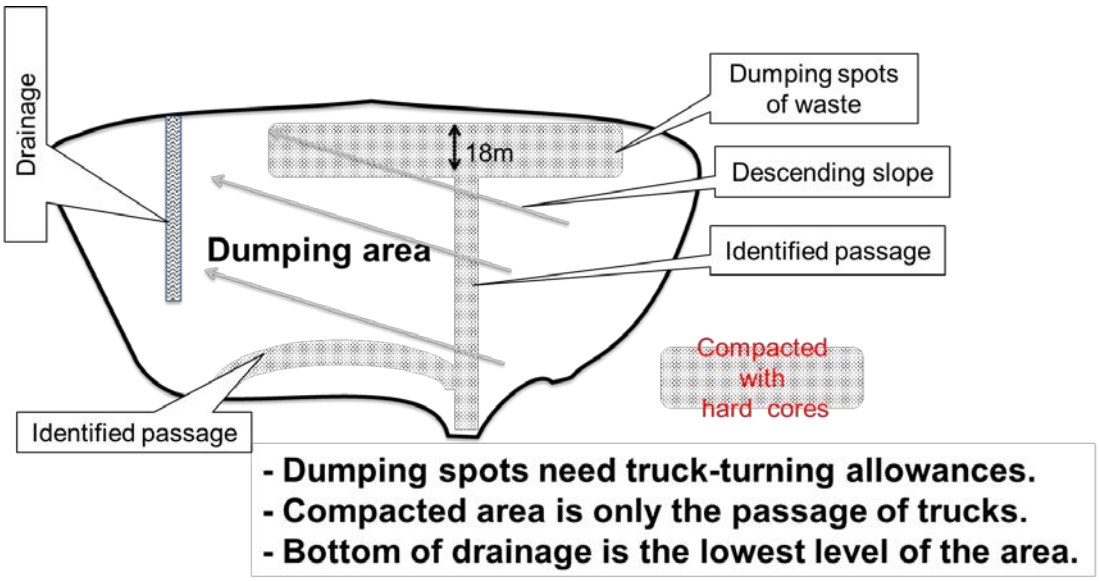


Figure 20: Passage improvement of dumping areas (initial phase)

6.2 Pilling up of waste

For the physical stability of the landfill layers, the waste should be piled with a gradient of 1 to 2.5 as shown in the figure below. Another key point for stabilization is to limit the height of a pile to a maximum of 2m. Basically, one pile of waste should correspond to one day of operation, not two days or more.

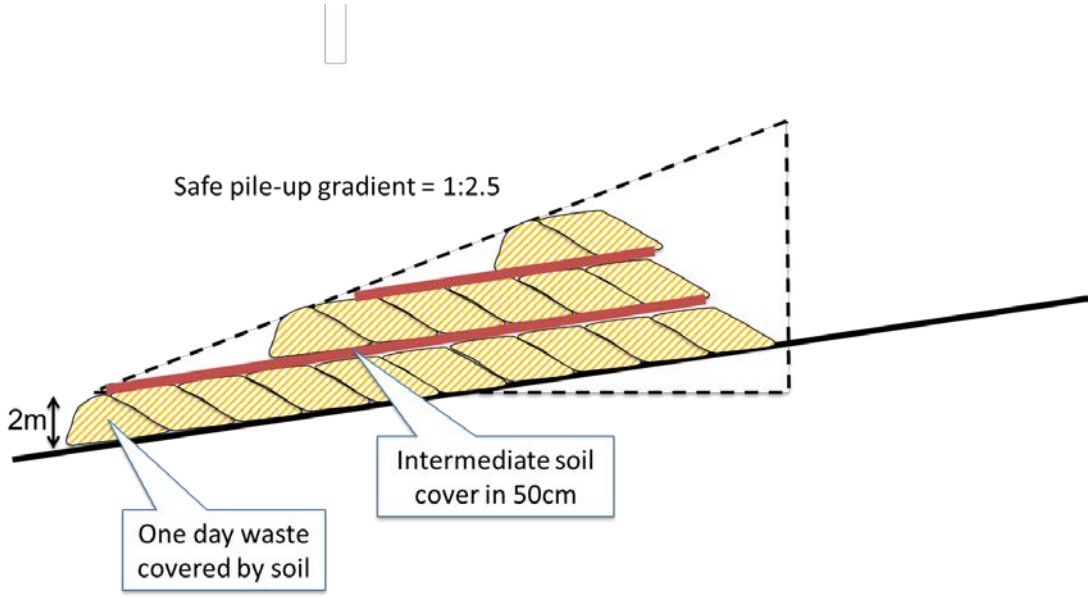


Figure 21: Practice of waste piling and soil covering

6.3 Maintenance of access road

To remove a large amount of stagnant water from the road, the installation of drain spots can be effective as shown in the figure below.

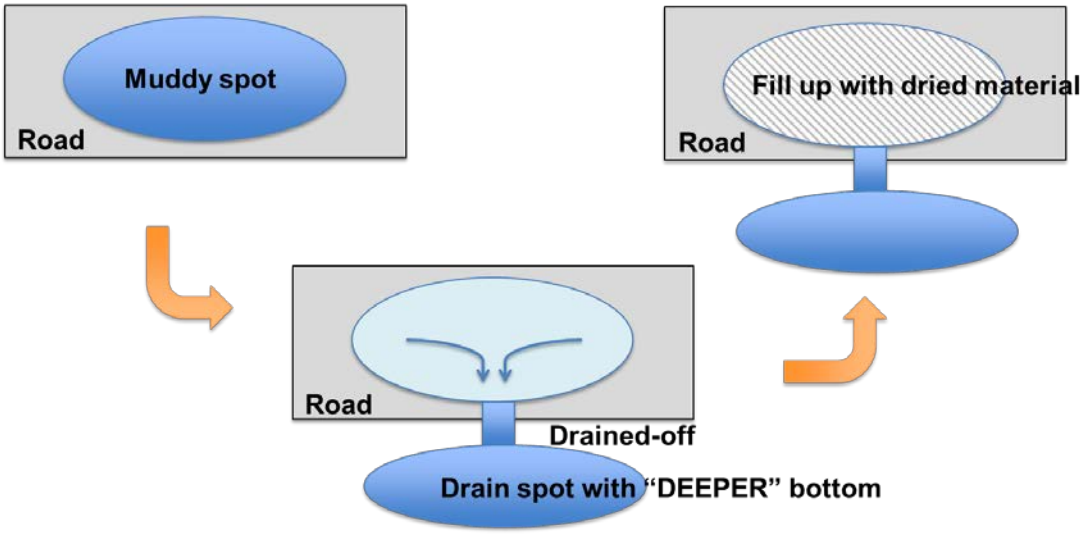


Figure 22: Temporary drainage spot

6.4 Drainage

If there is no drainage, rainwater may damage the foundations of access roads. In practice, most temporary roads in landfills are made of compacted soil or other natural materials, because they are just temporary. High durability is therefore not required for temporary roads, nevertheless, damages to temporary roads shall be minimized for secure operation.

In that context, the drainage of temporary roads is crucial. If there is no road drainage system, wheel tracks will form after rain and the temporary roads will no longer be suitable for the passage of garbage trucks. If drainage is installed, the water flows away by gravity.

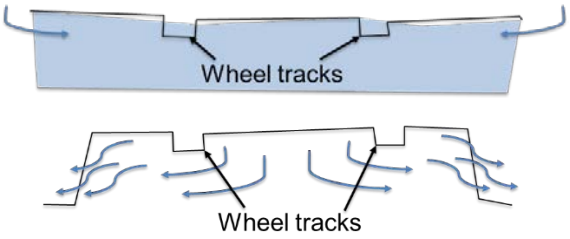


Figure 23: Importance of drainage system for temporary roads

a. One side drainage

Road drainage systems should be installed on both sides of the road, however, to save time and money, drainage can be installed on one side of the road. In this case, the slope of the road is important as shown in the figure below. If the gradient is wrong, rainwater can damage the roads by stagnating as shown in the figure below on the right.

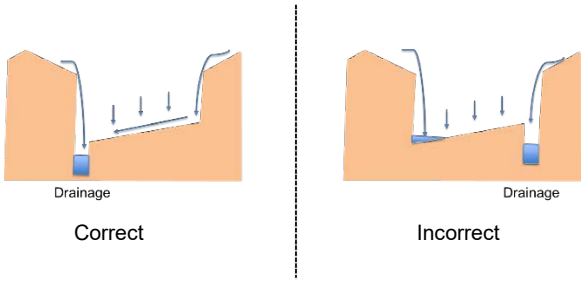


Figure 24: One-side drainage

Some concrete examples of one side drainage are shown in the following pictures.

Figure 25: Examples of drainage installation

b. With or without drainage

At Deglos Sanitary Landfill in Saint Lucia, as shown in the pictures below, the drainage system is working. On the left, the temporary road is higher than both sides of the road so that rain can drain off the road. On the right, there is a drainage system on both sides of the temporary road so that the road can be used after a rainfall.

Figure 26: Good examples of drainage (Deglos Sanitary Landfill)

c. Use of gabion

For a long-lasting use of the drainage system, the installation of gabion under the ground is effective as the photo below shows.

Figure 27: Gabion installation

d. Drainage for the administrative road

Drainage of the administrative road surrounding the landfill area has to separate the rainwater from the leachate. A gentle slope on the road will work as shown in the figure below.

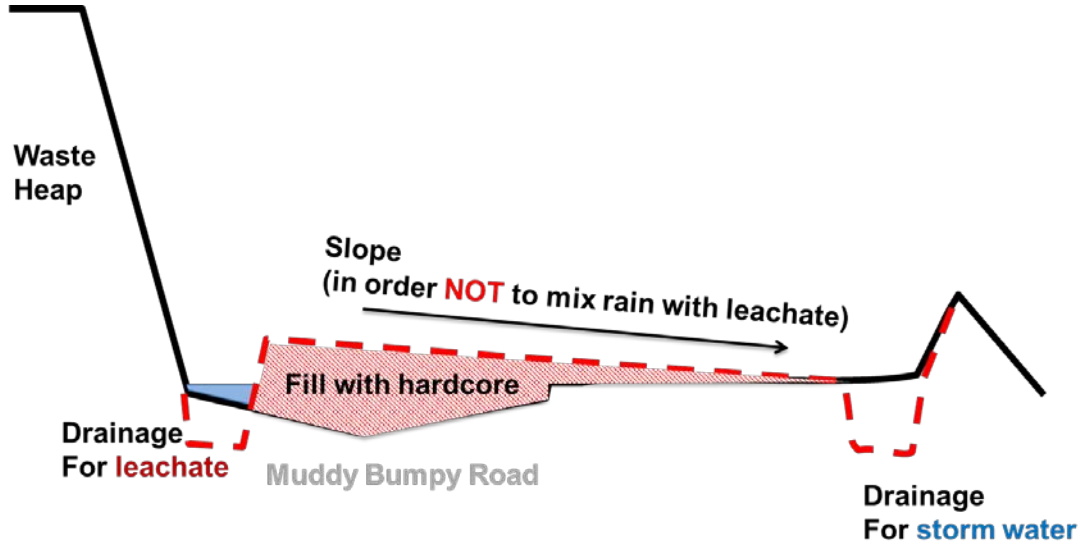


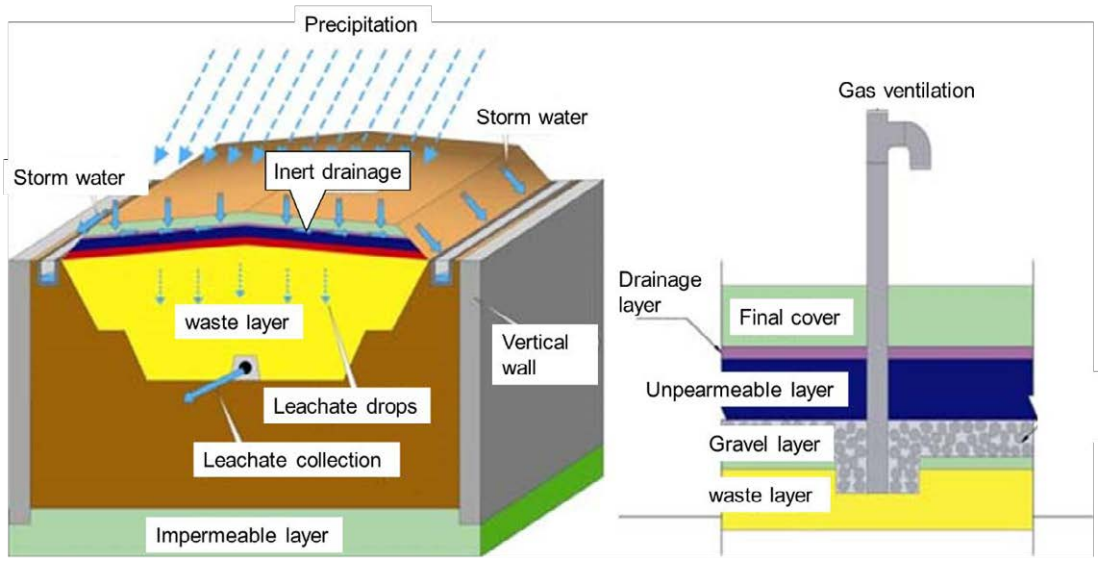
Figure 28: Drainage installation in the administrative road

7 Safe closure of landfills

At the end of the service life of the landfill, a safe closure process should be implemented to protect the surrounding area. Even after the operation of the landfills finished, there is still a lot of waste and leachate that could pollute the environment if appropriate measures are not taken.

Therefore, the leachate isolation system from storm water and gas ventilation system must remain functional even after the landfill is closed.

The most important features for a safe closure are shown in the figure below.



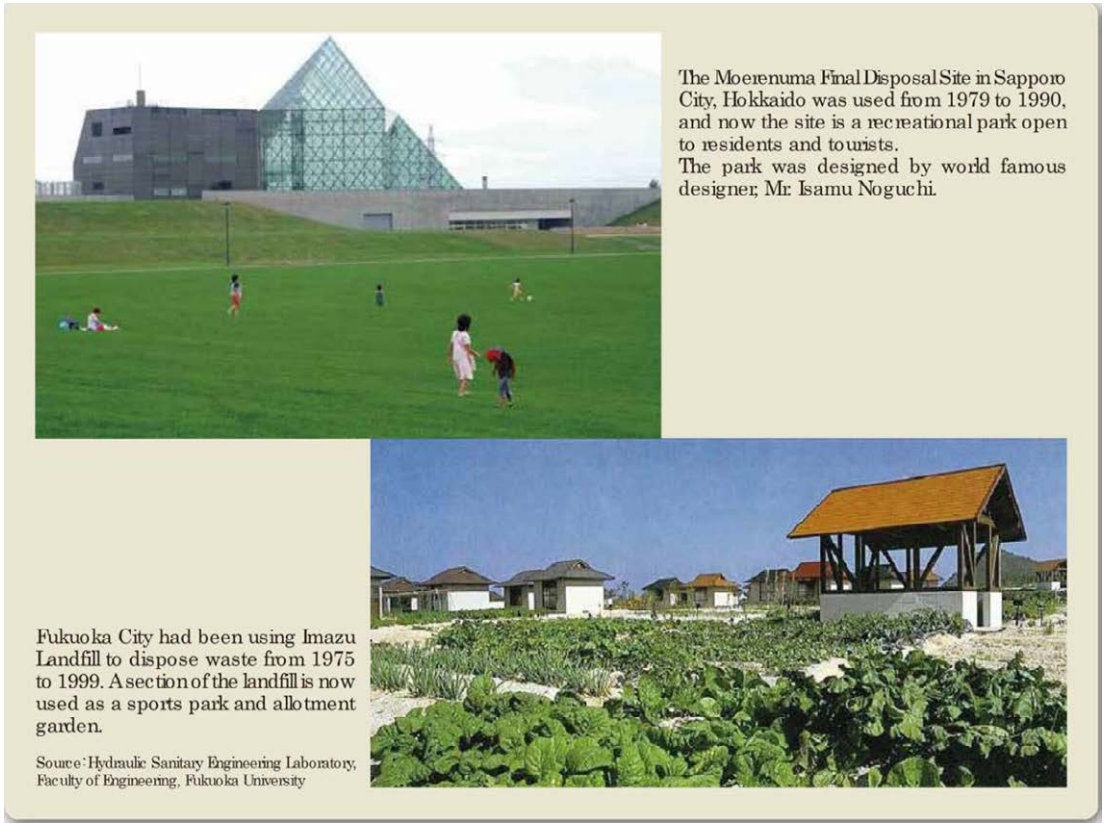
Source: Konoike Construction Co., Ltd. Homepage, https://www.konoike.co.jp/works/detail/000212.html

Figure 29: Features for a safe landfill closure

The followings are examples of safe closure in Japan.

Total area	36,000m^2
Landfill area	16,000m^2
Capacity	128,000m^3
Land improvement	120,000m^3
Vertical liner	22,017m^2
Capping area	21,950m^3

Figure 30: Former landfill of Ryugasaki (Ibaraki, Japan)



Source: Sapporo City Homepage (Top), Fukuoka City Homepage (Bottom)

Figure 31: Other examples of safe landfill closure

8 Recent technologies

In Japan, as well as in the Caribbean countries, suitable land for landfills is limited. Therefore, complaints from residents have been increasing and requirements on the landfill are getting serious. New technologies have recently been developed to address such issues.

8.1 Landfill with movable roofs

To save on the capacity of the leachate treatment area and to control rainwater entering the landfill layers, some landfills have movable roofs above the active landfill cells. Two examples are shown in the following figures.

Location: Wakkanai, Hokkaido, Japan
Total area: 17.34ha
Landfill area: 28,700m^2
Capacity: 189,000m^3
Operation start: 2007.10
Project Scheme: BTO (Build Transfer Operate)
Constructed by:
Penta-Ocean Construction Co., Ltd.

Location: Ochi Town, Kochi, Japan
Total area: 2.8ha
Landfill area: 2,400m^2
Capacity: 19,000 m^3
Operation start: 2007.10
Constructed by:
Kumagai Gumi Co., Ltd.

Figure 32: Examples of landfills with movable roofs

8.2 Leak detection

To detect leaks of leachate in landfill liners, a leak detection system was developed in Japan. Several types of leak detection system are currently used in Japan.

When a leak occurs on the liner structure, the gauge pressure of the vacuum pump, which continuously sucks, suddenly drops and the leak is detected. The system uses a double liner

system, therefore, even if there is a leak in the upper sheet, there is no leakage of leachate into the environment.

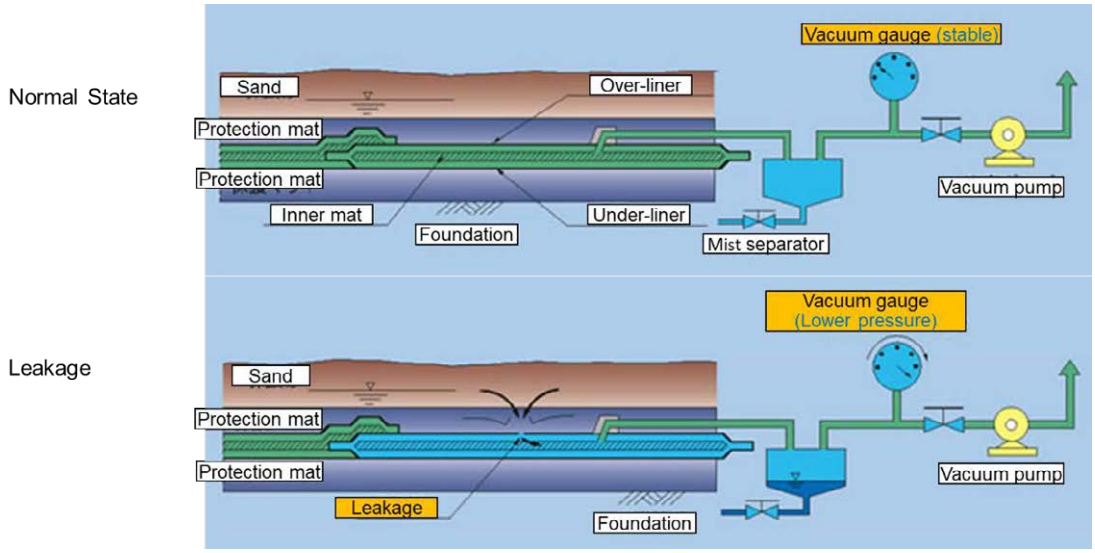


Figure 33: Leak detection system

Technical Project on Advisor for Marine Plastic Litter Management in the Caribbean Region

Technical Note No.6

Fees for Municipal Solid Waste Services

JICA
Japan International Cooperation Agency

October 2023

Technical Project on Advisor for Marine Plastic Litter Management in the Caribbean Region

Technical Note No.6

Fees for Municipal Solid Waste Services

Prepared by Taisuke WATANABE, JICA Advisory Team
October 2023

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1 Objective

As the SWM sector is an underbudgeted sector, responding to increasing expenditure and reducing cost is not easy. Raising revenue is the first thought coming to mind. Since most readers are already familiar with the expenditure (cost) aspect, the revenue side is addressed here for knowledge sharing with a focus on fee charging.

- Taxes and fees are the main revenue instruments. Tax revenues tend to be included in general revenues. Meanwhile, fees are understood as payment for a service.
- The objective of this technical note is to provide knowledge on how to design a waste fee and to better understand the practical issues related to waste fees in order to achieve sustainable financing of SWM.
- This technical note deals with general revenues for SWM, while there are other financing mechanisms such as Extended Producer Responsibility (EPR) that can be applied to specific products/wastes.

2 Revenue

2.1 Financing principles

There are alternative approaches to setting waste taxes/fees. It is important to understand the principles of public services when considering revenue. The principles commonly used to design charges include the following.

- ✓ Cost recovery: Reflecting the costs associated with providing service including operation and maintenance, capital, replacement and financial costs. Efficient allocation of resources and efficient supply of services also considered.
- ✓ Affordability: Considering the capability of payers such as income level and willingness to pay for the service.
- ✓ Equity and fairness: Equitable treat for the users on services and keeping transparency with visibility.
- ✓ Polluter pay: Considering the responsibility of waste generators.
- ✓ Behaviour change: Avoiding illegal dumping and non-payment.

2.2 Sustainable financing

SWM is a daily and essential service. It needs to be supported by a secure financial system. Therefore, understanding the nature of costs and revenues is the first step to making SWM sustainable.

It is essential that the municipality and its waste management department understand the full costs of operating its SWM services and the individual components that make up these costs.

Revenue streams must cover the full cost of the operating system, asset replacement and long-term liabilities. Identifying and generating the annual revenue required to maintain the system on a continuous, reliable and predictable basis is key to achieving sustainable SWM.

2.3 Sources of revenue

Once the current costs and revenues are understood, the process of forecasting future revenues and expenditures may commence. Forecasts of future revenues are required to set user fees. The types of revenue are shown in the table below.

Table 1: Types of revenue

Type of revenue	Description
Budget transfer from government	Allocation in the government budget (often development budget and operating budget). It is usually done through a budget request/proposal from the competent department/ministry.
Tariff/fee revenue	Depends on the design and implementation.
Sales of goods	Sale of recyclables, compost, etc.

Another method to generate revenue is to cut costs, especially avoidable costs.

2.4 Revenue collection mechanism

Different revenue collection mechanisms are possible, including through a tax, a user fee or a combination of both.

Revenue collection methods require service improvements and awareness-raising campaigns in order to ensure public acceptance. Penalties and their enforcement are important factors for compliance.

3 General design on waste management fee system

3.1 General requirements

Waste management fees must meet many different requirements. General requirements include the following:

- ✓ User pays
- ✓ Tariffs incorporate/represent an incentive to support the system's policy (such as the 3Rs)
- ✓ Keep it simple and stupid (reduce administration efforts, reduce regulatory requirements and improve transparency)
- ✓ Tariffs are due on a regular (monthly to yearly) basis
- ✓ Set a differentiation between "household waste" and "institutional, commercial and industrial wastes"

3.2 User pays

When saying "the user pays", it is important to think about what it means and what the objective is. It is also important to clarify who the user is and what the relationship is between the user and the user-related costs.

So-called "full cost recovery", i.e. where all costs are covered by the user fee, is difficult to achieve, although it is the principle of financial institutions. If it is difficult to set a fee that covers all costs, it is important to at least keep in mind the possibility of increasing the user fee.

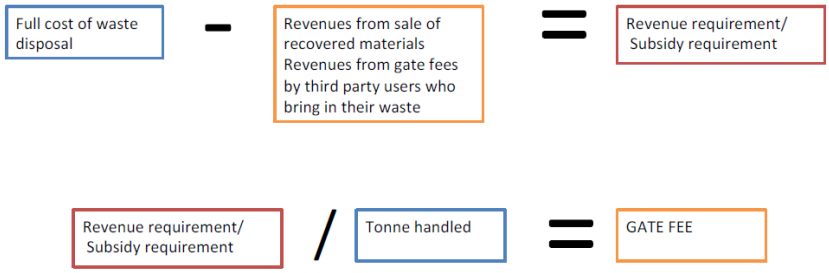
3.3 Objective of the fee and budgeting

The specific reason/justification will be explained when the fee is set. If the purpose of the fee is to cover a specific SWM expenditure, the fee collected shall be allocated to the SWM budget for that expenditure. If the collected fee is allocated to the general budget (not just for SWM) and the budget and expenditure do not meet the objective of the fee, the fee payer will be dissatisfied and this may lead to non-payment.

4 Types of fees

4.1 Gate fee for disposal[1]

The establishment of a gate fee for disposal is a good practice likely to encourage recycling, provided that the control of illegal dumping is carried out by the environmental authorities and/or the municipality. The figure below shows, for reference, how to set the gate fee in full cost. The gate fee for disposal will be paid by the service operator, be it a private company, a public company or a different kind of organization. This will then become their cost and will be charged to the user. This way, the user fee includes the full cost of waste disposal, including the gate fee of the disposal site or any treatment site that is part of the waste management system.

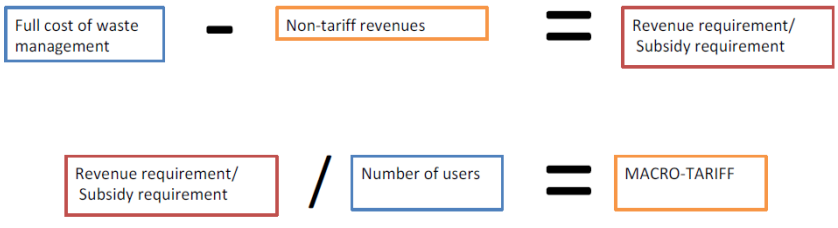


Source: Reka Soos, Financial Aspects of Solid Waste Management

Figure 1: Full cost of disposal and gate fee

4.2 User fees[2]

User fees are charges levied directly on the service user. If there is income other than the fee, this is deducted from the fee to be charged to the user to cover the full cost. This is the fee, so-called macro-tariff, that would be charged equally to all users. Once the macro-tariff is calculated, the fee is set for each user, taking into account the user's waste discharge characteristics and economic level.



Source: Reka Soos, Financial Aspects of Solid Waste Management

Figure 2: Full cost and fee

[1] Reka Soos, Financial Aspects of Solid Waste Management
[2] Ibid.

4.3 Taxes

Some taxes may partially include SWM in the objective. For example, a property tax may have the purpose of taxing the services provided by the property. In this case, the property tax covers many types of services, including SWM. As the purpose of the taxes is not specific, the revenue collected is added to the general budget.

4.4 Quantity based fees

Quantity-based (variable rate) charging scheme (also known as “pay-as-you-throw" scheme) relate to the amount of waste collected. This scheme aims to incentivize service users to adjust their behaviour in a way that contributes to the achievement of governments’ waste management policy objectives.

Incentives can take two forms:

- Encourage users to reduce the amount of waste they produce. The charging scheme is designed to meet waste minimisation objectives.
- Encourage users to reduce the amount of waste they produce and to separate their waste into recyclable and residual fractions. Users must consider both (i) the total amount of waste they put out for collection and (ii) the respective amounts of recyclable materials and residual waste they put out for separate collection, as differentiated rates apply.

5 Fee collection

5.1 Important elements for successful fee collection

Service that has value to users: People are usually willing to pay for a good waste collection service. However, if the service fails to ensure a clean and healthy environment, they are less likely to agree to pay.

Financial flows of the revenues are controlled by the Municipality: i) Enforcement of payments is possible through administrative or financial penalties, and ii) The municipality can control the quality of the services and impose financial penalties on the operator in case of non-performance.

5.2 Efficient revenue collection methods

Tax such as property tax or public utility tax may include the SWM cost in its justification. In this case, revenues can be collected through the property tax or a billing procedure linked to a public utility bill. Pros and cons are described in the table below.

Table 2: Pros and cons of property tax and public utility

Fee collection method	Pros	Cons
Property tax	Low administrative cost as it is collected once a year	May not be affordable for poor households to pay a large sum of money once a year.
Public utility such as electricity	High payment rates High cost efficiency	Potential issues with the legality of sanctions such as cutting off electricity or water to users in case of non-payment.

5.3 Type of fee collection (linked to the fee system)

Indirect billing by government: Billing of a waste management fee (tax) linked to an existing tax such as property tax.

Direct billing by government: The government is directly responsible for all aspects of preparing and maintaining service user registers, setting waste fees, billing users, collecting payments, recovering arrears and enforcing penalties.

Direct billing by the operator: The government appoints a licensed private municipal waste management company to be responsible for both waste management operation and fee collection.

5.4 Non-payment issues

Enforcement of payments is possible through administrative or financial penalties. The government can control the quality of the services and impose financial penalties on the operator in case of non-performance.

Enforcing sanctions is very important to reduce non-payment, but many governments are unwilling to do so.

6 Points to consider

6.1 Analysis of the current situation

To discuss revenue, the relationship between expenditure and performance becomes the first issue. The discussion then moves to the relationship between revenue and the expenditure required to improve performance. An analysis of these relationships is essential to understand the current and required situation. In the case of waste collection, for example, it is useful to break down costs, determine unit costs and compare costs with the ideal service. It is also useful to make comparisons with another city or with other collectors.

These analyses also provide an explanation of why revenues need to be increased and fees raised in order to improve the service.

6.2 Willingness to pay and affordability

Willingness to pay (WTP) and affordability to pay (ATP) analysis is another important consideration when setting fees. This analysis will tell you how much users are willing or able to pay for the service.

WTP can be assessed using a variety of research techniques, but the most widely used approach in the municipal waste sector is the “contingent valuation” method, whereby survey and questionnaire-based tools are used to assess the WTP of residents of a community for improved service levels. The question would be “How much are you willing to pay for the improved service?”

Affordability is often considered in terms of the income of service users. Household income is one of the important indicators to analyse whether citizens are able to pay the fee.

6.3 Required data

Each fee model requires data that must be administrated. The minimum data required includes:

- Address of the property
- Name and address of the owner
- Name and address of the person who pays the waste management fee (if different from the owner)

> **Example:**
>
> If waste is collected from containers situated in public places, the fee cannot be based on single containers. In such a case, the fee has to be based on measurable data related to a single premise on which the waste is being generated. Such data can be, for example, the number of residents, floor space, or the value of the property.
>
> Source: ISWA, How to Design an Appropriate Waste Fee

6.4 Cost factors to be covered – fixed and variable costs

- Cost analysis is critical to express revenue needs to stakeholders.
- Fixed costs include administrative costs, costs for public relations and costs for the collection of recyclables.
- Variable costs include waste treatment costs and a small part of collection costs.

6.5 Citizens' behaviour

- The fee system should contain elements to reward desired behaviour with a financial incentive.
- Fee payment is often avoided. Raising public awareness and an easy payment system are needed.

6.6 Fees for private companies

- Integrating the management of institutional, commercial and industrial waste into municipal waste management allows municipalities to receive additional revenue to cover the fixed costs if municipalities provide SWM service for these generators.
- Generally, the private sector is more able to pay than households.

6.7 Political support

Generally, the setting of the fee system or the revision of the fee rate is subject to a political decision such as approval by parliament. Communication with political leaders is key to gaining support and for this communication, persuasive materials are essential. Examples include:

- Benefits of improving SWM service from a health, environmental, economy and society perspective (see "Section 5.2 of Global Waste Management Outlook[3]").
- Current cost and cost required to improve the SWM service.

[3] UNEP and ISWA, Global Waste Management Outlook, 2015

7 Lessons learned from case studies

7.1 Eight case studies on result-based financing by the World Bank[4]

- Collecting sufficient baseline information on the needs of the sector enables the development of fee models tailored to the challenges and needs of each city or country.
- Baseline information may include MSW practices, solid waste collectors, equipment and method of waste collection, treatment and disposal of MSW, and policies and regulations.
- Active involvement of all stakeholders from an early stage through:
  - ✓ Consultation of stakeholders and actors through workshops or/and targeted surveys.
  - ✓ Involvement of the national and local governments, private and informal waste collectors, and community members and leaders.
  - ✓ Discussion of the proposed design in a final stakeholder workshop where all actors are given the opportunity to voice their opinions.
- Ensure project prerequisites in the early stages of project implementation. Prerequisites may include:
  - ✓ Established and institutionalised SWM subject committees and operational units.
  - ✓ SWM strategies and service improvement plans.
  - ✓ Established performance and service delivery monitoring systems, etc.
- Fundamental changes in behaviour can take time to establish, so it is important to set realistic targets. Improvements are expected to occur gradually over time.
- Institutional arrangements and flow of funds should be simplified as much as possible, taking into account the capacity of the implementing agency.
- Supplementing financial subsidies with educational outreach and technical assistance provides greater leverage.

7.2 Case of Phnom Penh, Cambodia (new city government fee setting)

The private company that obtained the exclusive rights for solid waste collection (with a fee charged by this company together with the electricity invoice) was denied its license by the Prime Minister. The city of Phnom Penh started to take over waste management by selecting collection companies and collecting the fee by itself from 2022. A new fee table was set for non-business locations (by type of house) and businesses (36 categories). The city of Phnom Penh introduced the fee system by:

- ✓ Establishing a payment system with several tools including electronic payment through mobile apps.
- ✓ Warning non-payers of the risk of additional penalties, including public naming on social media and loss of operating licenses for businesses.
- ✓ Establishing performance and service delivery monitoring systems, etc.

[4] World Bank, Results-Based Financing for Municipal Solid Waste

8 Reference documents

- ISWA (International Solid Waste Association), How to Design an Appropriate Waste Fee - Principles, Practices and Applications of Waste Management Fees, 2011
- Reka Soos, RWA Group, Financial Aspects of Solid Waste Management, 2017
- UNEP and ISWA, Global Waste Outlook, 2015
- World Bank, Bridging the Gap in Solid Waste Management – Governance Requirements for Results, 2021
- World Bank, What a Waste 2.0, 2018
- Environmental Affairs Department, Republic of South Africa, Municipal Solid Waste Tariff Strategy, 2012
- Environmental Affairs Department, Republic of South Africa, Solid Waste Tariff Setting Guidelines for Local Authorities, 2012

Reference[5]

Data on costs and fees

Table 5.2 Typical Waste Management Costs by Disposal Type

US$/tonne

	Low-income countries	Lower-middle-income countries	Upper-middle-income countries	High-income countries
Collection and transfer	20–50	30–75	50–100	90–200
Controlled landfill to sanitary landfill	10–20	15–40	20–65	40–100
Open dumping	2–8	3–10	—	—
Recycling	0–25	5–30	5–50	30–80
Composting	5–30	10–40	20–75	35–90

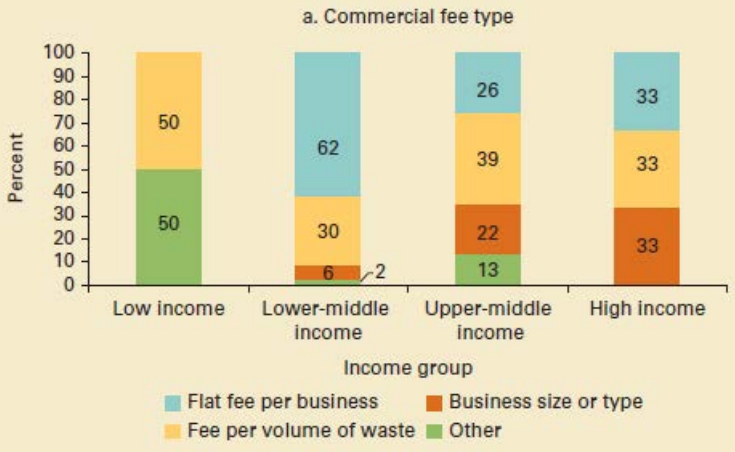
Source: World Bank Solid Waste Community of Practice and Climate and Clean Air Coalition.
Note: — = not available.

Table 5.5 Waste Management User Fees by Income Level

	Average fees, US$ per year	
Income group	Household	Commercial
High income	$168	$314
Upper-middle income	$52	$235
Lower-middle income	$47	$173
Low income	$37	$155

Note: All currency amounts are in US$.

Figure 5.1 Waste Management Fee Type and Billing Method



[5] World Bank, What a Waste 2.0, 2018

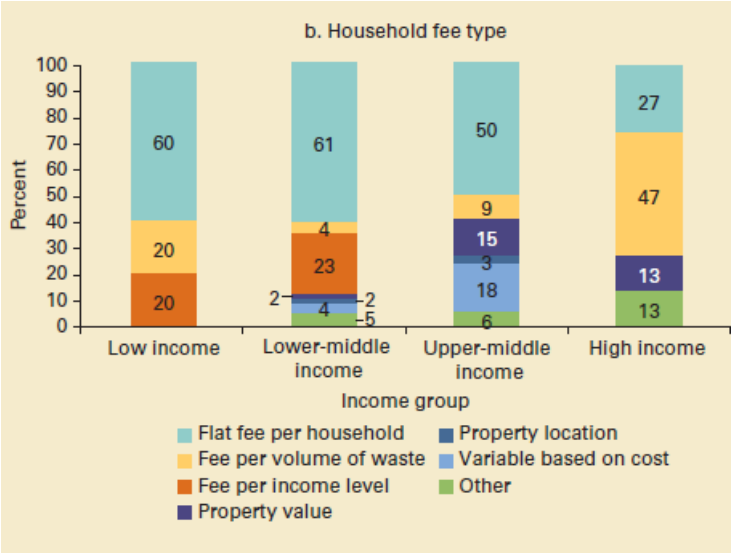
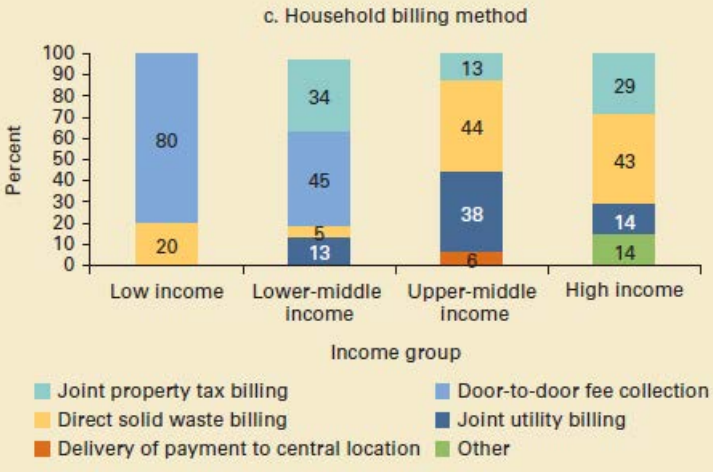


Figure 5.1 Waste Management Fee Type and Billing Method *(continued)*



Technical Project on Advisor for Marine Plastic Litter Management in the Caribbean Region

Technical Note No.7

Information, Education and Communication

JICA
Japan International Cooperation Agency

October 2023

Technical Project on Advisor for Marine Plastic Litter Management in the Caribbean Region

Technical Note No.7

- Information, Education and Communication -

Prepared by Makoto YAMASHITA and Christine YOLIN, JICA Advisory Team
October 2023

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1 Definition and objectives of IEC

Humans are at the core of society so that public awareness and cooperation are always crucial when introducing new measures or implementing a project. Information, Education, and Communication (IEC) can be leveraged as a strategic approach to disseminate information, create awareness, and drive behaviour change among target populations. If planned and rolled out well, an IEC campaign can be a powerful tool for creating a sense of ownership and responsibility among individuals and communities toward a specific issue and mobilize them to take action.

The objectives of an IEC campaign depend on the specific topic or issue being addressed, but some common goals include:

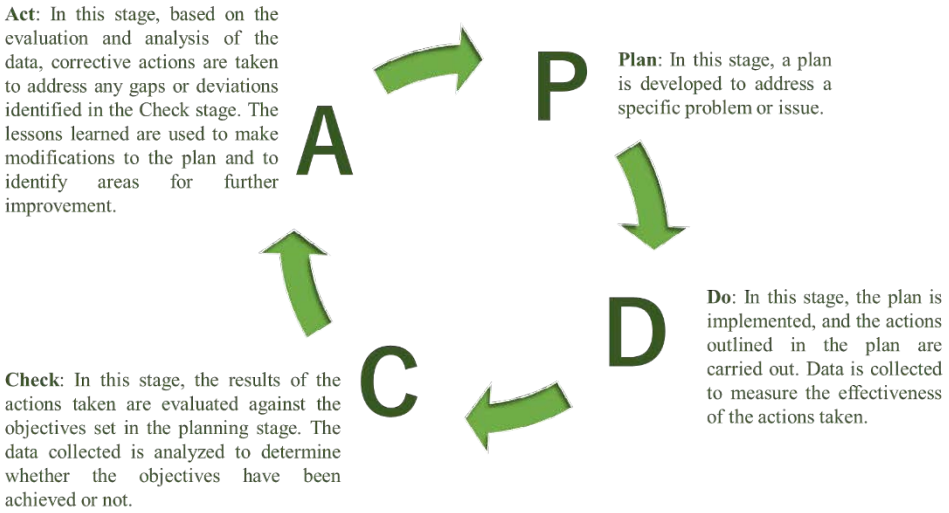
- **Raising awareness**: The campaign aims to increase awareness among the target audience about a particular issue, problem, or opportunity. In the field of waste management, IEC campaigns can help raise awareness about the importance of proper waste disposal and the impact of mismanaged waste on the environment, human health, and public finances.
- **Enhancing knowledge and skills**: The campaign aims to increase the public's understanding and knowledge of the topic or issue being addressed and provides people with the information and skills they need to make informed decisions and take appropriate action. Many residents are not aware of the dangers of improper waste disposal, and IEC campaigns can help address this knowledge gap. People are more likely to participate in programs and activities if they understand their benefits and impacts.
- **Encouraging behavioural change**: The campaign aims to change the way people think or feel about a particular issue, in order to motivate them to adopt new behaviours or practices that are beneficial to themselves and/or others. IEC campaigns can influence people to adopt responsible behaviours such as reducing, reusing, and recycling.
- **Strengthening social norms**: The campaign aims to reinforce existing social norms and/or establish new norms that support positive behaviours and discourage negative behaviours. If people feel that littering is frowned upon by their community, they will probably stop for fear of rejection.
- **Building partnerships**: The campaign aims to build and strengthen partnerships among stakeholders, including government agencies, non-governmental organizations, communities, and the private sector. Collaboration is often critical for the success of waste management programs, and IEC campaigns can help promote dialogue, cooperation, and coordination among stakeholders.

An IEC campaign is more than the mere production of slogans, leaflets, TV commercials or events. A well-planned strategy with coordinated efforts is often necessary to reach the target audience with the appropriate messages and materials. Among the wide variety of online and offline channels, the choice of the suitable media will mainly depend on the target audience, budget, and campaign objectives. This technical note will guide the readers through the different steps to plan, implement and monitor effective IEC campaigns for waste-related topics, give tips on how to create impactful messages and design, and introduce successful cases from around the world.

Toolbox 1: PDCA (Plan, Do, Check, Act)

The PDCA (Plan, Do, Check, Act) cycle, also known as the Deming Cycle, is a widely recognized method for continuous improvement in organizations and often used in project management. It is a powerful tool that helps organizations to identify and eliminate inefficiencies, improve processes, and enhance the quality of their products and/or services.

The PDCA cycle consists of the following four stages:



It is an iterative process, meaning that once the last stage (Act) is completed, the cycle starts again, and the process is repeated until the objectives are achieved. Each iteration builds upon the previous one, leading to incremental improvements over time. This technical note will explain how to roll out an IEC campaign following these stages.

2 Plan

Before launching any project, it is critical to first plan carefully. This initial stage includes i.a. defining the scope of the project, identifying the resources available/necessary, setting objectives, and establishing a timeline for implementation.

2.1 Baseline analysis

A baseline analysis is an assessment of the current situation before the project or program starts. It provides a starting point for measuring progress and evaluating the effectiveness of interventions or improvements over time.

The baseline analysis involves the collection and analysis of data to establish a set of key performance indicators (KPIs) that will be used to measure progress against a predetermined set of targets.

2.1.1 Confirm local circumstances

The success of an IEC campaign will depend on the relevance and effectiveness of the messages being delivered to the target audience. By understanding the local context, the campaign planners can tailor the campaign to the specific needs and socio-cultural context of the local community.

Socioeconomic factors such as income, education, and type of housing can for example impact waste management practices. Understanding these factors can help design messages that are relevant and practical for the target audience. Geographic conditions, cultural sensitivity, current waste disposal practices, etc. are also valuable information to customize waste-related initiatives.

Besides, as a prerequisite for the introduction of new behaviours, it is essential that the operational waste management systems are in place. For instance, before launching a campaign to encourage residents to segregate their waste at home, it must be ensured that the local system will really be able to collect waste separately.

2.1.2 Confirm available resources

Campaign planners often have many great ideas in mind, but the scope and scale of an IEC campaign will be limited by several factors, such as manpower, budget, and time. It is therefore critical to assess the resources available before spending efforts on projects.

Resources	Examples
Human Resources	Local governments, NGOs, community organizations, teachers, local/international experts, religious leaders, etc.
Materials	Goods and tools such as computers/printers, existing teaching materials, cleaning equipment (e.g. for a beach cleanup event), etc.
Money	Budgeted public funds, subsidies, donations, etc.
Timing & Duration	A full week, seasonal, commemorative day every year, etc.
Opportunities	Festivals, community events, school subject, etc.
Information	Implicit and explicit knowledge of the target audience.

Certain activities, such as visits of recycling facilities or clean-up of a public park, may require authorization. It is therefore important to ensure that the necessary permissions are obtained in a timely manner.

It may also be worth identifying and exploring how IEC activities can be linked with other programs and initiatives as collaboration may reduce the burden while reaching/broadening the audience and spreading the message further.

2.1.3 Reference data

Objective data will help clarify the scale of the issue and is necessary to monitor and evaluate the impact of an IEC campaign (KPIs). The data collected at this stage will constitute the baseline scenario which will be used to measure progress and changes induced by the implementation of the activities.

The current state of the local community, economy, and waste management can be identified from existing data or obtained through field surveys, interviews, or citizen science[1] projects.

[1] Citizen science encourages members of the public to voluntarily participate in the scientific research. It is a cost-effective way to gather data over a large geographical area, while simultaneously raising public awareness on environmental issues such as plastic waste.

2.2 Determine issue(s) to address

Not all issues can be addressed at the same time, so it is important to identify which priority issue(s) to focus on with the limited available resources. It is recommended to involve all stakeholders to obtain a representative and objective overview of the needs and expectations, building a common understanding and creating a sense of ownership. If the issue is complex and/or involves many stakeholders, it might be more efficient to repeat the analysis process with the different parties separately.

Several techniques that can help grasp the complexity of a problem and the underlying causes that contribute to it are presented below. A comprehensive understanding of the issue is indeed key to finding potential solutions and developing effective strategies to address it.

2.2.1 5W1H analysis

The 5W1H analysis is a simple technique used to ensure that all the relevant information is captured and considered in problem-solving or decision-making. 5W is an acronym for Who, What, Where, When, and Why, while the letter H stands for How. Here are the six questions that the 5W1H analysis aims to answer:

- **Who**: Who is involved in the problem? Who are the stakeholders or affected parties?
- **What**: What is the problem? What are the symptoms or effects of the problem?
- **When**: When did the problem first arise? When is it most acute?
- **Where**: Where is the problem occurring? Where are the stakeholders located?
- **Why**: Why is the problem occurring? Why is it important to address it? Why have previous solutions failed?
- **How**: How does the problem manifest itself? How can the problem be addressed?

By answering these six questions, the 5W1H analysis helps understand a problem better and find the problem's root cause.

2.2.2 Problem tree analysis

A problem tree analysis is a technique used to find solutions by mapping out the causes and effects around a central issue. By visualizing the relationships between the causes and the effects, it provides a systematic approach to identify effective solutions and develop strategies.

The problem tree analysis typically takes the form of a brainstorming with relevant stakeholders. After agreeing on a single central issue, participants write down on separate cards the effects (outcomes or consequences directly related to the central issue) and underlying causes (reasons why the problem is occurring). The "effect" cards are then placed above the central issue, while the "causes" cards are sticked below. Next, participants identify the linkages between the causes, effects, and the central issue. This helps to understand how the causes are interrelated and how they contribute to the central issue. As a final step, participants discuss potential interventions or solutions to solve the central issue.

The following is a problem tree analysis on the central issue "Residents throw away rubbish in an arbitrarily decided location".

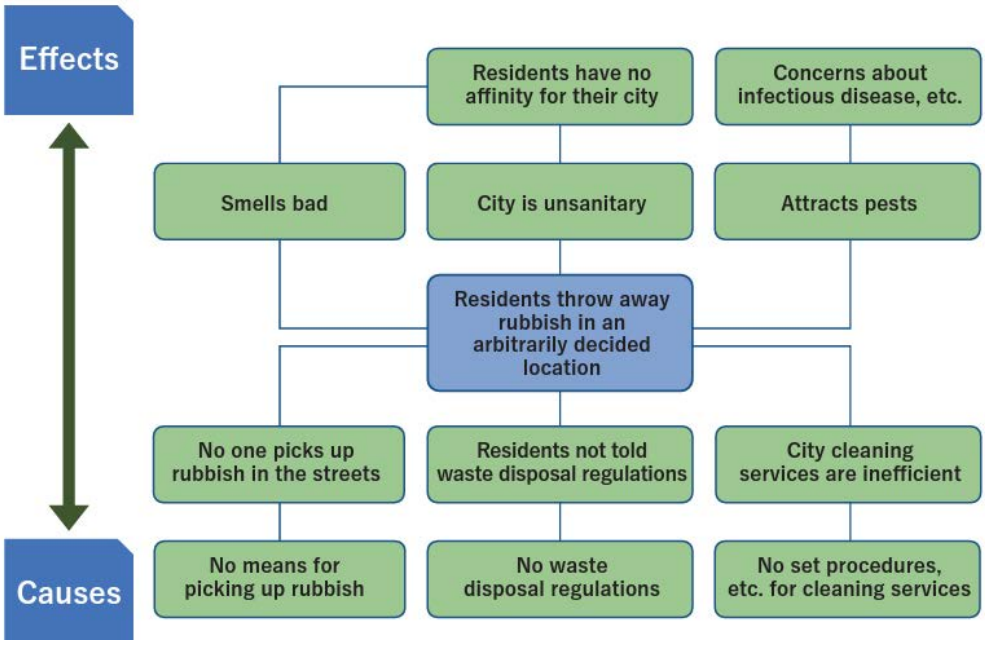


Figure 1: Problem Tree Analysis

Source: ACCP Guidebook for Environmental Education on Solid Waste Management, JICA 2019

2.3 Identify the target audience

The success of an IEC campaign depends on how well the message is received and understood by the intended audience. Different audiences have different levels of education, literacy, and cultural backgrounds, which can impact their ability to understand and respond to the messages. By clearly identifying the target audience, campaign planners can tailor the message to their specific needs and preferences, increasing the chances of success. On the contrary, if the target audience is not precisely identified, the IEC messages might end up being generic and non-focused.

In the field of waste management, stakeholders can be identified based on their role in the waste flow.

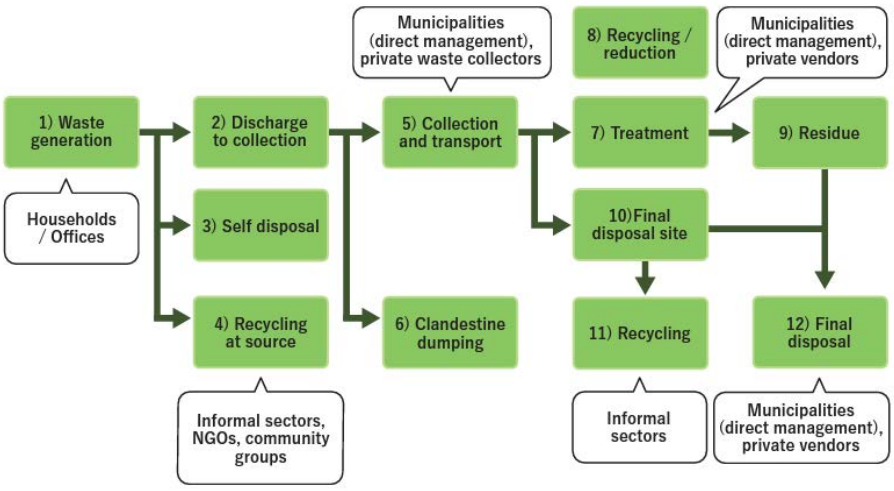


Figure 2: Stakeholders at each stage of the waste flow

Source: ACCP Guidebook for Environmental Education on Solid Waste Management, JICA 2019

While commitment from all community members is necessary to establish a sustainable waste management system, some groups of citizens require more involvement and special attention considering the role they play in society. For instance, youth and children are key target groups as habits are usually formed at very young stage and they represent the future – they are the ones who will shape the society of tomorrow. By integrating SWM in school curricula, it is possible to instil the right behaviour and mindset to the young generation. In addition, campaigns targeting kids have often demonstrated that they influence the parents as well, especially when they take place in educational institutions. Women should also be given special attention, as they often play the main role in SWM. Community-based organizations can also be a relay to reach community members, for example by holding clean-up events or training activities on composting. The target audience can thus be divided into primary audience (direct beneficiaries of the project) and secondary audience (other party who can be leveraged to inform and educate the primary audience).

Once the target audience has been determined, the basic characteristics of each group should be investigated to identify specific drivers and barriers to the desired change. By understanding what is important to them, it is possible to create tailored IEC messages that highlight the direct benefits for them.

2.4 Set goals

Based on the above analyses and discussions, the scope to be addressed by the activities must be refined and the goals of the IEC strategy must be set. Goals should be SMART, i.e.

- **Specific**: Goals should be well-defined and answer the 5W1H questions.
- **Measurable**: Goals should be measurable so that progress can be tracked and evaluated. This can be achieved by setting concrete targets or milestones and monitoring the KPIs.
- **Achievable**: Goals should be realistic and achievable within the given time frame, taking into consideration available resources.
- **Relevant**: Goals should be relevant and aligned with the overall objectives of the project or organization.
- **Time-bound**: Goals should have a specific deadline or timeframe for completion.

SMART goals provide a roadmap, and planned activities should be designed to achieve these objectives.

2.5 Formulate an action plan

Once the current situation is fully grasped, the issue(s) to address and target audience identified, and the objectives to be achieved through the IEC campaign set, it is time to formulate an action plan to translate the strategy into concrete activities.

Action plans are used to break down larger goals into smaller, more manageable tasks, and to establish a roadmap for achieving the desired outcomes. A detailed plan of the campaign activities should be developed, including the timeline, budget, and resources needed for each activity. The connection between goal and activities must be clear and consistent, and activities should progressively build up to achieve the objectives. Monitoring indicators should also be defined for each activity to measure their performance and evaluate whether the desired outcomes are being achieved. Monitoring indicators for a waste management program might include the amount of waste generated, the proportion of waste that is recycled or composted, or the public's awareness of waste reduction and reuse practices. When setting the indicators, it is important to bear in mind that data should be easy to collect and be clearly related to the IEC activity.

To build momentum and motivate stakeholders to maintain their efforts towards the final objective, it is recommended to plan "quick wins." These small, low-cost actions can be implemented quickly and easily and provide immediate and visible benefits to the community. By achieving tangible successes early on, individuals gain confidence in their ability to attain the larger goals and may inspire others. Examples of quick wins in waste management might include implementing a small-scale clean-up event in a particular neighbourhood, holding a community eco-festival, or launching a pilot education program on plastic marine litter at a couple of schools.

Reporting the results of an activity or the whole campaign can also be an item to be included in the IEC action plan to show gratitude toward the efforts of the residents and to further raise awareness. In any case, results should be shared with the people who have been asked for collaboration, for example to fill in a questionnaire or disseminate information within their community.

3 Do (Implementation)

3.1 Media/Channels of communication

Many media or channels of communication exist but they can be broadly divided into three categories, namely Offline, Online, and Face-to-face.

Offline	Online	Face-to-face
• Broadcasting media: TV, radio • Print media: national/local newspapers, magazines, posters, flyers, leaflets, advertorials, etc. • Outdoor media: hoardings, banners, posters, etc. at schools, marketplaces, government offices, and any other relevant public spaces.	• Official website • Social media: Twitter, Facebook, YouTube, Instagram, WhatsApp, etc. • Smartphone apps • Audio-visual materials on Internet: videos, animations, podcasts, e-newsletters, etc.	• Festivals, events, etc. • Conferences, seminars, etc. • Thematic workshops, training, etc. • School activities • Interpersonal communication (home visits, phone calls, etc.) • Field trips, such as visits to a waste treatment plant, etc.

3.1.1 Select the appropriate media or channels of communication

The selection of the communication channel is critical for the effective delivery of the message to the target audience. There is no one-size-fits-all media. Each medium is unique and caters to a distinct audience. A successful IEC campaign will often require a combination of various communication tools to effectively reach the target audience and deliver the message at the right time and place. When planning a campaign, it is necessary to select a strategic mix of media and formats to achieve the objectives. ☞ *See the example of "Brussels Zero Waste Challenge".*

Understanding the strengths and limitations of each media will help select the most appropriate. But before looking at the pros and cons of the most common communication supports, some factors that may limit the choice must first be considered.

- **Access**: Confirm that the medium is easily available or accessible to the target audience (e.g. access to electricity - thus TV, radio, etc. - might be limited in rural or low-income areas), and that the target audience is likely to be exposed to this kind of medium.
- **Type of message:** Some materials are best suited for transmitting official messages from governmental authorities, while others are better at building a relationship with the target audience. For instance, flyers are useful in getting the collection schedule into the residents' home and hands, while social media platforms are more suited for sharing photos and progress of a clean-up campaign in real time.
- **Costs/Human resources:** Some materials are more costly than others to produce and disseminate (due to the need for professional expertise, production equipment, printing costs, etc.) so it is important to identify the media that is the most resources/cost-effective to reach the target audience. Also, it must be ensured that adequate budget has been allocated for the whole duration of the campaign (e.g. even if the resources are sufficient for the production of a TV spot, enough money should be provisioned for the broadcast phase; or when creating a Facebook page, someone must be in charge of updating it regularly and responding quickly to questions from followers).
- **Time:** The time frame between planning, production, and distribution varies depending on the media/communication channels. Production time constraints and other factors must be considered carefully when scheduling a campaign.

Media or channel of communication	Strengths	Weaknesses
Printed materials such as brochures, posters, leaflets, display boards, etc. (excluding mass media such as newspapers and magazines)	● Attractiveness: Printed materials can be designed with eye-catching visuals and concise messaging to quickly convey the campaign's message. ● Distribution: Flyers can be distributed easily in a variety of settings and/or reused on different occasions. ● Wide reach: Posters can be displayed in public places and reach a wide audience. ● Customization: Printed materials can be localized (e.g. message is written is several languages) to cater to a diverse audience. ● Ability to provide detailed information: Brochures and leaflets can provide complex and detailed information (e.g. detail the steps for compost production at home). ● Value: Handouts with relevant information can be kept by the target audience for a long time (e.g. collection schedule or sorting rules hung on the fridge).	● Cost: Printed materials can be costly to produce and distribute. ● One-way communication: It can be difficult to know if the message reached the target audience and was properly understood as there is no interaction or feedback. Potential misunderstandings are hard to detect. ● Limited lifespan: Flyers are sometimes thrown away immediately and can quickly become outdated or lose relevance. ● Access: Materials with a lot of text can be difficult to apprehend by some people, such as children, the visually impaired or people with reading difficulties.
Mass media such as TV, radio, newspapers and magazines	● Wide reach: Mass media have a large public, making it possible to reach people even beyond the initial target audience. ● Credibility: News outlets and magazines are often seen as credible sources of information, which can provide trust to the message conveyed.	● Cost: TV/radio spots and advertising in newspapers and magazines can be expensive, making it unaffordable for smaller organizations with limited budgets. ● Short attention span: Mass media are full of information, making it difficult to catch the attention of the target audience and people may only skim over the message. ● Lack of control: It can be difficult to control the message being conveyed as journalists and editors may choose to

		focus on different aspects of the campaign than what was intended. ● Limited access: TV/radio require access to electricity and distribution of newspapers/magazines might be limited in some areas (rural, illiterate population). ● Lack of customization: When using mass media, it is not possible to tailor messages to specific audiences.
Social media	● Wide reach: Social media platforms like Facebook, Twitter, and Instagram have billions of users worldwide. ● Cost-effective: Setting up social media accounts and posting content is generally free, which can be particularly beneficial for organizations with limited budgets. ● Interactivity: Social media platforms allow for two-way communication, making it possible to engage directly with the audience, address questions or concerns quickly, and foster a sense of community. ● Shareability: Social media content can be easily shared and spread virally, giving more visibility to the message. If shared by an "influencer", it may be seen as an endorsement by an expert and the post might gain credibility. ● Performance indicators: Several success metrics are directly available (likes, comments, retweets, etc.) to efficiently monitor the campaign in real time.	● Limited attention span: Social media users have a short attention span, making it difficult to convey complex information. ● Lack of control: Social media platforms have their own algorithms that determine what content is shown to users, making it uncertain which posts the target audience will actually see. ● Risk of negative feedback: Social media platforms also provide a platform for people to voice their opinions, which can sometimes be negative or critical. ● Regularity and reactivity: Lack of update or delay in responding to comments may give a bad image. To be regular, it is recommended to assign a community manager and develop a social media content calendar to plan, execute and track social media posts efficiently.
Events	● Relationship: Events bring together all key stakeholders which facilitates constructive dialogue and exchange of	● Resources: Holding events can be costly, time-consuming and often requires a skilled team to plan and

	learnings and experiences. They also provide an opportunity to engage with the target audience directly and create a more personal connection. ● Motivation: During events, interactive activities and demonstrations can be organized to educate and inform the audience in a more engaging way. ● Visibility: Events can generate buzz and media coverage, increasing the visibility and reach of the campaign. ● Digital events: Seminars held fully online or in hybrid format allow to reach a wider audience at lower cost.	implement, especially if multiple events are planned in different locations. ● Limited reach: The impact of events may be limited to those who attend. ● External factors: The effectiveness of events may be impacted by factors such as weather, strikes, and competing events happening at the same time. In case of online events, technical constraints (unstable internet connection, etc.) can be an obstacle or even source of failure.
Interpersonal communication *☞ See the example of the "Plastic Bag Robbery" awareness-campaign in Indonesia*	● Customization: A personalized approach can be tailored to the specific needs of the individual. ● Relationship: Through direct communication, it is possible to better understand the needs/issues of the target audience, clarify information and provide immediate solutions, thereby building trust. ● Interactivity: Two-way communication is more engaging and motivating for individuals. Improvements can also be initiated immediately based on the feedback received.	● Resources: Interacting with people one-on-one is time-consuming and requires financial and human resources. ● Limited reach of the message: Cannot reach a broad audience and difficult to disseminate information on a large scale.

Example: Interpersonal communication

"Plastic Bag Robbery" campaign, Indonesia

The Plastic Bag Diet campaign in Indonesia, initiated in 2010 by the NPO Indonesia Plastic Bag Diet Movement (GIDKP), employs a range of in-person awareness-raising tactics in addition to digital engagement. In the "Plastic Bag Robbery", volunteers approach people who are not carrying their own reusable bags in supermarkets or public places to "rob" them of their single-use plastic bags. The stolen bags are then replaced with reusable bags and the person is explained about the negative impacts of plastic bags on the environment. The campaign aims to encourage people to bring their own reusable bags and reduce their reliance on single-use plastic bags. The one-on-one engagement and in-person connection taps into positive emotions and encourage people's commitment while reinforcing positive social norms. The campaign also highlights the importance of each person's contribution and demonstrates the significance of long-term behaviour change.

Sources: Indonesia Plastic Bag Diet Movement (https://dietkantongplastik.info/); Reducing plastic pollution: Campaigns that work, SEI and UNEP 2021 (https://www.campaignsthatwork.org/)

Example: Strategic mix of communication tools and channels

"Brussels Zero Waste Challenge", Belgium

Brussels has engaged in a Zero Waste Strategy to educate its citizens on how they can reduce waste and prevent plastic pollution. Public awareness activities that form part of the Zero Waste Challenge include:

- A monthly zero waste newsletter
- A Facebook page and an agenda for the promotion of zero waste events
- An online resource showcasing best practice projects
- The organisation of municipal Zero Waste Challenges involving hundreds of participating families
- Personalised coaching and support to help families reduce their waste
- Participants receive a specific challenge, several of which target alternatives to single-use packaging and products, such as the "Bulk sales challenge" and the "Zero waste picnic challenge".

Participants in the city's first Zero Waste Challenge in 2019 reduced their waste by 30% in one year, from an initial 61 kg per year to 43 kg per year, which is 75% less waste than the average Brussels citizen.

Sources: Plastic Smart Cities (https://plasticsmartcities.org/); Project website (https://zero-waste.brussels.be/)

3.1.2 Engaging with journalists and other influencers

Journalists are part of the secondary audience. They will disseminate the message to a large public, allowing to reach a wider audience than one could on their own. As they are usually seen as credible sources of information, having a campaign covered by them may be interpreted as a third-party endorsement and increase the credibility of the message. In addition, getting coverage in news outlets acts as free publicity, saving money on advertising and other promotional efforts. Hence, Public Relations can play a key role in the visibility and effectiveness of the campaign but engagement with journalists and news outlets must be planned strategically and with caution. The most common ways to interact with them are as follows:

- Press releases, media kit
- Press conference, media briefing, media roundtable
- Invitation to site visits, events
- One-on-one interviews
- Opinion pieces

When engaging with journalists and news outlets, it is important to be clear and concise and to provide them with all the information they need to cover the story. It is also essential to be fully prepared to respond to any questions or concerns they may have about the campaign.

It is worth noting that other "influencers" can spread awareness about a campaign and encourage more people to take action to support the cause. Since people tend to pay more attention and trust recommendations from those close to their heart, having celebrities or opinion leaders as spokespersons for a campaign can significantly influence and mobilize the target audience. In this context, it might be worth exploring the opportunity to develop a partnership with influencers who have many followers and whose values align with the message of the campaign.

Example: Word-of-mouth to spread information

Lessons Learnt on Public Awareness when introducing a container deposit schemes in the Republic of the Marshall Islands (RMI).

The effort to inform the public was quite small and simple in the case of the RMI. In fact, it was useful to avoid much advance publicity prior to the system starting, as this would encourage people to start stockpiling old cans and bottles, and so add to the legacy waste problem and the finance required to buy up this non-deposit waste. Once the system was set up and ready to roll, and the regulation had been gazetted and was in effect, the EPA public information unit then took out some advertising in the local newspaper, the Marshall Islands Journal, and had some adverts on the local radio. But the most important source of information was word-of-mouth: when the recycling system actually opened for buying cans & bottles at 5¢ each, the immediate expected rush didn't happen, but after two weeks it really took off. Once people saw that they really were going to get 5¢ each for cans & bottles, the word went around Majuro very fast, and no more publicity was needed. It is notable that in places such as Fiji and Vanuatu, where local beer bottles have a refund value for refilling, no markings or advertising of the fact is required, but everyone who needs to know surely does. Some people such as tourists do not need to know about the refunds as they are unlikely to turn up at the recycling centre with their cans, and anyway, the minimum refund number is twenty units ($1). Word of mouth in a small place is the most effective advertising, and it is cheap. The most useful formal advertising is around what items are covered, and that items must be reasonably clean and whole to get a refund. These are the key messages that any public engagement campaign must put out.

Source: Container Deposit Schemes in the Pacific Islands - A Guide for Policy Makers, JICA and SPREP (March 2022), p.63-64

3.2 Create IEC materials

This stage includes message design and material production. The content and format of IEC materials should be appropriate for the audience's preferred communications channels.

While reuse is promoted in waste management, reusing existing IEC materials from other regions must be practiced with caution. Indeed, it generally requires less time and resources than starting from scratch, but it is usually impossible to reuse IEC materials from other campaigns without adaptation to fit to the culture and specific needs of the target audience.

3.2.1 Design messages

Based on the objectives defined, clear, concise messages that communicate the key information must be developed. These messages should be easy to understand and resonate with the target audience. Though adaptation might be necessary to fit the requirements of the different communication channels used, it is important to remain consistent among the IEC materials, without diluting the core message.

Message should be…	Explanations & Tips
audience specific	• IEC materials should address real needs and problems facing the target audience. • Content should be customized to make it relevant for the target audience.
simple and focused	• The information should be specific and single-minded as multiple messages in one communication will confuse the audience. The benefit must stand out clearly. • Get to the point and be clear about the desired outcome. Tell people what to do (expected behaviour), and not only what should not be done (provide a solution).
easy to understand	• Taking into consideration the age, literacy level, etc. of the target audience, use words people are familiar with. Avoid technical terms or jargons. • Create content in local languages or dialects to ensure messages are understandable by the target audience. Avoid literal word-to-word translation but rather try to convey the essence of the concept. ☞ *See the example of "transcreated" tags in the next section.*
attractive and attention catching	• A catchy slogan will be easier to remember. • Illustrate technical content with simple visuals and understandable figures and numbers. Explore formats, such as photos, infographic, animations, etc. ☞ *See next section "Make your message appealing".*
evidence-based and credible	• Trust is generally generated by tone, presentation, believable images and figures, and a solid information foundation. Support your content with facts, statistics, and examples. Data should be verified and come from trusted sources (UN agencies, established NGOs, etc.). • Be careful not to betray expectations of the target audience; otherwise, they might permanently lose trust in your organization.
emotional and inspiring	• IEC materials are aimed at humans so that embedding an emotional dimension in the content can help establish a personal connection with the audience. Telling stories or including quotes may reinforce the authenticity of the message. • Positive and energizing catchphrases can also stimulate the audience to take action. Include a clear "Call to Action" to immediately convert this motivation. • Encourage people to adopt a proper behaviour through nudges. ☞ *See the toolbox below on nudging.*

culturally sensitive	• Refrain from using cultural/religious expressions or symbols that might offend the audience or to which some people cannot relate.
consistent	• Uniformize tone, slogans, and visuals to avoid confusion and create a feeling of familiarity. ☞ *See the example of a successful recycling campaign for beverage cans in Cyprus in the box below.*

Figure 3: Effective strategies for better campaigns – and mistakes to avoid

Source: Reducing Plastic Pollution: Campaigns That Work, SEI and UNEP 2021 (https://www.campaignsthatwork.org/)

Before launching the campaign, it is recommended to test the IEC materials and messages with a small group of people to ensure they are effective and not misinterpreted. The approach can then be refined as needed based on feedback received.

Toolbox 2: Nudging

Nudging is a concept in behavioural economics that uses positive reinforcement and indirect suggestion to influence behaviour and decision-making. By introducing small, subtle changes in the environment or the presentation of information, people are encouraged to make better decisions without constraints. This approach is based on the idea that people are more likely to make positive choices when those choices are made easier, more convenient, or more attractive.

Unlike traditional information/communication practices that rely on providing information and education to change behaviour, nudging works by making desired behaviours easier and more convenient to adopt.

Common nudging techniques include placing signage and prompts at strategic locations, setting a default option, referring to social norms, reminding people to do something, sending positive feedback, reviewing the product design, offering a reward, etc.

Example: Bin it for Good (UK)

The objective of the Bin it for Good initiative designed by The Wrigley Company and Keep Britain Tidy was to reduce littering and incentivise people to place their waste in the bins.

Bin It For Good was first piloted in Rayleigh Town Centre in 2014 by The Wrigley Company, Rochford District Council and Keep Britain Tidy. For three months, all bins within a defined target area have been transformed into charity collection boxes featuring a new local charity or cause each month. On the ground communication (stickers, posters), media coverage and social media outreach explained that more litter in the bins and less on the ground leads to larger donations for local charities. Thus, by throwing their trash in the bin, people support their community in two ways: 1) by improving the appearance of their local area and 2) supporting a donation to a local charity.

The Bin it for Good nudge is that (a) local bins are made more salient through a change to their appearance and local publicity, and (b) the act of binning litter is given a direct, tangible positive consequence – a donation to a local good cause. Behavioural scientists have previously found that rewards can be an effective way to influence people's behaviour. By offering a reward that benefits the community rather than the individual, Bin it for Good reinforces the intrinsic values that often lead to more positive environmental and social behaviours in the long term.

The Bin it for Good pilot successfully reduced litter by an average of 42% during the charity bin months.

Sources: Nudging for Good (http://www.nudgingforgood.com/2017/03/02/the-wrigley-company-and-keep-britain-tidy-bin-it-for-good/); Keep Britain Tidy (https://www.keepbritaintidy.org/local-authorities/reduce-litter/general-litter/bin-it-good)

Example: Message consistency (Cyprus)

In the northern part of Cyprus, facilities for proper waste disposal are limited and recycling activities are mostly carried out by civil society organizations to generate charitable income. Drink cans for example are collected and then sold to raise money for children's hospitals. With the ultimate objective to reduce landfill dependency, a series of measures, funded by the EU, were developed to support these organizations through increased material capture. The campaign focused on three material streams, namely cans, textiles and left over food. For cans, the agency created a multi-channel campaign centred around a common message and visual. They visually linked the message from advertising boards or bus stops to the point of action (collection containers).

Sources: Webinar of be Waste Wise "Behaviour Change and Recycling Contamination" July 20, 2020 – Presentation of Stephen Bates (https://wastewise.be/2020/07/behaviour-change-and-recycling-contamination-insights-and-reflections/); Website of Mobius Agency (https://mobiusagency.org.uk/work/northern-part-of-cyprus/)

Toolbox 3: Environmental education programs

On the right-hand side is a list of elements that can be included in environmental education programs to raise interest, develop understanding, and drive behaviour change. It is not necessary to incorporate all seven items into one activity, but they can be combined based on target audience and objective.

Source: ACCP Guidebook for Environmental Education on Solid Waste Management, JICA 2019

Table : Elements to include in environmental education programs

	Interest	Understanding	Behavioural Change
(1) Fun	◎		○
(2) Sense of Crisis	◎	◎	○
(3) Responsibility	○	◎	○
(4) Effectiveness	○	◎	○
(5) Feasibility		○	◎
(6) Cost benefit			◎
(7) Normative awareness			◎

Example: Ocean Guardian School Program (NOAA, USA)

An Ocean Guardian School makes a commitment to the protection and conservation of its local watersheds, the world's ocean, and special ocean areas, like national marine sanctuaries. The school makes this commitment by proposing and then implementing a school- or community-based conservation project.

Source: Website of NOAA

(https://sanctuaries.noaa.gov/education/ocean_guardian/)

An Ocean Guardian School:

- provides project(s) for students related to the conservation of local watersheds, the world's ocean, and/or special ocean areas, like national marine sanctuaries.
- provides opportunities for students, teachers, parents and friends to participate in a range of environmental and sustainable activities.
- provides learning programs and opportunities that reflect environmentally sustainable practices that enable all students to be environmentally active and committed "Ocean Guardians".
- provides ways for classrooms to promote best environmental practices within local communities, while at the same time projecting a positive image of the school itself.

3.2.2 Make the message appealing

If an IEC material is not attractive, people will not pay much attention to it and the message will not reach the target audience. In addition, certain groups such as children, people with a low-literacy level, or those with visual impairments or other disabilities, may also be harder to reach with text alone. Elements like images, music or animation can help capture the attention of the target audience, convey complex ideas or concepts more simply, and reinforce key messaging points. Such tools can also make the campaign more engaging and memorable for the target audience.

Some visuals that can be used in an IEC campaign for waste management include:

- **Infographics**: Infographics are a popular way to convey complex information in a visual and easy-to-understand manner. They can be used to show statistics, projections, comparisons, etc.
- **Illustrations**: Illustrations can be used to depict specific actions or behaviours, such as how to properly sort waste.

- **Photographs**: Photographs can be used to illustrate a specific issue, such as the impact of plastic waste on marine animals. Photographs show a real situation and can therefore be more impactful that illustrations.
- **Icons and symbols**: Icons and symbols can be used to represent key concepts or actions, such as the recycling symbol or the trash can icon.

When incorporating audio and/or visual elements, it is important to consider the target audience, the key message the material shall convey, the overall tone, and style of the campaign.

Audio/visuals should be…	Explanations & Tips
clear	• Audio/visuals should be easy to understand in consideration of the intended audience. • Ensure that images cannot be misinterpreted without the text that accompanies them. • Add captions or transcripts to TV spots or animated videos on social media for people with hearing difficulties.
localized	• IEC materials should reflect the experience of the target audience so they can better identify with and relate to the message. For example: characters of an illustration must be depicted as members of the local population (clothing, hairstyle, etc.), use local music in a radio spot to make it feel more typical of the area. • Ensure that images or symbols are culturally appropriate (easily understandable by all, not offensive for some members of the target audience). ☞ *See the example of positive and negative tags below.*
customized	• For example, if the campaign is targeted at a younger audience, the visuals and/or audio may be more playful and engaging. ☞ *See the example of waste characters created in Wagga Wagga (Australia).*
clearly related and aligned with the key message	• Visuals should complement, not compete with, text or narrative. • Audio/visuals should be designed to reinforce the message and to help the audience understand and remember the key concepts.
match the overall tone and style of the campaign	• Audio/visuals can increase recognition and create a sense of familiarity by tying together different parts of a whole campaign. ☞ *See the example of a successful recycling campaign for beverage cans in Cyprus in the section above.*
of high-quality	• Keep technical and legal considerations in mind, such as the file format, resolution, or intellectual property rights.

Example: Positive and negative tags to reinforce good recycling habits (USA)

American waste management service provider WM identified a city about 35 miles outside of Chicago that was seeing high volumes of contamination. As part of a pilot project to reduce this contamination, IEC materials have been developed, including positive and negative tags that waste collectors would put on the bins. Considering the high Hispanic population, tags have been "transcreated" from English to Spanish. In addition, several templates have been tested with different visuals. It turned out that non-Americans do not relate to letter grades (1) or expressions like "All Star" (2) and the project team finally opted for emojis (3) that can be understood by anyone.

Source: NEWMOA-NERC webinar "Effective Education Strategies for Proper Recycling" Jun 7, 2018 - Presentation of Cindy Jolicoeur & Anna DeMers, C+C (https://www.newmoa.org/event/effective-education-strategies-for-proper-recycling/)

Example 4: Waste characters (Australia)

A new kerbside waste service was introduced in Wagga Wagga, Australia in April 2018. The new service introduced a weekly food and garden organics collection, with the general waste bin becoming a fortnightly collection. An extensive IEC campaign was developed and delivered to assist and support residents in the transition. The campaign called "Your Waste – got it sorted?" leveraged a diverse range of engagement tools to ensure maximum reach and took into account the communications needs of the community. To engage young residents in the new service, characters have been created. They colour match the bins and are reproduced on the corresponding garbage truck. Munch & Crunch represent respectively food waste and garden waste and work hand-in-hand to produce compost. Trixie is a magician who has plenty of tricks up her sleeve to turn recyclable waste into new products. And finally General Waste who has a tough character and doesn't want any food or garden waste nor recyclables in his bin.

Sources: CoffsWasteConference "Education 7 - 'Your Waste - got it sorted?' education and communications campaign" May 16, 2019 – Presentation of Alice Kent, Waste Education and Communications Officer, Wagga Wagga City Council; Website of Wagga Wagga City Council (https://wagga.nsw.gov.au/).

3.3 Creative Brief

A creative brief is a document that outlines the key objectives, messaging, and creative direction for an advertising or marketing campaign. It serves as a roadmap for developing the narrative and visual components of the IEC materials for ensuring that they are consistent and aligned with the overall goals and objectives of the campaign. It will assist those who will carry out actual material design and production, whether it be an "in-house" effort, or outsourced to a production company, by clarifying expectations.

Background information:
☞ Provide information about the overall goals and objectives of the project or campaign, and any relevant background information or context that may be necessary to understand the project.

Target audience:
☞ Provide information about the population intended to be reached with the IEC material, such as sociodemographic data, characteristics, psychographics, current attitude towards the issue addressed by the campaign, etc.

Goal:
☞ Describe precisely the specific objective(s) of the IEC material to be created. Indicate clearly what the IEC material is expected to make the target audience think, feel, believe, do, or not do.

Key message:
☞ List the key messaging points and benefits that the material should convey to the target audience.

Tone and style:
☞ Indicate the approach that best suits the target audience (informative, emotional, urgency based, playful, etc.) as well as any specific design or creative elements that should be included.

Media/channels:
☞ Indicate the media/channels of communication that will be used to disseminate the campaign materials, such as social media, radio spot, or brochures, as well as any technical or design specifications that need to be followed.

Budget and timeline:
☞ Include any deadlines or milestones that need to be met, as well as any constraints or limitations that may impact the development and implementation of the campaign.

Other details:
☞ Add any other points that need to be considered while designing the IEC material, e.g. obstacles (cultural practices, preconceived opinions, etc.) that may stand between the target audience and the objectives of the IEC material.

For example, a creative brief for an IEC campaign on marine litter prevention would specify that the campaign should focus on encouraging teenagers to reduce their consumption of single-use plastics, and should employ an engaging and challenging tone to capture their attention and stimulate their motivation to take action. The brief would also include that the campaign will be distributed through social media platforms such as Facebook and Instagram, and that the posters and other promotion materials should be designed to fit specific size and resolution requirements.

4 Check & Act

In the "Check" stage, it should be confirmed whether the implemented actions in the "Do" stage have achieved the intended results and whether they have resolved the issue(s) identified in the "Plan" stage. To this end, data must be collected and analysed to evaluate the effectiveness of the activities that have been carried out. For example, in an IEC campaign on marine litter prevention, it would be relevant to check if the campaign has successfully raised awareness among the target audience about the harm caused by plastic bags to marine animals and whether it has led to any changes in their behaviour such as bringing their own bag when shopping. It may also be worth checking if the campaign has increased community participation in beach clean-up drives or encouraged businesses to adopt more sustainable practices to reduce plastic waste.

The actions to be taken in the "Act" stage will depend on the results of the "Check" stage. If the data indicate that the IEC campaign is achieving its objectives, the actions may simply be to maintain the campaign activities as is and continue to monitor progress. However, if the indicators show that the campaign is not achieving its objectives, corrective actions must be taken, which may involve revising the campaign strategy, adjusting the messaging/materials, or changing the target audience. The aim is to continually improve the IEC campaign and ensure that it is effective in achieving its objectives.

Periodic monitoring and evaluation throughout the campaign, as well as continuous tracking of the KPIs, is recommended to confirm progress regularly. By setting milestones and identifying deviations from the plan early on, it is possible to make the necessary corrections in time to still achieve the objectives before the end of the campaign.

4.1 Performance indicators

On the one hand, it is important to ensure that the campaign is rolled out as defined in the "Plan" stage from an operational perspective. For that purpose, it should be for example confirmed that the planned material has been created according to the specifications (Have posters been designed and printed? Was the TV spot shot?), that the target audience has actually been exposed to the material (Have the TV/radio spots been actually broadcasted on the days and times with the frequency and in the order agreed upon? Have the expected number of leaflets been distributed? Did the predicted number of participants joined the event?), that budget and other resources are being used efficiently and effectively, etc.

On the other hand, it is also essential to check if the target audience has correctly understood the message and reacted as expected. The following components (KPIs) should be monitored in consideration of the objectives:

- **Awareness level**: Does the desired percentage of the target audience can recall the key messages presented in the IEC materials? If not, printed materials may need to be redesigned or displaced, TV/radio spots may need to be broadcasted more often, on other stations, or at a more appropriate time.
- **Feedback and response**: Are there any positive and/or negative reactions from the target audience or stakeholders? It is important to listen carefully to their opinion and take it into account as much as possible, especially in case of critical comments.
- **Behaviour change**: Did the audience take recommended action? Is the campaign successful in changing the target's behaviour or steering it towards the desired direction? If not, try to identify the barriers (message is not clear, etc.).

4.2 Data collection methods

To measure the performance of the campaign, it is critical gather the information and data corresponding to the KPIs and compare them with the reference data collected during the baseline survey. Necessary data can be gathered using various methods, including:

- **Questionnaires**: Before/After questionnaires can be used to measure changes in awareness level, knowledge, beliefs, and behaviour.
- **Focus groups**: Discussions can be used to gather in-depth information on the target audience's perceptions and opinions of the campaign and to detect possible confusion or misunderstandings.
- **On-the-ground observations**: Observations can be used to measure the effectiveness of campaign activities on-site and in real-time.
- **Social media analytics**: Social media analytics can be used to measure the reach and interactions of the users with the content.
- **Web analytics**: Web analytics can be used to track website traffic and engagement with IEC materials.

4.3 Review for the future

At the end of an IEC campaign, it is important to conduct a comprehensive review to evaluate the effectiveness of the activities and identify areas for improvement. This assessment process can help the organization determine its future direction, demonstrate the impact of the campaign to stakeholders and funders, and finally provide valuable information for future IEC campaigns. This final step includes the following key actions:

- **Review the objectives**: Evaluate if the campaign has achieved its objectives and identify any gaps or shortcomings.
- **Analyse the data**: Collect and analyse data on the campaign's reach, impact, and outcomes, including any feedback received from the target audience and other stakeholders.
- **Assess the strategy**: Review the overall campaign strategy and assess whether it was effective in engaging the target audience and achieving the campaign objectives.
- **Appraise the activities and materials**: Determine to what extent each of the different activities and materials developed contributed to achieving the campaign objectives.
- **Identify lessons learned**: Identify the successes and challenges of the campaign, and document the lessons learned to improve future campaigns.
- **Formulate recommendations**: Based on the findings of the review, develop recommendations and best practices for future campaigns, including any necessary changes to the campaign strategy, materials, and operations.
- **Create a campaign manual**: Document the campaign planning and implementation process as well as all other useful information and recommendations in a campaign manual for future reference.

5 Tools

5.1 JICA (Japan)

The African Clean Cities Platform (ACCP) is a platform to share knowledge and promote the Sustainable Development Goals (SDGs) on waste management with the aim of realizing clean and healthy cities in Africa.

The section "resources" includes a Guidebook for Environmental Education on Solid Waste Management as well as other relevant publications.

https://unhabitat.org/african-clean-cities-resources

5.2 NOAA (USA)

The National Oceanic and Atmospheric Administration (NOAA) provides a wide range of edutainment activities for kids, parents, and educators as part of its Marine Debris Programme.

The tools include i.a. an assortment of puzzles, brainteasers, colouring activities, activity books, and videos. All resources are available for download and print for free.

https://marinedebris.noaa.gov/our-work/education

5.3 UN-Habitat

The advocacy toolkit and guide "My Waste, Our Wealth" is a community education and awareness strategy designed by UN-Habitat to support cities in its commitment to establish a sound waste management system in the county.

https://unhabitat.org/sites/default/files/2022-06/awareness_toolkit_and_guide_my_waste_our_wealth_0.pdf

5.4 Sustainable Lifestyles and Education (SLE) Programme of the One Planet network

The report "Reducing Plastic Pollution: Campaigns That Work" was developed through a collaborative effort led by Stockholm Environment Institute (SEI) and the United Nations Environment Programme (UNEP) and is an output of the Sustainable Lifestyles and Education (SLE) Programme of the One Planet network. The SLE Programme is co-led by Japan's Ministry of the Environment represented by Institute for Global Environmental Strategies (IGES) and the Government of Sweden represented by Stockholm Environment Institute (SEI).

https://www.campaignsthatwork.org/

https://www.sei.org/wp-content/uploads/2021/02/210216-caldwell-sle-plastics-report-with-annex-210211.pdf

Technical Project on Advisor for Marine Plastic Litter Management in the Caribbean Region

Technical Note No.8

Environmental Impact Assessment for Solid Waste Management

JICA
Japan International Cooperation Agency

October 2023

Technical Project on Advisor for Marine Plastic Litter Management in the Caribbean Region

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- Environmental Impact Assessment for Solid Waste Management-

Prepared by Taisuke WATANABE, JICA Advisory Team
October 2023

Content

Tables

Figures

1 General

1.1 Objective

The Environmental Impact Assessment (EIA), which also covers social impacts, is an important part (often a requirement) of the planning phase of a solid waste management facility. EIA influences site selection and facility design to meet the requirements.

This technical note provides an overview of important points regarding the EIA.

1.2 SEA and EIA according to the project preparation stage

There are two types of EIA depending on the stage of preparation of the project:

- Strategic Environmental Assessment (SEA) at the formulation stage of master/regional plans and sectoral plans/sector policies, if they include overall/general planning of waste management facilities.
- Environmental Impact Assessment (EIA) at the project planning stage when the construction and/or major modification of a waste management facility becomes clearer, e.g., when the site for the facility has been decided.

1.3 General Procedure of SEA and EIA

The following shows the general procedure of SEA and EIA:

- Scoping: Scoping is clarifying the scope of the study.
- Study, prediction and assessment of the environmental and social impacts including mitigation: Studies of SEA/EIA are conducted to understand the present condition (baseline), predict the impacts based on the project design and location, and then assess the impacts considering the mitigation measures.
- Evaluation: The impacts caused by the project are evaluated with preparing environmental management plan (EMP). For example, the benefits of the project and the cost of the impacts are compared.
- Monitoring: Monitoring is implemented following the EMP ensuring the mitigation measures.
- Public involvement: The SEA/EIA has processes for involving the public and gathering opinions (e.g. public consultation and information disclosure).

1.4 Impact items in solid waste sector

Many items with a potential impact must be considered. It is important to examine all the items, even if some of them may have only a negligible impact (see Table 2: Environmental Checklist for Waste Management). Information on present status and legal requirements should be collected item by item.

2 Strategic Environmental Assessment (SEA)

2.1 Need for SEA

2.1.1 Evaluation of entire system

First, the obligation to carry out a Strategic Environmental Assessment (SEA) depends on the EIA legislation of each country. Some countries do not require SEA but recommend that it be conducted for public sector projects. It is recommended to confirm the legal requirements in the country and region.

Waste management is an area of great concern to residents who request further improvements in terms of objectivity and reliability of environmental considerations. In an SEA, regional/sectoral planners are expected to appropriately evaluate their environmental conservation efforts and formulate new plans by reviewing their overall policies.

The purpose of SEA is: [1] to integrate environmental considerations into decision-making from the outset in the formulation and implementation of policies and plans that affect the environment, and [2] to compensate for the limitations of environmental assessment at the project implementation stage by expanding the scope of environmental considerations or by examining wide-area and cumulative impacts. The comprehensive evaluation of the entire waste disposal system through the introduction of SEA is expected to reduce the environmental impacts of the entire system. In addition, the exchange of opinions with residents is expected to improve the objectivity of environmental considerations leading to greater reliability and increased public support for the plan/project.

2.1.2 Significance of SEA

The following points show the significance of SEA in the case of regional/local waste management plans.

a. Reducing the environmental and social impacts of the entire waste treatment system

Waste management involves a variety of processes, including collection, transportation, treatment, and disposal. In addition to environmental considerations from the perspective of emission control, proper recycling, and proper disposal, which are the original objectives of waste policies, it is necessary to reduce the environmental impacts from the perspective of various environmental factors, such as global warming and the impacts on the natural environment. For this, it is necessary to conduct a comprehensive assessment of environmental impacts, considering the trade-offs between various environmental factors.

With the introduction of SEA, it is expected that the environmental impacts of the entire waste management system will be assessed comprehensively and that the environmental impacts of the entire system will be reduced.

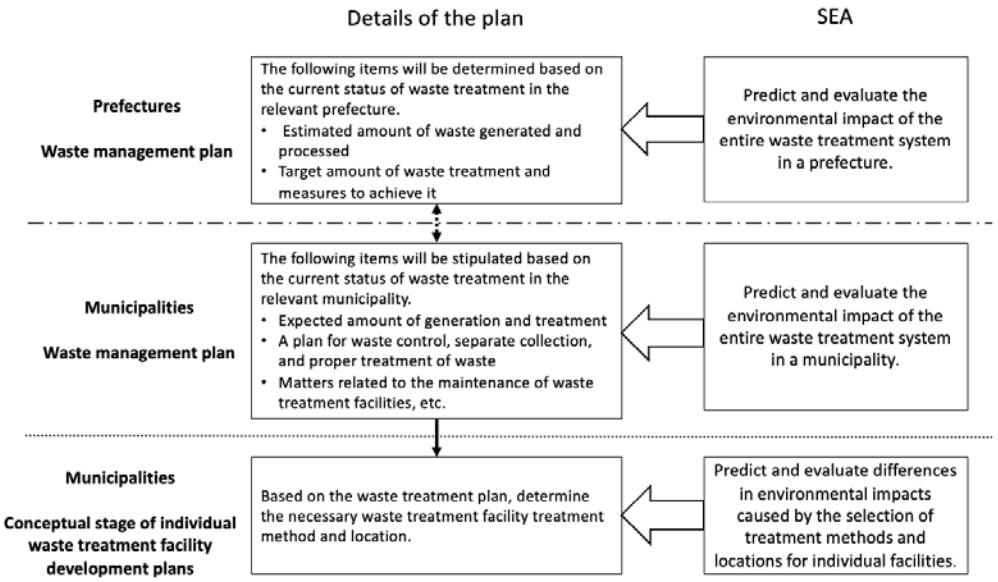
b. Improvement in objectivity and credibility

In order to promote various measures for a circular/recycling-oriented society, residents, businesses and others often request to provide sufficient explanations on environmental considerations, as they are highly interested in environmental issues. In addition, the measures must be understood by and promoted in cooperation with a wide range of entities, including residents and businesses, who are at the same time waste generators and the targets of the measures. The implementation of SEA is expected to improve the objectivity of environmental considerations through the exchange of information with residents, which in turn will improve the credibility and public support for the plan.

For example, if the SEA enables good communication with local stakeholders including residents regarding the plan that sets the target amount for landfilling, incineration and other treatments, it is expected that the environmental assessment and subsequent implementation of the project for the establishment of waste treatment facilities will proceed smoothly as a result.

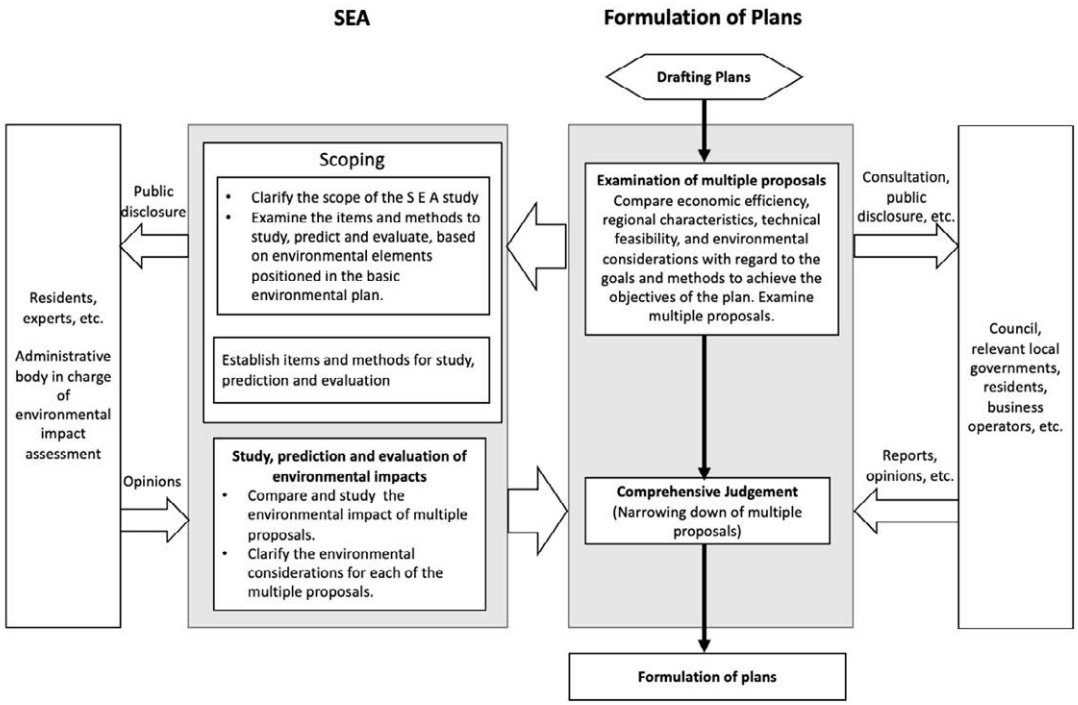
2.2 Waste management planning and SEA

SEA focuses on the concept stage of waste management plans and individual waste management facility development plans, which are in the planning and development stages. Waste management plan is not limited to municipality level but also regional/national levels (see the Figure below).



Source: Ministry of Environment of Japan website

Figure 1: Relation between waste management plans and SEA



Source: Ministry of Environment of Japan website

Figure 2: Relation between SEA and plan formulation in SWM

2.3 SEA process

2.3.1 Basics

The SEA is implemented by the entity that formulates the waste management plan. The SEA process is affected by the formulation process of waste management plan, reflecting the results of SEA to ensure that appropriate environmental considerations are given to factors such as economy, regional characteristics, and technical feasibility.

For the SEA, a process including scoping, survey/prediction/assessment, disclosure of evaluation documents, public consultation such as exchange of opinions among residents/experts and the planning body, comparison and examination of multiple alternatives will be carried out.

2.3.2 Scoping

Scoping is important as it clarifies the scope of the study. Several proposals for environmental conservation are reviewed after the scoping phase.

In addition, it is essential that the “study, prediction, and assessment” phase be carried out exhaustively. To this end, the items must be narrowed down from among all the environmental elements mentioned in the environmental law and according to the content of the plan and regional characteristics during the scoping phase.

2.3.3 Study, prediction and assessment of the environmental and social impacts

The study, prediction and assessment of environmental impacts will be conducted based on the assessment items and methods determined by scoping. It is important to use a method that is appropriate to the uncertainty of the various elements and assumptions of the plan. In addition, it is important to compare and examine multiple proposals and to evaluate the entire system from a comprehensive perspective.

a. Study

In the case of SEA in the waste sector, the study to understand the technical characteristics of the measures and the basis for the prediction is sometimes more important than the investigation of the environmental impact of the plan itself. In addition, the calculation of the environmental impact generated by the recycling process of circulating resources usually requires a detailed investigation.

Furthermore, it may not be necessary to conduct an exhaustive detailed field survey depending on the nature of the plan. Fundamentally, it is important to collect, organize, and effectively utilize the existing environmental information that indicates the environmental conditions of the region. If there are unclear or uncertain points in the existing environmental information, it is necessary to supplement it with targeted field surveys.

It is considered that a more detailed SEA study can be carried out for decision-making once the development phase of the individual waste treatment facility plan has progressed significantly.

b. Prediction methods

For SEA in the field of waste management, it is difficult to accurately predict the pollution generation by simulation when the scale of the facility and other details of the project are unknown, and such a precise prediction is not always necessary for the comparison of proposals to be meaningful. In this case, the difference in the degree of environmental impact can be determined by taking a holistic view of the total environmental load.

When quantitative prediction is difficult, qualitative prediction (e.g., clarifying the presence or absence of impacts, the degree of change from the current situation, etc.) is also considered meaningful.

c. Uncertainty in predictions

The conditions on which projections of population and industrial activity are based are subject to uncertainty because future trends will be affected by the development of various systems and technological progress. The prediction methods also contain uncertainties.

When describing predictions and evaluations, it is recommended to mention uncertainties. Also, rather than sticking to a single result based on a single set of assumptions and a single prediction method, it is recommended to make a wide range of predictions by setting up several scenarios, taking uncertainty into account when necessary.

d. Assessment

As part of the SEA, it is necessary to conduct a comparative evaluation of several proposals. However, it is not always necessary to narrow down to one proposal in the SEA. Rather, comparisons of the advantages and disadvantages of several proposals in terms of environmental conservation may be carried out to allow the selection of a proposal after a comprehensive review during the planning phase.

It is important to evaluate the total reduction in environmental impact across the entire waste treatment system, taking into account the cumulative impacts with other projects that are difficult to evaluate for each individual facility.

When comparing several proposals, it is important not only to check and assess the individual environmental elements separately, but also to analyse the trade-offs between the environmental elements. For example, by increasing the amount of incineration, the final disposal amount can be reduced, but measures against the emissions of carbon dioxide and dioxins must be taken. In such a case, a thorough understanding and reflection on how to evaluate the results will be necessary. In order to evaluate such trade-offs, it may also be useful to organize the elements (pros and cons of each proposal) into a matrix combining several proposals and evaluation items.

3 Environmental Impact Assessment (EIA)

3.1 EIA requirement

a. By legislation

Usually, EIA for waste management facilities is required by legislation such as the solid waste management law or EIA law. The EIA legislation of the targeted country should be checked first (see the table below for reference). In the waste sector, intermediate treatment facilities and disposal facilities may be targeted. In addition, depending on the impact items that need to be considered, it is important to clarify which procedure is required for which facility in the legislation. Depending on the country, there are two types of procedure: the comprehensive EIA and the Initial Environmental Examination (IEE). The IEE is the primary stage of the EIA of a project and can include simple description on the current condition, potential impacts, mitigation measures and environmental management plans.

Table 1: EIA legislation in the target countries

Country	Legislation
Antigua and Barbuda	Physical Planning Act, 2003
Grenada	Physical Planning and Development Control Act, 2016
Guyana	Environmental Protection Act, 1996
Jamaica	Natural Resources Conservation Authority Act, 1991
St. Lucia	Physical Planning and Development Act, 2005 Waste Management Act, 2004 (as waste management plan)

Source: Legislative Framework for Environmental Impact Assessment in the Caribbean, Caribbean Law Institute Centre, 2018

b. Key points of designing an EIA study

- The implementing body for the waste management facility must be clearly identified, as it is the implementing body that conducts the EIA. Often, the project entity (implementing body) outsources the EIA study to consultants.
- The preparation of the Terms of Reference (TOR) of the EIA study is critical to follow the required procedure. Therefore, the project entity must fully understand the requirements to properly design the EIA study.
- It is important to confirm which impacts need to be assessed by the EIA. Often not only the environmental impacts but also the social impacts are covered. Also, additional studies may be required by other legislations, for example in the case of land acquisition/resettlement.

3.2 Major concerns in the solid waste sector

- The waste sector raises particular concerns. In the case of a landfill site, the typical concerns, which are the items to be evaluated, include:
  - ✓ Leachate generation
  - ✓ Breeding of domestic flies and their maggots
  - ✓ Odours
  - ✓ Fire hazards
  - ✓ Methane (CH4) and carbon dioxide (CO2) emissions
  - ✓ Vegetation damage
  - ✓ Community health effects
- The NIMBY (Not in My Backyard) mindset tends to cause people concern. Typical concerns on landfill siting are as follows:
  - ✓ Land ownership (need for resettlement)
  - ✓ Concerns about nearby residential or agriculture areas (including distance)
  - ✓ Access to the site (increase in the number of trucks)
- These concerns shape public opinion about the facility. For example, people may voice their objection to the facility and take action against the project.
- The role of EIA is to respond to these concerns by providing information on possible impacts and their mitigation.

3.3 Impact study

The following is an example of how items are reviewed in the case of a landfill:

- Water quality - Present situation
  - ✓ Check latest surface and groundwater quality (parameters come from water quality regulations).
  - ✓ Check standards such as effluent standard, ambient water quality standard and groundwater quality standard.
  - ✓ Check water utilization in nearby areas for both surface water and groundwater.
  - ✓ For groundwater, check geological conditions to understand the coefficient of permeability.
- Water quality - Prediction and mitigation
  - ✓ Estimate the leachate quality and design a leachate treatment method to meet at least the effluent standard.
  - ✓ Check the geological data and design prevention measures against leachate infiltration.
  - ✓ Design monitoring of discharge and groundwater quality.
- Social impacts in case of landfill construction
  - ✓ Check the impact and mitigation measures on land acquisition and resettlement.
  - ✓ Check the impact and mitigation measures on the increase in traffic along the access roads.

- ✓ Check the impact and mitigation measures on the informal sector (typically waste pickers) in the existing landfill, as informal sector workers may lose their income source due to the construction of the new landfill.
- ✓ For the above matters, it is important to communicate well with residents and the informal sector.

3.4 Assessment

Since there are many items, a tool to check the main impacts, JICA's Checklist on Waste, is shown below.

Table 2: Environmental Checklist for Waste Management

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
1 Permits and Explanation	(1) EIA and Environmental Permits	(a) Have EIA reports been already prepared in official process? (b) Have EIA reports been approved by authorities of the host country's government? (c) Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied? (d) In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government?	(a) (b) (c) (d)	(a) (b) (c) (d)
	(2) Explanation to the Local Stakeholders	(a) Have contents of the project and the potential impacts been adequately explained to the Local stakeholders based on appropriate procedures, including information disclosure? Is understanding obtained from the Local stakeholders? (b) Have the comment from the stakeholders (such as local residents) been reflected to the project design?	(a) (b)	(a) (b)
	(3) Examination of Alternatives	(a) Have alternative plans of the project been examined with social and environmental considerations?	(a)	(a)
2 Pollution Control	(1) Air Quality	(a) Do air pollutants, such as sulphur oxides (SOx), nitrogen oxides (NOx), and soot and dust, and dioxins emitted from various sources, such as incinerators, and vehicles used for waste collection and transportation comply with the country's emission standards and ambient air quality standards?	(a)	(a)
	(2) Water Quality	(a) Do effluents from various facilities comply with the country's effluent standards and ambient water quality standards? (b) Does the water quality of leachates from the waste disposal sites comply with the country's effluent standards and ambient water quality standards? (c) Are adequate measures taken to prevent contamination of surface water and groundwater by these effluents and leachates?	(a) (b) (c)	(a) (b) (c)
	(3) Wastes	(a) Are wastes, such as treatment residues, cinder, and fly ash generated from crushing and segregation processes, and diverted wastes from composting process properly treated and disposed of in accordance with the country's regulations? (b) Are hazardous and dangerous wastes properly segregated from other wastes, stabilized, treated, and disposed of in accordance with the country's standards?	(a) (b)	(a) (b)
	(4) Soil Contamination	(a) Are adequate measures taken to prevent contamination of soil and groundwater by leachates from the waste disposal sites?	(a)	(a)

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
	(5) Noise and Vibration	(a) Do noise and vibrations generated by the facility operations (especially incinerators, waste segregation and crushing facilities), and vehicle traffic for waste collection and transportation comply with the country's standards?	(a)	(a)
	(6) Odor	(a) Are adequate odour control measures taken?	(a)	(a)
3 Natural Environment	(1) Protected Areas	(a) Is the project site located in protected areas designated by the country's laws or international treaties and conventions? Is there a possibility that the project will affect the protected areas?	(a)	(a)
	(2) Ecosystem	(a) Does the project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)? (b) Does the project site encompass the protected habitats of endangered species designated by the country's laws or international treaties and conventions? (c) If significant ecological impacts are anticipated, are adequate protection measures taken to reduce the impacts on the ecosystem? (d) Is there a possibility that the project will adversely affect aquatic organisms? If impacts are anticipated, are adequate measures taken to reduce the impacts on aquatic organisms? (e) Is there a possibility that the project will adversely affect vegetation and wildlife? If impacts are anticipated, are adequate measures taken to reduce the impacts on vegetation and wildlife?	(a) (b) (c) (d) (e)	(a) (b) (c) (d) (e)
	(3) Management of Abandoned Sites	(a) Are environmental protection and restoration plans (such as landfill gas and leachate collection and treatment systems, prevention of illegal dumping, and reforestation) after facility closure considered? (b) Is a sustainable management framework for the abandoned sites established? (c) Are adequate financial provisions secured to manage the abandoned sites?	(a) (b) (c)	(a) (b) (c)

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
4 Social Environment	(1) Resettlement	(a) Is involuntary resettlement caused by project implementation? If involuntary resettlement is caused, are efforts made to minimize the impacts caused by the resettlement? (b) Is adequate explanation on compensation and resettlement assistance given to affected people prior to resettlement? (c) Is the resettlement plan, including compensation with full replacement costs, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement? (d) Is the compensations going to be paid prior to the resettlement? (e) Is the compensation policies prepared in document? (f) Does the resettlement plan pay particular attention to vulnerable groups or people, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples? (g) Are agreements with the affected people obtained prior to resettlement? (h) Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan? (i) Are any plans developed to monitor the impacts of resettlement? (j) Is the grievance redress mechanism established?	(a) (b) (c) (d) (e) (f) (g) (h) (i) (j)	(a) (b) (c) (d) (e) (f) (g) (h) (i) (j)
	(2) Living and Livelihood	(a) Is there a possibility that the project will adversely affect the living conditions of inhabitants? Are adequate measures considered to reduce the impacts, if necessary?(b) Are considerations given to the existing recovery systems, including waste pickers? (c) Is there a possibility that waste transportation will adversely affect the regional traffic? (d) Is there a possibility that effluents from the project and leachates form the waste disposal sites will adversely affect fisheries and other water uses by local inhabitants (especially drinking water)? (e) Is there a possibility that pathologic insects or other disease vectors will breed as a result of the project?	(a)(b)(c)(d)(e)	(a)(b)(c)(d)(e)
	(3) Heritage	(a) Is there a possibility that the project will damage the local archaeological, historical, cultural, and religious heritage? Are adequate measures considered to protect these sites in accordance with the country's laws?	(a)	(a)
	(4) Landscape	(a) Is there a possibility that the project will adversely affect the local landscape? Are necessary measures taken?	(a)	(a)

3 Environmental Impact Assessment (EIA)

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
	(5) Ethnic Minorities and Indigenous Peoples	(a) Are considerations given to reduce impacts on the culture and lifestyle of ethnic minorities and indigenous peoples? (b) Are all of the rights of ethnic minorities and indigenous peoples in relation to land and resources respected?	(a) (b)	(a) (b)
	(6) Working Conditions	(a) Is the project proponent not violating any laws and ordinances associated with the working conditions of the country which the project proponent should observe in the project? (b) Are tangible safety considerations in place for individuals involved in the project, such as the installation of safety equipment which prevents industrial accidents, and management of hazardous materials? (c) Are intangible measures being planned and implemented for individuals involved in the project, such as the establishment of a safety and health program, and safety training (including traffic safety and public health) for workers etc.? (d) Are appropriate measures taken to ensure that security guards involved in the project not to violate safety of other individuals involved, or local residents?	(a) (b) (c) (d)	(a) (b) (c) (d)
5 Others	(1) Impacts during Construction	(a) Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)?(b) If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce impacts?(c) If construction activities adversely affect the social environment, are adequate measures considered to reduce impacts?	(a)(b)(c)	(a)(b)(c)
	(2) Monitoring	(a) Does the proponent develop and implement monitoring program for the environmental items that are considered to have potential impacts? (b) What are the items, methods and frequencies of the monitoring program? (c) Does the proponent establish an adequate monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework)? (d) Are any regulatory requirements pertaining to the monitoring report system identified, such as the format and frequency of reports from the proponent to the regulatory authorities?	(a) (b) (c) (d)	(a) (b) (c) (d)
6 Note	Reference to Checklist of Other Sectors	(a) Where necessary, pertinent items described in the Forestry Projects checklist should also be checked (e.g., projects including large areas of deforestation).	(a)	(a)

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
	Note on Using Environmental Checklist	(a) If necessary, the impacts to transboundary or global issues should be confirmed (e.g., the project includes factors that may cause problems, such as transboundary waste treatment, acid rain, destruction of the ozone layer, or global warming).	(a)	(a)

1) Regarding the term "Country's Standards" mentioned in the above table, in the event that environmental standards in the country where the project is located diverge significantly from international standards, appropriate environmental considerations are required to be made.

In cases where local environmental regulations are yet to be established in some areas, considerations should be made based on comparisons with appropriate standards of other countries (including Japan's experience).

2) Environmental checklist provides general environmental items to be checked. It may be necessary to add or delete an item taking into account the characteristics of the project and the particular circumstances of the country and locality in which the project is located.

Source: JICA website[1]

[1] https://www.jica.go.jp/english/our_work/social_environmental/guideline/ref.html

3.5 Environmental management plan (EMP)

A typical Environmental management plan (EMP) shall be composed of the following:

- Summary of potential impacts of the proposal
- Description of recommended mitigation measures
- Description of monitoring plan to ensure compliance with relevant standards and residual impacts
- Allocation of resources and responsibilities for plan implementation
- Implementation schedule and reporting procedures
- Contingency plan when impacts are greater than expected

3.6 Public involvement

- Public involvement or public consultation is the process by which the concerns of affected local people and other related stakeholders on the environmental impacts of the project or activity are ascertained.
- Public consultation is not a decision-making process, but a process to gather the views of the stakeholders. If the public agency conducting the public hearing is not convinced with the stakeholders, then the expressed views do not need to be considered.
- Typical public consultation involves two components: one is a public hearing, and the other is to invite written responses/objections via Internet/mail, etc., by posting the summary of the EIA report on a website.

3.7 Review/Evaluation

- The process and method of EIA review/evaluation depends on the legislation or the situation.
- Typically, the EIA Report/Environmental Impact Statement (EIS) is reviewed by the government agency responsible for the EIA. In this review, the level of compliance with the TOR defined for the study will be taken into account.
- There are several methods/aspects for the review/evaluation, such as:
  - ✓ Appropriateness of the EIA process, including clarity of the description of each process
  - ✓ Appropriateness of the TOR for the EIA study and the result of the study, especially reasonable assessment of each impact
  - ✓ Cost-benefit analysis of the project and alternatives
  - ✓ Response to public concerns
  - ✓ Recommendations for the next step can be included

4 Reference documents

- IFC, Environmental, Health and Safety Guidelines for Waste Management Facilities, 2007

- JICA, Environmental Checklist[2]
- Ministry of Environment and Forests, India, Technical EIA Guidance for Common Municipal Solid Waste Management Facilities, 2010
- Rwanda Environment Management Authority, Guidelines for Environmental Impact Assessment for Waste Management in Rwanda, 2009

[2] https://www.jica.go.jp/english/our_work/social_environmental/guideline/ref.html

Technical Project on Advisor for Marine Plastic Litter Management in the Caribbean Region

Technical Note No.9

Plastic Recycling Technology in Japan

JICA
Japan International Cooperation Agency

October 2023

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in the Caribbean Region

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Plastic Recycling Technology in Japan

Prepared by Yukihisa SAKATA, JICA Advisory Team

October 2023

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Tables

Figures

1 Classification of Recycling Methods

This chapter introduces technologies and advanced examples of plastic resource recycling obtained from literature surveys and other sources.

Recycling methods for plastics can be classified as follows.

Table 1: Recycling methods for plastics

<table>
<tr><th>Category (in Japan)</th><th colspan="2">Method of recycling</th><th>ISO 15270</th></tr>
<tr><td>Material Recycling</td><td colspan="2">Recycling to make:
• Plastic raw materials
• Plastic products</td><td>Mechanical Recycling</td></tr>
<tr><td rowspan="5">Chemical Recycling</td><td colspan="2">Monomerization</td><td rowspan="5">Feedstock Recycling</td></tr>
<tr><td colspan="2">Blast furnace reducing agent</td></tr>
<tr><td colspan="2">Coke oven chemical feedstock recycling</td></tr>
<tr><td rowspan="2">Gasification
Oilification</td><td>Chemical feedstock</td></tr>
<tr><td rowspan="2">Fuel</td><td rowspan="2">Energy Recovery</td></tr>
<tr><td>Thermal Recycling
(Energy Recovery)</td><td colspan="2">Cement kiln
Waste Power Generation
RPF, RDF</td></tr>
<tr><td>Alternative Plastics</td><td colspan="3">Biomass Plastics</td></tr>
<tr><td>Reduce/Reuse</td><td colspan="3">Emission Reduction / Reuse</td></tr>
</table>

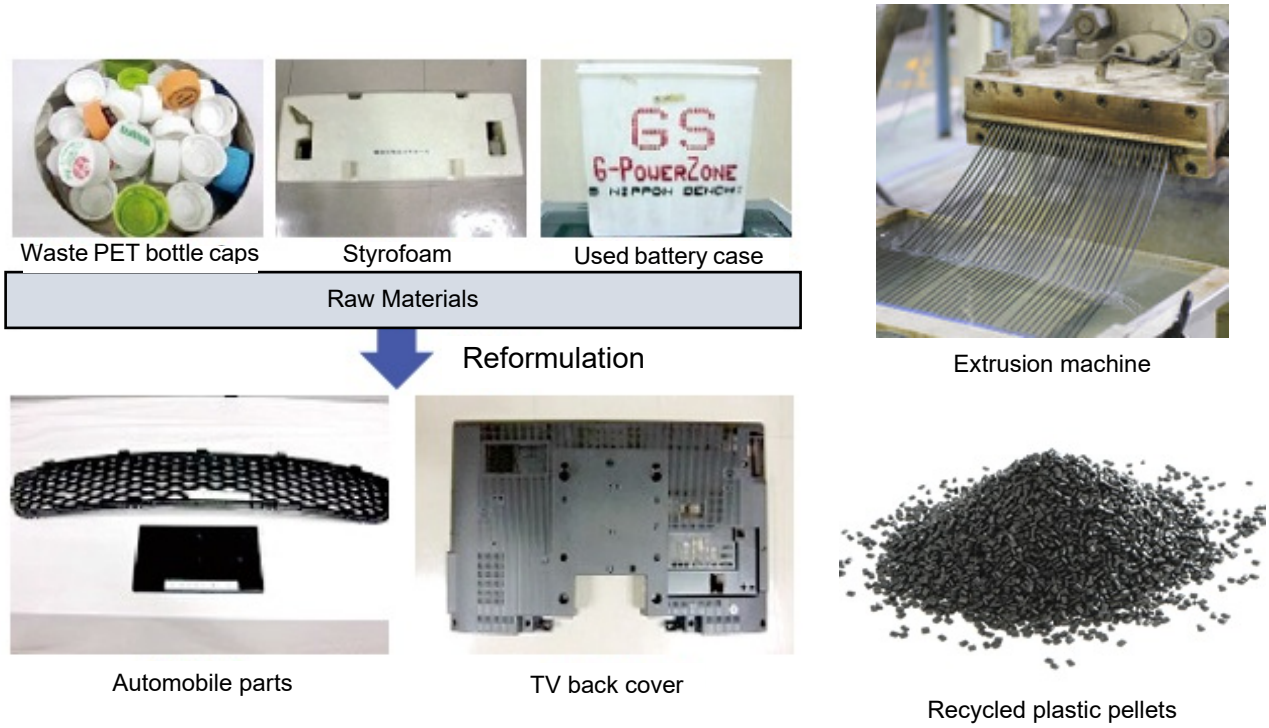
Source: “Basic Knowledge of Plastic Recycling 2022” (Plastic Waste Management Institute, 2022)

2 Material Recycling

2.1 Outline of Material Recycling

Material recycling of plastics is a technology to pre-process waste plastics discharged from used products and production processes so that they can be recycled and used as raw materials or materials for new products. In other words, waste plastics are melted down and recycled into plastic raw materials and processed to be products again.

According to the Plastic Waste Management Institute, this technology was developed in the 1970s, and there are currently several hundred recycling machinery manufacturers in Japan.



SOURCE: ADAPTED FROM DATA OF ISONO CO.

Figure 1: Example of material recycling of plastics

2.2 Applications of material recycling

In the case of material recycling, after resin sorting and impurity removal, the waste plastics are generally crushed into flakes and washed, and these flakes or pellets are melted in a granulator and transformed into granules that are then commercialized as raw materials.

Material recycling of plastics is said to be more difficult than that of steel, aluminum, paper, glass, etc. In general, plastic products are not made of a single material, and many types of resins exist, such as polyethylene, polypropylene, etc. Therefore, it is necessary to collect a large amount of the same type of material for material recycling. In this regard, material recycling of plastics requires pretreatment technologies such as crushing, sorting, washing, and drying.

Waste plastics for material recycling are mainly industrial waste plastics because the resins used can be easily identified, there are few contaminants and foreign matters, and a certain amount can be secured.

In recent years, recycled materials have also been used for manufacturing units and parts in various fields that require high performance and high functionality, such as automobile engine compartment parts, rainwater storage and infiltration system units, as well as fruit and vegetable cultivation system parts.

Plastic materials for civil engineering and construction

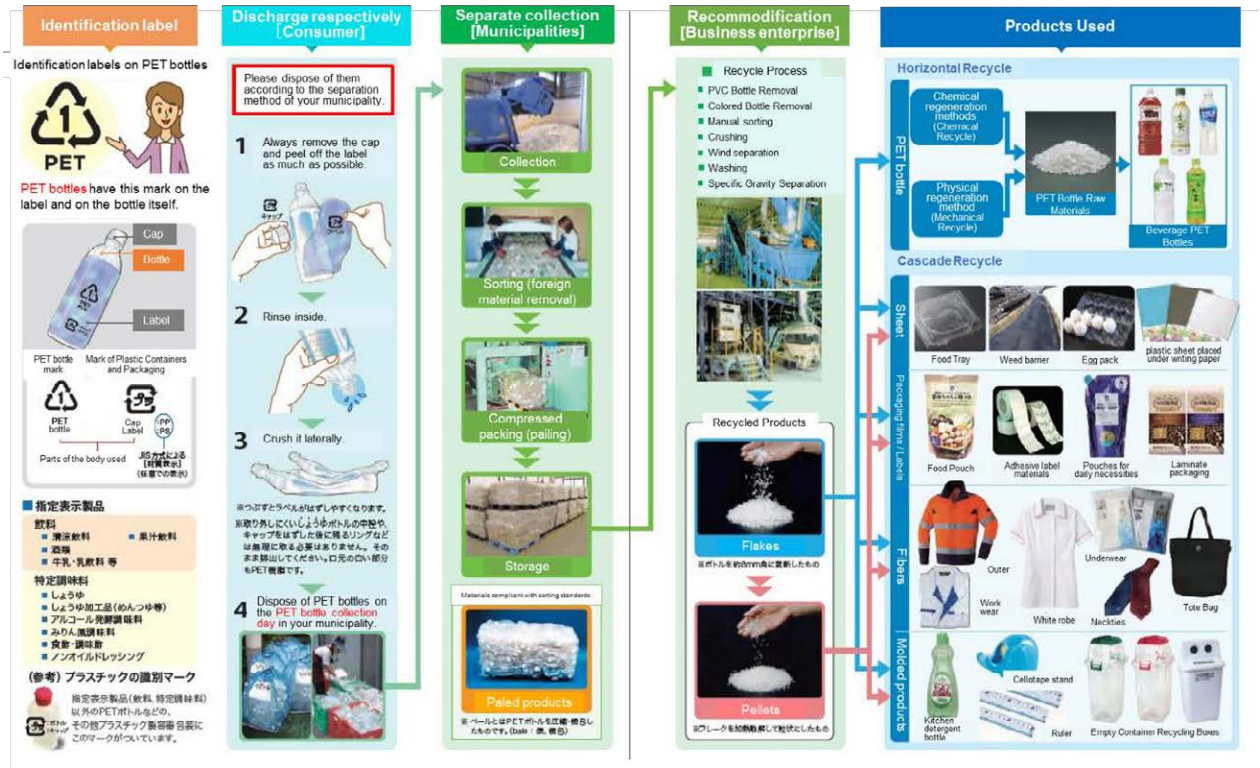
Figure 2: Examples of plastic products made of recycled materials (Aikuruzai: certified by Aichi Prefecture Recycled Material Evaluation System)

2.3 Material recycling of PET bottles

When recycling PET bottles, recycled raw materials are produced in the form of flakes in recycling plants through processes such as impurity removal, washing, foreign matter removal, and separation of different resins.

These recycled raw materials are then melted and transformed into products, such as textile, sheets, work clothes, and beverage bottles, in moulding plants.

This recycled PET material was initially not used for beverage PET bottles due to hygiene and odor issues but it is now recycled as raw material for beverage PET bottles through chemical and mechanical recycling as described below, and bottle-to-bottle (B-to-B) recycling is currently implemented by two companies.



Source: PET Bottle Recycling Annual Report 2020 (The Council for PET Bottle Recycling, 2020).

Figure 3: PET Bottle Recycling Flow

Table 2: Types and Applications of Plastics (Reference)

		JIS abbreviation	Resin name		Main applications
Thermoplastic Resins	General Purpose Plastics	PE	Polyethylene	Low-density polyethylene	Packaging materials (bags, wrapping film, food tube applications), agricultural film, electric wire coating, milk carton lining film
				High-density polyethylene	Packaging materials (films, bags, food containers), shampoo and rinse containers, miscellaneous goods (buckets, wash basins, etc.), gasoline tanks, kerosene cans, containers, pipes
		EVAC		EVA Resin	Agricultural films, stretch films
		PP	Polypropylene		Automobile parts, home appliance parts, packaging films, food containers, caps, trays, containers, pallets, wardrobe boxes, textiles, medical devices, daily necessities, garbage containers
		PVC	Polyvinyl chloride resin (Polyvinyl chloride)		Water and sewer pipes, fittings, gutters, corrugated sheets, sashes, flooring materials, wallpaper, vinyl leather, hoses, agricultural film, wrapping film, electric wire covering
		PS	Polystyrene (Styrene resin)	Polystyrene	OA and TV housings, CD cases, food containers
				Expanded polystyrene	Packaging cushioning materials, fish boxes, food trays, cup noodle containers, tatami mat cores
		SAN	AS Resin		Tableware, disposable lighters, electrical products (fan springs, juicers), food storage containers, toys, cosmetic containers
		ABS	ABS Resin		OA equipment, automobile parts (interior and exterior), game machines, construction materials (interior), electrical products (air conditioners, refrigerators)
		PET	Polyethylene terephthalate	Stretched film < 200 °C	Insulating materials, functional films for optics, magnetic tapes, photographic films, packaging films

		JIS abbreviation	Resin name		Main applications
				Non-oriented sheet < 60 °C	Containers for prepared foods, tsukudani, fruits, salads, cakes, beverage cups, clear holders, various transparent packaging (APET)
				Heat Resistant Bottle < 85 °C	Containers (PET bottles) for beverages (tea, drinking water), soy sauce, alcoholic beverages, etc.
				Aseptic filling < 70 °C	
		PMMA	Methacrylic Resin (Acrylic Resin)		Automobile rear lamp lenses, tabletop containers, light boards, aquarium plates, contact lenses
		PVAL	Polyvinyl alcohol		Vinylon fiber, film, paper processing agents, adhesives, PVC suspension polymerization stabilizers, automotive safety glass
		PVDC	Vinylidene chloride resin (polyvinylidene chloride)		Food wrapping film, ham and sausage casings, film coating
	Engineering Plastics	PC	Polycarbonate		DVD/CD disks, electronic component housings (cell phones, etc.), automobile headlamp lenses, camera lenses and housings, transparent roofing materials
	Engineering Plastics	PA	Polyamide (Nylon)		Automobile parts (air intake pipes, radiator tanks, cooling fans, etc.), food films, fish nets and tapes, various gears, fasteners
	Engineering Plastics	POM	Acetal Resin (Polyacetal)		Various gears (DVDs, etc.), automobile parts (fuel pumps, etc.), various fasteners and clips
	Engineering Plastics	PBT	Polybutylene terephthalate		Electrical parts, automotive electrical parts
	Engineering Plastics	PTFE	Fluoroplastic		Frying pan inner surface coating, insulating materials, bearings, gaskets, various packing, filters, semiconductor industry field, electric wire coating
Thermosetting Resins		PF	Phenol Resin		Printed circuit boards, iron handles, distribution board breakers, pot/kettle handles/knobs, plywood adhesive
Thermosetting Resins		MF	Melamine Resin		Tableware, decorative laminates, plywood adhesives, paints
Thermosetting Resins		UF	Urea Resin		Buttons, caps, electrical products (wiring fixtures), plywood adhesives
Thermosetting Resins		PUR	Polyurethane		Foam is mainly used for cushioning, automotive seats, and heat insulating materials. Non-foam materials are used for industrial rolls, packing, belts, paints, waterproof materials, and spandex fibers.
Thermosetting Resins		EP	Epoxy Resin		Electrical products (IC encapsulants, printed circuit boards), paints, adhesives, various laminates
Thermosetting Resins		UP	Unsaturated Polyester Resin		Bathtubs, corrugated sheets, cooling towers, fishing boats, buttons, helmets, fishing rods, paint, septic tanks

Source: Hello, Plastic (The Japan Plastics Industry Federation), Basic Knowledge of Plastic Recycling 2020 (Plastic Waste Management Institute, 2020)

2.4 Latest technology trends in material recycling

A review of recent trends in technology development for plastic material recycling shows that there are many examples of efforts to design and develop products that are easier to recycle, and technology development related to separation and selection of plastic resins and advanced sorting.

The latest technologies introduced below will focus on cases that are currently in the development and planning stages and those that are currently undergoing demonstration projects.

Table 3: Summary of the latest technological trends in material recycle

Project Name	Main Business Entities	Classification	Technology Development Summary/Abstract
(i) Resin recycling through the creation of a handy sensor for resin identification	Ricoh Company, Ltd. (Tokyo, Japan)	Advanced Sorting Recycled Resin Production	・ Conducted a technology development demonstration to produce recycled plastic of stable purity by utilizing a handy sensor for resin identification, which enables anyone to easily check the type of resin. ・ FY2019 Ministry of the Environment's "Demonstration Project for Establishing a Recycling System for Plastics and Other Resources to Support a Decarbonized Society".
(ii) Efficient sorting of mixed plastics and value chain formulation and commercialization	Re-Tem Corporation	Advanced Sorting	・ Using European sorting equipment, the company sorted plastics by resin type using "floating and sinking sorting + electrostatic separation" from mixed plastics derived from small home appliance recycling plants, conducted performance evaluations and business feasibility evaluations, and collaborated with customers. ・ FY2019 Ministry of the Environment's "Demonstration Project for Establishing a Recycling System for Plastics and Other Resources to Support a Decarbonized Society".
(iii) Demonstration of a resource-recycling model project for the horizontal recycling of single-use plastic	Kao Corporation Toppan Inc. Ichikawa Kankyo Engineering Co., Ltd., etc.	Easy recycling Product design and development (environmentally friendly design) Mono materials (single material) Utilization of recycled materials	・ The company aimed to develop specific products such as refill pouches made of a single material (mono-material), easily peelable tack labels (avoiding plastic contamination by direct printing), and bottle containers using recycled plastic, as well as to build a resource recycling system that includes the collection of used packaging containers and social implementation. ・ Selected in 2020 as a business operator for the Tokyo Metropolitan Government's "New Business Model for Sustainable Use of Plastics" public call for proposals.

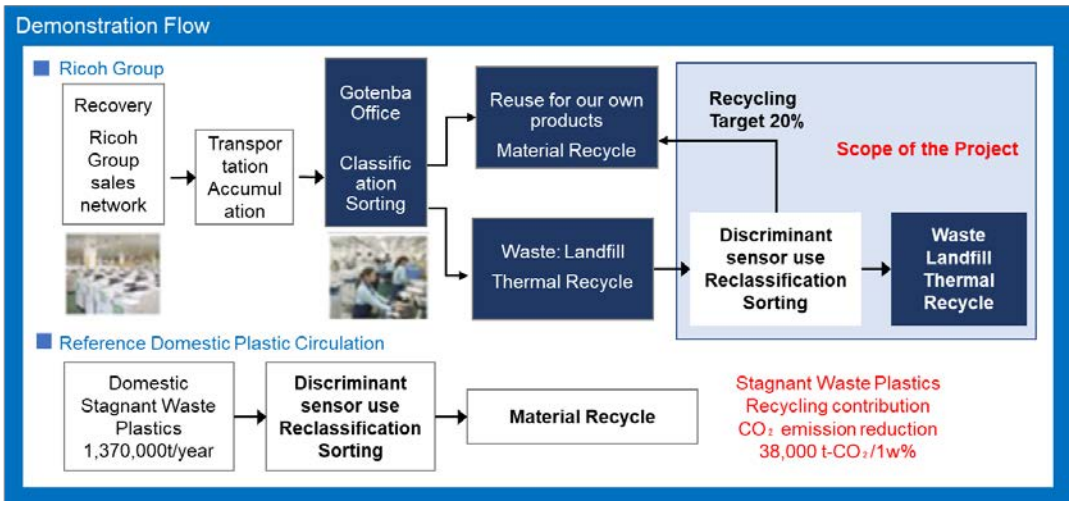
a. Resin recycling through the creation of a handy sensor for resin identification

Name	Resin recycling through the creation of a handy sensor for resin identification
Business entities	Ricoh Company, Ltd. (Tokyo, Japan)
Classification	Use of recycled materials, etc. (Advanced sorting, recycled resin production) Research and Development
Target plastics	(Resins to be identified) PE, PP, PVC, PS, PET, ABS, PC, PC-PS, PC-ABS
Summary	Currently, details of individual technologies are not disclosed.

<Outline of efforts, (numerical) targets, results, etc.>

-Advanced sorting of waste plastics contributes to material and chemical recycling with stable composition-

- **Resin Recycling by Resin Identification Handy Sensor**
  - The goal was to provide measuring equipment to determine the type of waste plastic and sort discarded plastic by type to promote material recycling, reduce incineration of vinyl chloride (including PVC as well as other halogenated resins), and convert it into a re-producible material.
  - Discriminable resins account for more than three-quarters of resin production.
  - The new system allows anyone to perform sorting without prior knowledge of the process, which would otherwise require the judgment of highly skilled operators, and allows for quicker implementation, reducing working time and increasing throughput per unit of time.



- Adopted project for the Ministry of the Environment's "Demonstration Project for Establishing a Recycling System for Plastics and Other Resources to Support a Decarbonized Society in Fiscal Year 2019".

Source:
https://www.jora.jp/wp-content/uploads/2021/02/200302pamphlet_all.pdf

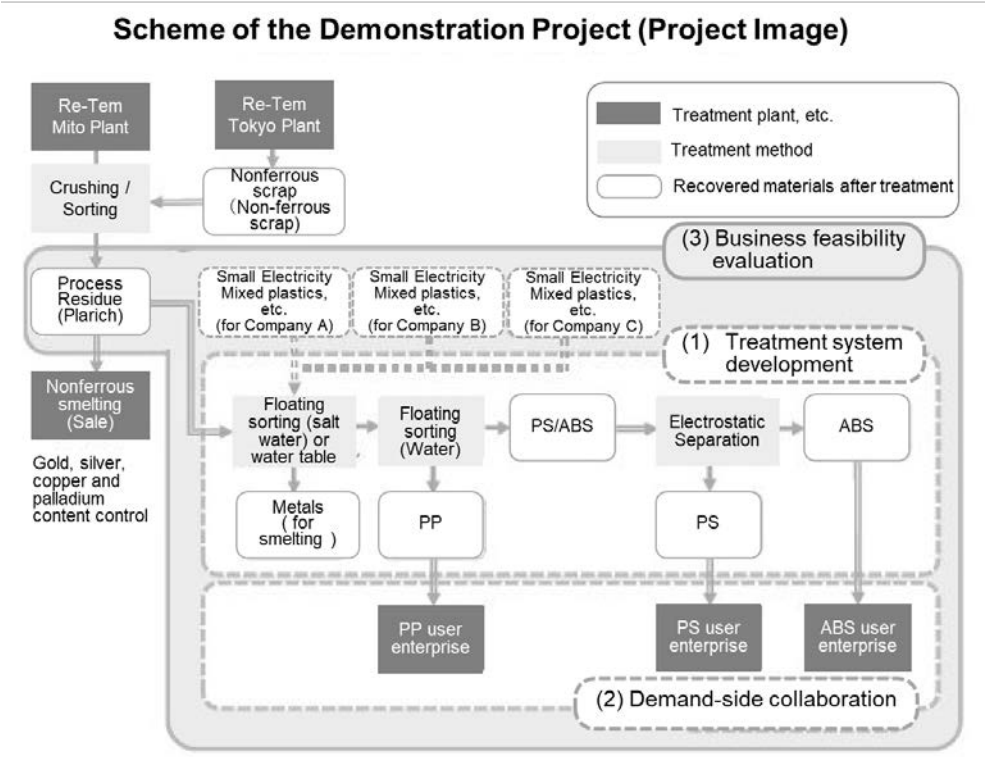
b. Efficient sorting of mixed plastics and value chain construction / commercialization

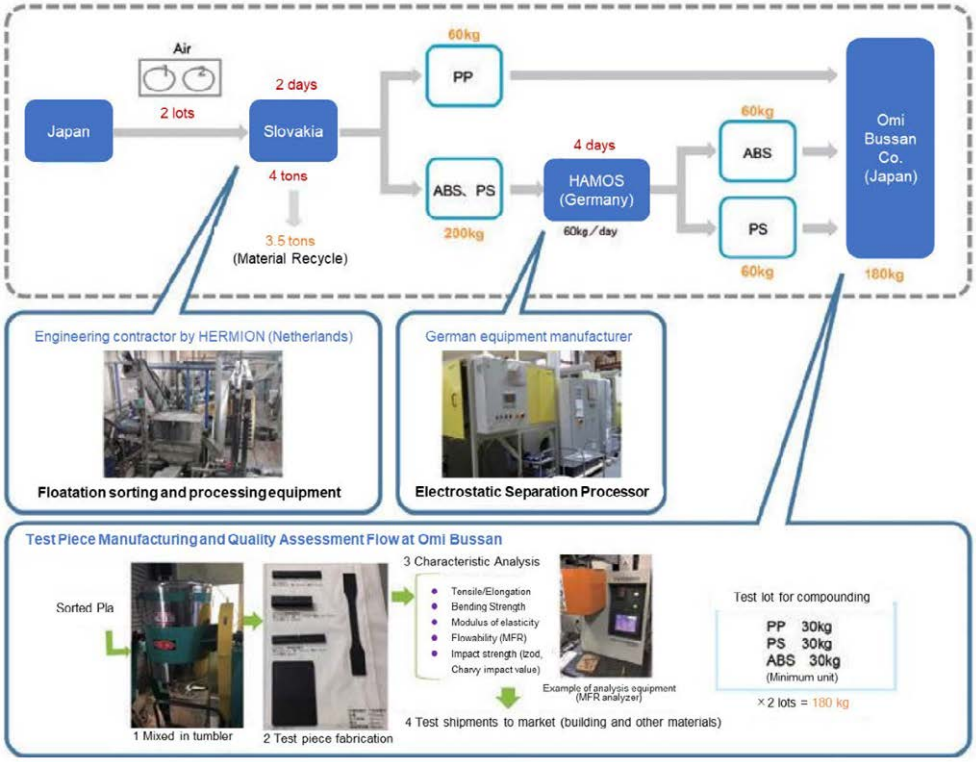
Name	Efficient sorting of mixed plastics and value chain formulation / commercialization
Business entities	Re-Tem Corporation
Classification	Use of recycled materials, etc. (Advanced sorting) Research and Development
Target plastics	Mixed plastics derived from small home appliances (mixed plastics recovered from plastic residues (plastic-rich) generated in the recycling process of small home appliances, etc.)
Summary	Sorting of plastics derived from small household appliances, which are difficult to MR due to the large variety of resins. Details of the technology are not disclosed.

<Outline of efforts, (numerical) targets, results, etc.>

-Introducing the advanced European model "Floatation Sorting + Electrostatic Separation"-

- **Development of processing systems**
  - Processing residue (plastic-rich) was sorted into plastic only and mixed plastics were produced.
  - Mixed plastics were brought to a recycling company in Slovakia that had installed a "floating sorting" equipment and were sorted into PP and PS + ABS through a demonstration test using actual equipment.
  - The sorting into PS and ABS was then carried out in Germany, using a demonstration machine for "electrostatic separation".





- **<u>Collaboration with end-users</u>**
  - The collected products were pelletized by Omi Bussan (compounder), and performance tests as recycled materials were conducted to develop new demand.
  - Adopted project for the Ministry of the Environment's "Demonstration Project for Establishing a Recycling System for Plastics and Other Resources to Support a Decarbonized Society in Fiscal Year 2019".

Source:
https://www.jora.jp/wp-content/uploads/2021/02/200302pamphlet_all.pdf

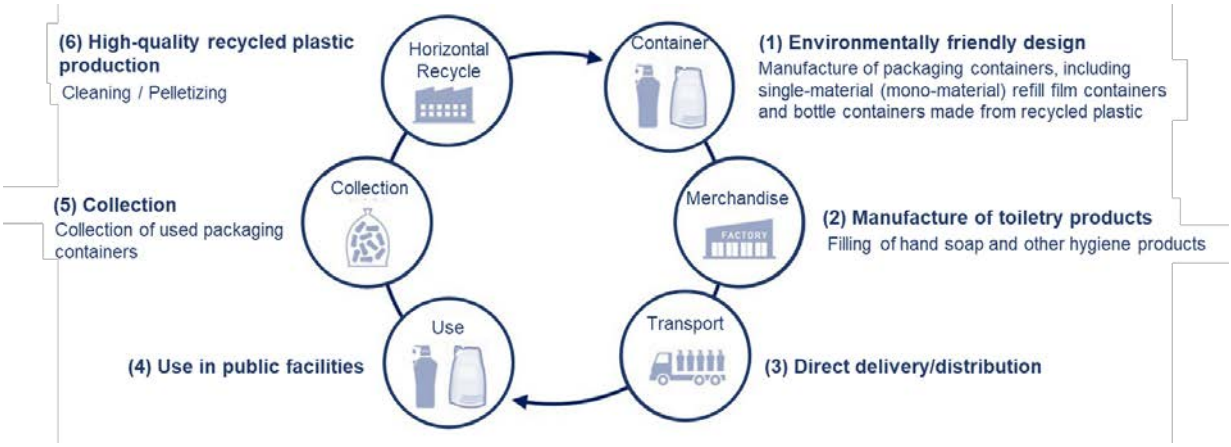
c. Demonstration of a resource-recycling model project for the horizontal recycling of single-use plastic

Name	Resource recycling model project for horizontal recycling of single-use plastic
Business entities	Toppan Inc., Ichikawa Kankyo Engineering Co., Ltd., NPO Earth Ship Club Ecomira Koto, NPO Genki Net for Creating a Sustainable Society, Viax. Co., Ltd.
Classification	Easy recycling, product design and development (environmentally friendly design), mono materials (single material), use of recycled materials Research and Development
Target plastics	Multi-layered refill container
Summary	-

<Outline of efforts, (numerical) targets, results, etc.>

-Promoting horizontal recycling of multi-layered refill containers through mono-materialization-

- **Outline of the Demonstration Project**
  - Single material (mono-material) or recycled plastic was used for plastic packaging and containers for toiletry products. The system utilized advanced recycling technology, container design and manufacturing techniques to achieve horizontal recycling of single-use containers.
  - During the demonstration period, prototypes of bottles made of recycled plastic and multi-layered refill containers made of a single material were produced and distributed to public facilities in Koto Ward, Tokyo.
  - PS food containers (food trays, etc.) cleaned by residents in Koto Ward, Tokyo, were collected individually and processed into high-purity pellets at Ecomira Koto, a facility in Koto Ward, Tokyo, where foreign matter was removed.
  - This system included the palletisation of used packaging and containers collected in the model project.



- **Role of each participating company/organization**
  - Kao: Overall design of the resource-recycling products and resource-recycling systems.
  - Toppan: Manufacture of resource-recycling single-material multi-layered refill containers.
  - Ichikawa Kankyo Engineering (and its partner companies), NPO Earth Ship Club Ecomira Koto: Development of easy-to-process recycled pellets and resource-recycling bottles using these pellets.

Source:
https://www.kao.com/jp/corporate/news/sustainability/2020/20200902-002/

d. Status of efforts in Aichi prefecture regarding material recycling

Name	Businesses on recycled plastics in Aichi Prefecture
Business entities	ISONO Co., Ltd. (Inazawa City, Aichi Prefecture)
Classification	Use of recycled materials, etc. (production of recycled materials, development of material reclamation processes) Research and Development
Target plastics	Plastic bottle caps, automotive plastic parts, etc.
Summary	-

<Outline of efforts, (numerical) targets, results, etc.>

- 60-year history of handling recycled plastic / Business focused on recycled plastic in Aichi Prefecture -

- **Focus on recycled plastic**
  - By collaborating with auto manufacturers, dismantlers, shredders, etc., a system was established to remove polypropylene (PP) parts and recycle them back to pellets that can be used for car parts.

Car-to-Car Plastic Recycling Business

- Based on the quantity and quality of materials requested by customers, the company created a purchasing plan and procured plastics as raw materials, making full use of the network it had built up over many years specializing in recycled plastics.
- The company developed a unique recycling compound technology that modifies waste plastics according to their quality, expanding the range of reusable waste plastics and improving the quality of pellets produced (2012 Aichi Prefecture Environmental Award, Prize of Excellence).

Exterior view of plant

Extrusion machine

Tumbler mixer (stirring machine)

Stock tank with circulation function (silo)

Crushing equipment

Quality management

Source:
http://www.isono21.co.jp/

2.5 Advanced material recycling examples

Three examples of advanced plastic material recycling projects are presented in the table below.

Material recycling of plastics itself is a process of sorting resins and removing impurities, followed by crushing, washing, and other processes to produce flakes, which are then melted in a granulator and transformed into pellets that are commercialized as raw materials. The basic technology is considered to be mature.

In terms of innovation, there are few examples of new projects, and so-called horizontally business growth, such as the recycling of PET bottles into PET bottles (B-to-B), can be recognized as an advanced one. In addition, as mentioned in the previous chapter on the status of technological development, the current trend of companies is to focus their R&D and initiatives on pre-processing for material recycling, sorting, eco-friendly design, and other aspects of material recycling.

Table 4: Major advanced examples of material recycling

Project Name	Main Business Entities	Classification	Technology Development Summary/Abstract
(i) Mechanical recycling of PET bottles (B-to-B)	Suntory Business Expert Limited / Kyoei Sangyo Co., Ltd.	Mechanical recycling (impurity removal)	・ Collected used PET bottles are sorted, crushed and washed to remove surface contamination and foreign matter, and then exposed to high temperatures to eliminate impurities embedded inside the resin. ・ PET flakes are heated under reduced pressure to remove contaminants adhering to or absorbed by recycled PET resin.
(ii) Eco-cap sorting system for PET bottles	Shineikasei	Sorting	・ Developed a machine for 4 types of sorting (PP, PE/white, others). Caps are poured into the line and sorted by a near-infrared light sensor. ・ Adachi City (Tokyo) Environmental Fund Subsidy Program.
(iii) Circular model of plastic recycling established by a manufacturer of food tray containers	FP Corporation	Recovery System Construction Recycled PET Production Production of food containers using recycled materials	・ FP Corporation is a leading manufacturer of simple food containers (trays) and has been collecting and recycling styrene foam trays since 1990. ・ FPCO Group is committed to resource conservation in its products and services and is actively engaged in the “FP method” recycling business, in which used food containers discarded by households are recycled into food containers.

a. Mechanical recycling of PET bottles (B-to-B)

Name	Mechanical recycling of PET bottles
Business entities	Suntory Business Expert Limited / Kyoei Sangyo Co., Ltd.
Classification	Use of recycled materials, etc. (Mechanical cycle (impurity removal))
Target plastics	Beverage PET Bottles
Summary	-

<Outline of efforts, (numerical) targets, results, etc.>

- Mechanical recycling of PET Bottles:
Developed MR-PET, a high-quality resin equivalent to virgin raw materials, using proprietary technology. Horizontal recycling of PET bottles is achieved. -

- **Mechanical recycling (physical reclamation)**
  - Collected used PET bottles are sorted, crushed, and washed to sufficiently remove surface contamination and foreign matter, and then exposed to high temperatures to eliminate impurities embedded inside the resin.
  - PET flakes are heated under reduced pressure to remove contaminants adhering to or absorbed by the recycled PET resin.
- **High safety and quality**
  - State-of-the-art technology thoroughly removes surface contamination and impurities that have seeped into the resin under vacuum and high temperature. This technology prevent deterioration of physical properties due to heat added during the recycling process, and restore IV (viscosity), which has been considered difficult to achieve. The resulting high-quality resin contains no foreign matter or impurities and achieves a high level of safety that guarantees quality even in applications where it is in direct contact with foodstuffs. The bottles can be used repeatedly as beverage bottles, contributing to reduced use of petroleum resources and significant reduction of CO_2 emissions.
- **Practical application in beverage bottles**
  - The new "Re-PET Bottle," which uses 100% MR-PET and does not use petroleum-derived raw materials, has been adopted for beverage bottles of Suntory Foods International Limited "Oolong Tea" and Kirin Beverage Company "Fresh Tea," the first initiative of this kind in Japan. In the future, it can be expanded to various applications such as labels for bottles, retort pouches for food products, and medicine bottles for medical use.

- **F to P Direct Recycle Technology**
  - Suntory Holdings Ltd. has developed "F to P Direct Recycle Technology" for beverage PET preform production in collaboration with Kyoei Sangyo, SIPA (Italy) and EREMA (Austria). Preforms are manufactured by Kyoei Sangyo Co., Ltd. and have been used in some of Suntory Beverage & Food Limited's PET bottled products since summer 2018 onward.

Completed CG of F to P molding

  - This technology can produce preforms directly from flakes made by crushing and cleaning collected PET bottles and processing them under high temperature and vacuum for a certain period of time after dissolving and filtering them. To mold preforms of uniform quality, melted flakes are poured into the molding machine at a steady pressure. Compared to the conventional system, which requires many processes, such as crystallization and drying before preform production, CO_2 emissions are expected to be reduced by approximately 25%.

PET Bottle Recycling Flow (Mechanical Recycling)

Source:
http://www.petbottle-rec.gr.jp/more/mechanical.html
http://www.kyoei-rg.co.jp/recycling/flow.html
https://www.suntory.co.jp/news/article/13135.html

b. Eco-cap sorting system for PET bottles

Name	Eco-cap sorting system for plastic bottles
Business entities	Shineikasei Co.
Classification	―
Target plastics	PET bottle cap
Summary	Commercial phase (already introduced)

<Outline of efforts, (numerical) targets, results, etc.>

-Developed a machine for sorting four types of PET bottle caps (PP, PE/white, other colors) -

- **Near-infrared light sensor**
  - Pellets recycled from Eco-caps have a low market value due to the mixture of resin types, and their use has been limited.
  - Developed and introduced a machine that uses a near-infrared light sensor to sort and crush eco-caps into four categories: two types of resin (PE, PP), white and other colors. (Supported by Adachi City Environmental Fund.)
  - Sorting capacity of over 1,000 Eco-caps per minute, accuracy of over 99.6%, capable of supplying high quality pellets, used for many products.

- **Recycled Products**
  - Products (recycled and utilized products): pellets, color plates, RPP100 bands (used PP strapping bands for bundling recycled back into PP strapping bands), collection boxes, ballpoint pens, planters for gardening, eco-cap collection bags, etc.

1. Raw materials (collected eco-caps)

2. Sorting and pulverizing (removal of impurities)

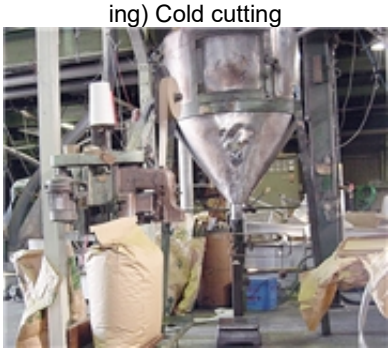
3. Cleaning and specific gravity sorting

4. Raw material mixing (resins, colorants, additives)

5. Granulation (1) (melting and mixing) Cold cutting

6. Granulation (2) (melting, mixing) Hot cutting

7. Drying (moisture removal)



8. Lightweight (packaging)

9. Inspection (Physical Properties Testing Building)

10. Storage

11. Shipment

12. Example of rebirth into product (Collection box)

Pictures of the eco-cap recycling process

Source:
https://balanca.jp/shinei/html/senbetsu.html
https://www.city.adachi.tokyo.jp/kankyo/kankyo-kikinbosyu.html

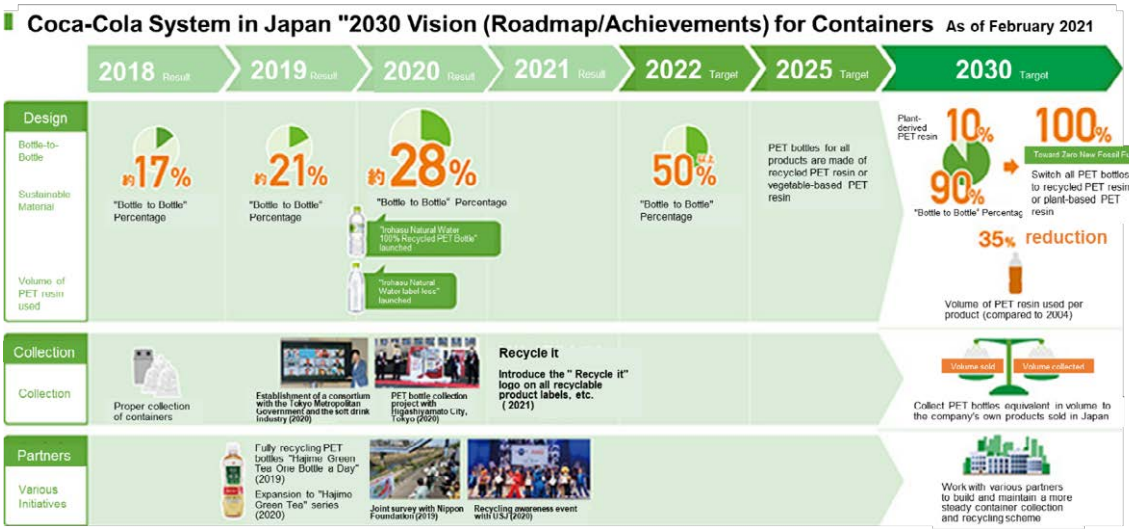
c. “Bottle-to-Bottle” plastic bottle recycling of beverage manufacturers (1)

Name	“Bottle-to-bottle” recycling promotion
Business entities	Coca-Cola (Japan) Company, Limited
Classification (b)	Use of recycled materials, etc. (Sorting) Activities to raise awareness among consumers, etc.
Target plastics	Beverage PET Bottles
Summary	-

<Outline of efforts, (numerical) targets, results, etc.>

-Recycled PET Resin Usage Rate to Increase to 28% by 2020
Introduced the “Recycle It!” logo sequentially to further contribute to a recycling-oriented society. -

The Coca-Cola System, consisting of Coca-Cola Japan Company, Ltd. (Head Office: Shibuya Ward, Tokyo; President: Jorge Garduño) and five bottling companies and other companies in Japan, announced that the percentage of recycled PET resin used for PET bottle containers in the domestic soft drink sector in 2020 was 28% (up 7 percentage points compared to the previous year).
Based on the “2030 Vision for Containers” announced in January 2018 (updated in July 2019), the Coca-Cola System in Japan is promoting “bottle-to-bottle,” in which used PET bottles are collected and recycled as new PET bottles. The goal is to achieve a recycled PET resin usage rate of 50% by 2022 and zero use of new petroleum-derived raw materials for PET bottles by 2030. In 2020, the introduction of 100% recycled PET bottles for Irohasu Natural Water 100% Recycled PET Bottle (March) and Irohasu Natural Water Label-less (April) contributed to a significant reduction in the use of plastic newly produced from petroleum.



Coca-Cola System in Japan "2030 Vision for Containers (Roadmap/Achievements)"

・Introduction of the “Recycle it” Logo

As part of its educational activities aimed at creating a plastics recycling society, the Coca-Cola System is strengthening its communication with consumers by sequentially introducing a common “Recycle it” logo on all recyclable product packaging since the end of February 2021. In particular, it was decided that the label of containers made from 100% recycled PET resin would carry the “100% recycled PET” label.
The “Recycle it” logo was then to be used not only on product packaging, but also on advertising materials, POP, recycling bins, etc.

"Recycle it" Logo

・Samples at the "Tokyo 2020 Olympic Torch Relay" venues

Samples of Coca-Cola products (not for sale) made from 100% recycled PET bottles were planned at venues such as the "Tokyo 2020 Olympic Torch Relay," which started on March 25, 2021. Coca-Cola System called for the proper collection and recycling of PET bottles at various points of contact with consumers, thereby contributing to improving the collection rate of PET bottles and other beverage containers and further promoting horizontal recycling of plastic resources.

Coca-Cola products made from 100% recycled PET bottles (not for sale)

・100% recycled PET for undiluted solution containers at the Coca-Cola Japan Moriyama Plant

As part of its efforts to efficiently use plastic resources and reduce carbon dioxide (CO_2) emissions in the manufacturing process, the Coca-Cola Moriyama Plant (Shiga Prefecture), which manufactures undiluted solutions for drink products, has been using recycled PET resin for containers used in the transportation of the undiluted solutions since January 2021 with the aim of reducing the environmental impact. This initiative has resulted in an annual reduction of approximately 51 tons of newly manufactured plastic from petroleum and a reduction of approximately 27 tons ofCO_2 emissions (18.2% reduction) compared to conventional undiluted solution containers. The efforts implemented at this factory have been replicated by other Coca-Cola System factories around the world.

Source:

https://www.cocacola.co.jp/press-center/news-20210303-10

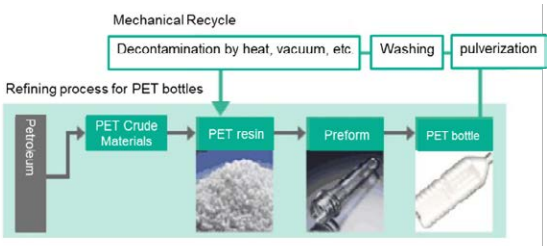
d. "Bottle-to-Bottle" plastic bottle recycling by beverage manufacturers (2)

Name	Horizontal circulation of PET resin in Japan
Business entities	Suntory Holdings Limited
Classification	Use of recycled materials, etc. (Sorting) Awareness-raising activities for consumers, etc.
Target plastics	Beverage PET Bottles
Summary	-

<Outline of efforts, (numerical) targets, results, etc.>

- Domestic horizontal circulation of PET resin "Re-PET Bottle"-

In 2011, Suntory Foods International Limited, in cooperation with Kyoei Sangyo Co., Ltd. established the first "bottle-to-bottle" recycling system in the Japanese beverage industry to recycle PET bottles into new PET bottles.
At the start of the introduction, 50% recycled PET resin was used, but based on the results of approximately one year of operation, it was confirmed that a stable supply was possible, and the amount of recycled PET resin used was expanded to 100%, significantly reducing CO_2 emissions (including CO_2 emissions during PET resin production) compared to bottles made from 100% petroleum-derived materials. These PET bottles made of 100% recycled PET resin are used in a number of products, including "Suntory Oolong Tea and "Iemon" 2L bottles.
This system received "The Minister of the Environment Award for Achievement in Promoting a Recycling-Oriented Society" in 2011 and 2012, "The Minister of the Environment Award for Global Warming Prevention Activities (Technology Development and Commercialization Category)" in 2011, "The Nikkei Global Environmental Technology Award for Excellence" in 2011 (the first in the food industry), and "The 21st Global Environment Grand Award" in 2012. In 2013, the company received "The Environmental Award for Excellence" sponsored by the Hitachi Global Foundation and the Nikkan Kogyo Shimbun, Ltd.



PET bottle refining process and "bottle to bottle" flow


Products using F to P Direct Recycle Technology

• **Introduction of "F to P Direct Recycling Technology"**
As part of its recycling efforts, Suntory worked in 2017 with Kyoei Sangyo Co., Ltd. and overseas machinery manufacturers (EREMA, Austria; SIPA, Italy) to develop "F to P Direct Recycling Technology," which was expected to further reduce the environmental impact, and began production in the fall of 2018. "F to P Direct Recycling Technology" is a technology that can directly manufacture preforms after melting and filtering flakes made from collected and cleaned PET bottles at high temperatures, reducing CO_2 emissions by 25% (per kilogram of PET bottle preforms produced) compared to the conventional system.

Source:
https://www.suntory.co.jp/company/csr/activity/environment/reduce/resources/recycle/

e. "Bottle-to-Bottle" plastic bottle recycling by beverage manufacturers (3)

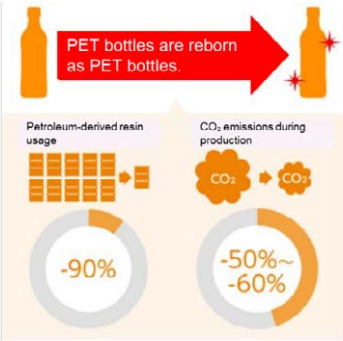
Name	Bottle-to-Bottle Recycling
Business entities	Kirin Holdings
Classification	Use of recycled materials, etc. (Sorting) Awareness-raising activities for consumers, etc.
Target plastics	Beverage PET Bottles
Summary	

<Outline of efforts, (numerical) targets, results, etc.>

- "R100 PET Bottle" made from 100% recycled PET resin-

In February 2019, the Kirin Group formulated and announced the Kirin Group Plastics Policy, which includes the goal of converting "50% of PET resin use in Japan to recycled resin by 2027" as its policy for addressing the "plastic waste issues".
In addition, "R100 PET bottles" made from 100% recycled PET resin have been used for "Kirin Nama-Cha Decaf" since mid-June2019.
In recent years, a safe method of PET resin recycling allowing PET bottles to be turned back into PET bottles has been developed. In this "mechanical recycling" method, after washing, the resin is treated at high temperature under near-vacuum conditions to volatilize and remove impurities that remain inside the resin, thereby restoring the molecular weight that was lowered during the recycling process to a level suitable for bottle molding.
PET bottles are planned to be transformed into PET bottles, which can eliminate the use of new petroleum as raw material, thereby reducing CO_2 emissions by 50-60%. In addition to "Kirin Nama-cha Decaf," some "Kirin Afternoon Tea Delicious Unsweetened" also uses PET bottles made from recycled PET resin. The "R100 PET Bottle" of "Fresh Tea Decaffeinated" made from 100% recycled PET resin, together with the lightest 2L PET bottle used for "Alkaline Ionized Water" in Japan, were exhibited at the "G20 Innovation Exhibition" in Japan.

R100 PET bottle



Petroleum Materials and CO_2 Reduction Effects

Source:
https://www.kirin.co.jp/csv/eco/topics/2019/package_190711.html

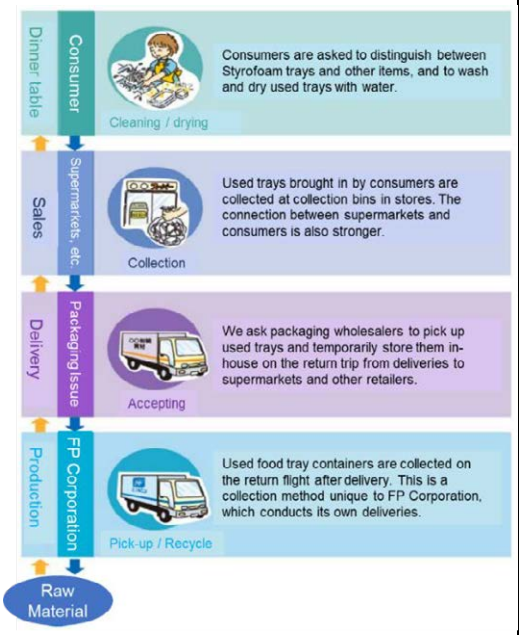
f. Circular recycling model for plastic recycling set up by a food tray container producer

Name	Circular recycling model for plastic recycling set up by a food tray container producer
Business entities	FP Corporation
Classification	Use of recycled materials, etc. (establishment of collection system, bottle-to-tray recycling, etc.)
Target plastics	Collected used trays and PET bottles (utilize own established collection network)
Summary	Started to consider collaboration with DIC to realize complete circular recycling of polystyrene through chemical recycling (November 2020).

<Outline of efforts, (numerical) targets, results, etc.>

- Circular recycling model for plastic recycling set up by a food tray container producer -

- **Establishment of a system to collect and recycle plastics**
  - FP Corporation is a leading manufacturer specializing in the production of simple food containers (trays) and has been collecting and recycling styrofoam trays since 1990.
  - FPCO Group is committed to conserving resources in its products and services and is actively developing the "FPCO Method" recycling business, in which used food containers discharged from households are recycled into food containers.
  - Fukuyama Recycling Plant, Chubu Recycling Plant, Kanto Recycling Plant, and other plants have been established, and in FY2019, 6,787 tons of foamed trays, 2,341 tons of transparent containers, and 73,500 tons of PET bottles were recycled and used.



- **Recycling by everyone (Recycling by all 4 parties together)**
  - Used trays that have been washed and dried are collected at collection boxes placed in supermarket storefronts, etc. FP Corporation picks them up on trucks on the way home from deliveries and recycles them.
  - By integrating consumers, sales (distribution), delivery, and production, a large number of used trays and PET bottles can be recycled smoothly without waste.

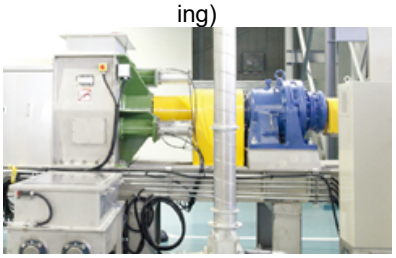
- **Establishment of tray-to-tray recycling system (horizontal development)**
  - FP Corporation has been collecting and recycling styrene foam trays since 1990.

Tray-to-tray recycling system flow

1. Delivery (Styrofoam trays)

2. Sorting (white tray and colored tray sorting)

3. Wind sorting and primary crushing (foreign material removal and crushing)



4. Primary cleaning

5. Secondary cleaning

6. Rinsing and washing - Dehydration

7. Secondary crushing

8. Melting and molding

9. Pellet

10. Eco Tray(R): Product

- **Establishment of a recycling system for transparent containers**
  - The company has established a recycling system for transparent containers which, unlike Styrofoam trays, were considered difficult to recycle due to the wide variety of materials used.
  - Completed a material identification system using near-infrared rays and succeeded in sorting transparent containers (full-scale operation started in October 2008).
  - Materials are classified into BOPS material (biaxially oriented polystyrene sheet material), PET, and others.

Transparent Container Recycling Flow

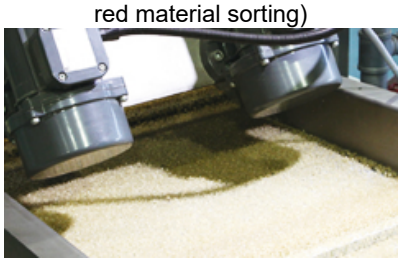
1. Delivery

2. Manual sorting and alignment

3. Material identification (near-infrared material sorting)

4. Material sorting
Classified into OPS material, PET material, and others

5. Crushing and cleaning



6. Melting and molding

7. Pellet

8. Eco Tray(R): Product

- **<u>Bottle-to-Tray recycling (development and production of multi-layered trays)</u>**
  - Operations started at the Kanto Eco-Pet Plant (Ibaraki Prefecture) in October 2017.
  - A series of systems to recycle collected PET bottles as raw materials to produce material sheets, which are then used to produce Eco APET (the company's environmentally friendly transparent containers), thus establishing a recycling system that enables in-house production of food container trays from used PET bottles.
  - Using proprietary technology, the company produces Eco APET containers that use recycled resin for the intermediate layer and coat the food-contact surface with virgin PET resin to create a multi-layered container.

Bottle-to-Tray Recycling Flow

Kanto Eco-Pet Plant

Inside the factory

1. Used PET bottle storage

2. Pretreatment process (foreign material removal, crushing, etc.)

3. Cleaning process

4. Pelletizing process

5. Food container compliant grade pellets completed

6. Sheeting process

7. Molding and cutting process

8. Eco APET completed

- Approximately 24,000 tons of recycled PET material pellets are produced annually at the Kanto Eco-Pet Plant.
- <u>Recycled resin is used for the intermediate layer, and the surface in contact with the food is multi-layered with virgin PET resin.</u>
- FP Corporation has two other PET recycling plants, and the entire FPCO Group produces approximately 60,000 tons of recycled PET materials annually.

Source:
https://www.fpco.jp/esg/environmenteffort/fpco_recycle/pet.html

2.6 Overseas Trends in Advanced Technologies for Material Recycling

An overview of major overseas advanced technology trends in material recycling is shown in the table below.

Technology to remove odor, color, and other contaminants from used PP, technology to watermark containers and packaging products after use to facilitate sorting, and technology development (some of which have already been put into practice) such as the incorporation of tracers into product raw materials, etc. are currently being implemented.

Table 5: Summary of Overseas Advanced Technology Trends in Material Recycling

Initiative	Main Business Entities	Classification	Technology Development Summary/Abstract/Source
(i) Technology to remove odor, color, contaminants, etc. from used PP	Pure Cycle Technologies, Inc. P&G Company, etc. (U.S.A.)	Mechanical Recycling (Cleaning and refining)	・ Precycle's recycling process was developed and licensed by P&G, the world's largest consumer goods company. The technology allows to separate colour and remove odours and other contaminants from plastic waste materials, and convert them into virgin-like resin. ・ Plans for plant development in collaboration not only with P&G, but also with Milliken, a global industrial manufacturer, and Nestlé, the world's largest beverage maker. https://purecycletech.com/ http://chemical.milliken.com/news/purecycle-technologies-partners-with-milliken-nestle-to-accelerate-revolutionary-plastics-recycling
(ii) Sorting technology using digital watermarking technology (invisible barcodes)	P&G Company (U.S.A.) Digimarc (U.S.A. and Europe)	Sorting Technology (Watermarking technology (tracer))	・ Developed sorting technology using electronic watermarking technology (invisible barcodes) to embed information into plastic containers and packaging and sort this information using advanced optical sensor technology. ・ Many companies are participating in the demonstration project (HolyGrail2020 project). http://www.aim.be/priorities/digital-watermarks/ https://kyodonewsprwire.jp/release/202009104172 https://www.newplasticseconomy.org/assets/doc/Holy-Grail.pdf
(iii) Development of technology to attach unique chemical barcodes to plastic products to facilitate sorting	BASF Corporation (Canada)	Sorting Technology (Tracer based sorting)	・ Molecular tracers (unique chemical barcodes) are placed in plastic materials and the information is traced using blockchain technology. Demonstration of technology to facilitate sorting and separation of plastics. https://www.basf.com/ca/en/who-we-are/sustainability/Sustainability-in-Canada/reciChain.html https://www.recyclingproductnews.com/article/34534/major-companies-join-pilot-program-to-improve-circular-economy-traceability-of-recycled-plastics-in-canada
(iv) Sorting technology based on magnetic flux density separation technology	Umincorp (Netherlands)	Sorting Technology (Magnetic flux density separation)	・ MDS (magnetic flux density separation) allows sorting of PP, HDPE, PS, PET, ABS, PVC, or other plastics with high purity. ・ Sorting equipment has already been developed. http://www.umincorp.com/solutions https://solarimpulse.com/efficient-solutions/mds-separation-technique

3 Thermal Recycling

3.1 Outline of Thermal Recycling

Thermal recycling of plastics is a technology to incinerate waste plastics (e.g. plastic scraps) from used products and production processes for heat utilization and power generation. The methods include waste incineration with heat utilization, waste incineration with power generation, conversion to raw cement fuel, and conversion to solid fuel (RPF), taking advantage of the high calorific value of plastics.

3.2 Thermal Recycling Amount

According to data estimated by the Plastic Recycling and Reuse Association, the amount of thermal recycling was about 5.03 million tons, or 56% of the total 8.91 million tons of waste plastic discharged in 2018, of which about 1.73 million tons (19%) was for solid fuel/cement raw fuel, 2.64 million tons (30%) for incineration for power generation, 660,000 tons (7%) for thermal incineration.

3.3 Latest Technology Trends in Thermal Recycling

Conventional technologies for thermal recycling are based on direct incineration or heat utilization by converting (plastic and paper) waste into RPF, and no active technological development is underway.

In the case of incineration of plastics in general waste, the policy to actively recover energy from small incinerators has been adopted in recent years, and thermal recycling of general waste has the potential to make progress.

3.4 Advanced cases of Thermal Recycling

As a representative example of plastic-fueled power generation, the initiatives of Sanix Energy (Tomakomai Power Plant) are outlined below.

Plastic fuel power generation by SANIX ENERGY INCORPORATED (Tomakomai Power Plant)

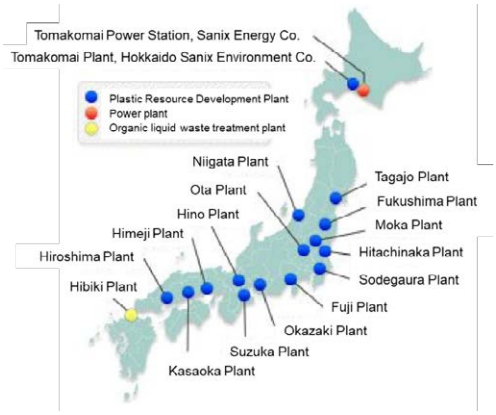
Name	Large-scale plastic fuel power generation project
Business entities	SANIX ENERGY INCORPORATED
Classification	Use of recycled materials, etc. (Thermal Recycling: Power Generation)
Target plastics	Mainly industrial waste plastics converted into fuel

<Outline of efforts, (numerical) targets, results, etc.>

– Power generation business using plastic fuel –

- **Power plant operation with plastic fuel**
  - SANIX ENERGY INCORPORATED was established in 2001 as a 100% subsidiary of SANIX INCORPORATED.
  - Hokkaido Tomakomai Power Station, a power plant fuelled exclusively with plastic, started operation in 2003.
  - The maximum power generation capacity is 74,000 kW (equivalent to 24,000 households), with approximately 20% of the power used onsite and 80% sold.
  - The designed power generation efficiency is 27%.
  - There are two circulating fluidized bed incinerators, using 705 tons of plastic per day, or approximately 200,000 tons of fuel plastic per year.

Panoramic view of Tomakomai Power Station



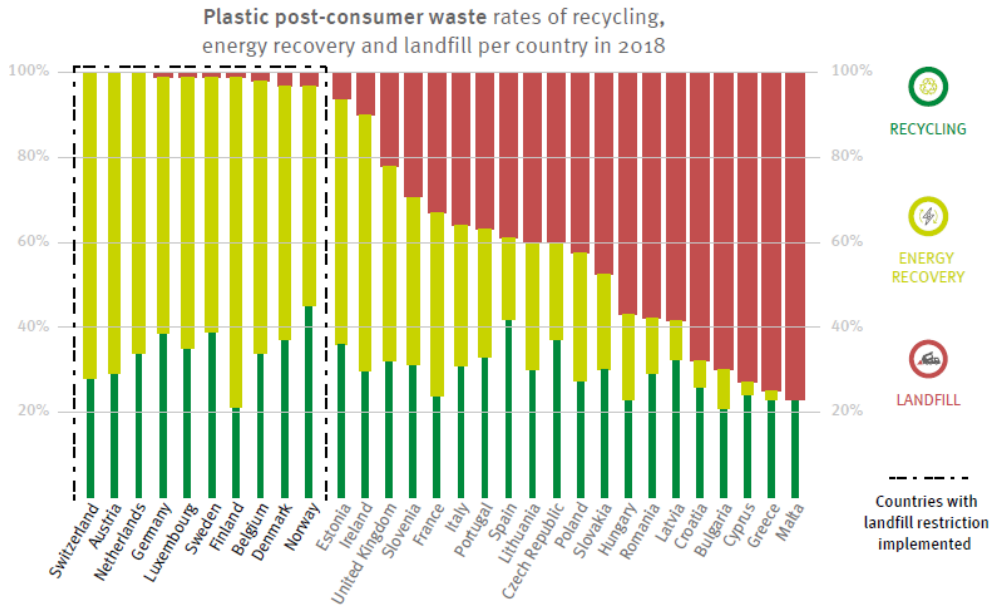
Location of the plastic fuel conversion plants and power plants

- **Plastic fuel procurement**
  - SANIX Group, Inc. maintains 15 plastic recycling (fuel conversion) plants nationwide.
  - In order to supply as much high-quality fuel for power generation as possible, the SANIX Group's fuel production plant properly separates incoming industrial waste, crushes it into small pieces with a dedicated crusher, and ships it to SANIX ENERGY.
  - Among the soft waste plastics that are processed at the recycling plant, those that can be used to generate electricity are used at the Tomakomai Power Plant.
  - The delivery form is compressed and packed bales, and all products outside of Hokkaido are transported by ship, using the Tomakomai Port.

Source:
http://www.sanix-energy.com/

3.5 Trends in advanced overseas technology development related to Thermal Recycling

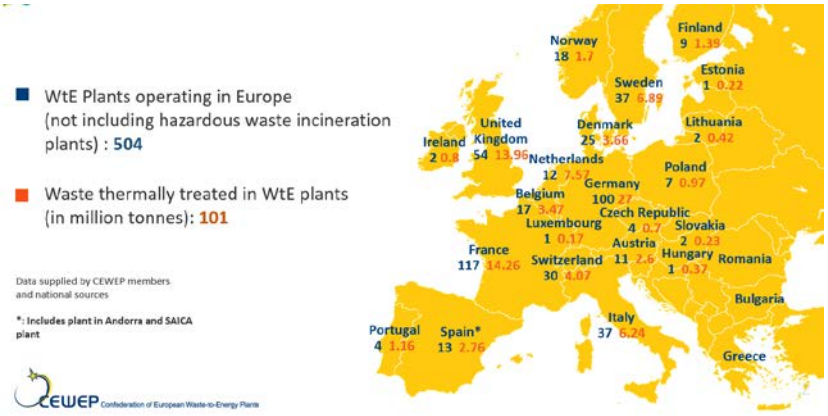
Figure below represents the proportion of plastic recycling, thermal recycling, and landfill disposal in European countries in 2018 (the black dotted box in the figure indicates countries with landfill regulations) and shows a high rate of 60-80% for thermal recycling in European countries with landfill regulations.



Source: Plastics Europe, Plastics-the Facts 2020)

Figure 4: Ratio of Waste Plastic Recycling, Thermal Recycling, and Landfill in 30 European Countries

There are currently about 504 Waste-to-Energy plants spread across 30 European countries, with a processing capacity of 101 million tons as of 2020. The figure below shows the number of Waste-to-Energy plants by country (excluding hazardous waste treatment facilities) in blue and the amount of waste treated (in millions of tons) in red. France has the largest treatment capacity, followed by Germany and the United Kingdom.



Source: CEWEP (2023)

Figure 5: Location of waste-to-energy plants in Europe in 2020

The table below provides an overview of trends in advanced thermal recycling technologies.

While "thermal recycling of plastics is undesirable from the viewpoint of CO_2 emissions," there is a trend, mainly in Europe, to expand efforts in energy use (thermal recycling) taking into account power generation efficiency and other factors, in order to address various issues such as reduction of microplastics and landfill disposal volume.

Table 6: Overseas Trends in Advanced Thermal Recycling Technology Development

Initiative	Main Business Entities	Technology Development Summary/Abstract/Source
(i) WtE roadmap to 2035	CEWEP (Confederation of European Waste-to-Energy Plants)	・ The roadmap of CEWEP for 2035 aims to expand processing capacity from the current 101 million tons to 142 million tons. ・ CEWEP's approach to the promotion of Thermal Recycling of Plastics is as follows. ・ Although burning plastics to generate power from waste is undesirable because it contributes to increased CO_2 emissions, CEWEP will continue to promote initiatives to (i) reduce the amount of landfill disposal, (ii) curb exports to countries with low environmental standards, and (iii) reduce the risk of marine pollution from microplastics, by thoroughly removing hazardous substances and promoting the increment of power generation efficiency. . https://www.cewep.eu/wp-content/uploads/2019/09/WtE_Sustainability_Roadmap_Digital.pdf
(ii) Coordination of heat supply and power generation	WSW (Wuppertal Stadtwerke), AWG (Waste Management Division of WSW)	・ In 2018, AWG combined a waste-to-energy plant with a district heat supply system in Wuppertal to improve energy efficiency and further reduce air pollution impacts. ・ At the same time, the city closed its coal-fired power plant and switched from coal-derived to waste-derived heat supply, achieving a significant reduction in CO_2 emissions.
(iii) Hydrogen production from waste power generation		・ WSW introduced 10 new FC (fuel cell) buses in 2019 (WSW Public Transportation Department). ・ Hydrogen fuel utilized for FC buses is produced using electricity from AWG's waste-to-energy facility (the hydrogen station is adjacent to the waste-to-energy plant). ・ Continue to promote efforts to expand CO_2-free public transportation. https://www.cewep.eu/wp-content/uploads/2019/09/WtE_Sustainability_Roadmap_Digital.pdf
(iv) Promotion of SRF (Solid Recovered Fuels) use	Austria, Italy, etc.	・ SRF is RDF that meets European standards as fuel (excluding hazardous substances, PVC, PET (PET should be recycled through material recycling), etc.). ・ According to European standards, quality levels are classified as Low, Medium, and Premium, which are used for waste power generation (fluidized bed), cement kilns (secondary fuel), and cement kilns (primary fuel), respectively. ・ In Austria, about 0.5 mt of alternative fuels are consumed annually, of which about 60% are plastics (2015, 2016). ・ In Italy, SRF and mixed inputs such as plastic and rubber account for more than 90% of the total fuel used in cement kilns, at about 0.3 mt/year (2017). ・ In recent years, the use of SRF in cement kilns has been increasing in Austria, Italy, and other countries, and the use of SRF is expected to expand in the future while maintaining strict quality control. https://www.vivis.de/wp-content/uploads/WM6/2016_WM_401-416_Lorber_Sarc.pdf https://www.ieabioenergy.com/wp-content/uploads/2020/05/Trends-in-use-of-solid-recovered-fuels-Main-Report-Task36.pdf

4 Chemical Recycling

4.1 Outline of Chemical Recycling

Chemical Recycling of plastics is a method to recycle waste plastics into chemical raw materials through chemical decomposition and other processes.

The types of conversion can be broadly classified into (i) feedstock/monomerization, (ii) blast furnace reducing agent, (iii) coke oven chemical feedstock recycling, (iv) gasification, and (v) liquefaction, as shown in the table below.

Table 7: Summary of Chemical Recycling

Method	Features
(i) Feedstock / monomerization	・ Waste plastic products are chemically decomposed back into raw materials and monomers, which are then utilized again for plastic products. ・ A typical example is the technology that returns used PET bottles (waste PET resin) to DMT (dimethyl terephthalate) and then to TPA (terephthalic acid) to make PET resin.
(ii) Blast furnace reducing agent	・ Plastic is used as a reducing agent instead of coke in blast furnaces. Unlike coke, the main components of plastic are carbon and hydrogen, resulting in low carbon dioxide emissions during pig iron production. ・ This method is mainly used by JFE Steel-affiliated steelmakers.
(iii) Coke oven chemical feedstock recycling	・ Waste plastics are pyrolyzed at high temperatures (600 to 1,300 degrees Celsius) under pressure to obtain coke as a reducing agent for blast furnaces, hydrocarbon oil as a chemical feedstock, and coke oven gas for use in power generation and other applications. ・ This method is mainly used by Nippon Steel Corporation-affiliated steelmakers.
(iv) Gasification	・ By heating with limited oxygen, most of the plastic is converted into hydrocarbons, carbon monoxide, and hydrogen, which can be used as raw materials for methanol, ammonia, acetic acid, and other chemical industries. ・ EUP technology developed by EBARA CORPORATION and Ube Industries, Ltd. and JFE Kankyo Corporation's Thermo-Select system are in operation at various locations.
(v) Liquefaction	・ The plastic is completely pyrolyzed with a reforming catalyst under about 400 degrees Celsius to obtain hydrocarbon oil. For the treatment of plastic in general waste, it is important how to remove the chlorine content. ・ Many facilities have been forced to withdraw due to high costs, but recently Idemitsu Kosan Co., Ltd. has been working on the practical application of chemical recycling which utilizes petroleum refining cracking facilities to break down recovered plastics and return them to chemical raw materials.

Source: Prepared with reference to the Survey on Trends in Chemical Recycling of Plastics (Ministry of Economy, Trade, and Industry, 2005)

4.2 Chemical Recycling Amount

According to data estimated by the Plastic Recycling and Utilization Association, only 390,000 tons, or 4% of the total 8.91 million tons of waste plastic generated in 2018, was chemically recycled in Japan.

4.3 Latest Technology Trends in Chemical Recycling

This section outlines the latest technological trends in chemical recycling. Some technologies are restricted by copyrights that cannot revealed in public, therefore only 2 technologies are introduced here.

The latest technologies introduced here are focusing on examples that are currently in the development and planning stages and those that are currently the subject of demonstration projects.

Table 8: Summary of Latest Technology Trends in Chemical Recycle

Project Name	Main Business Entities	Classification	Technology Development Summary/Abstract
(i) Complete recycling of polystyrene by chemical recycling	FP Corporation DIC Corporation	Feedstock / Monomerization	・ With a view to collaboration, DIC Corporation and FP Corporation aim to achieve complete recycling of PS products by outsourcing monomer reduction technology to recycle coloured and patterned foam PS containers, which have not been recycled as food packaging containers in the past.
(ii) Chemical recycling of waste plastic using petroleum refining cracking facilities	Idemitsu Kosan Co., Ltd.	Feedstock / Liquefaction	・ The company has a plan work on the practical application of chemical recycling which utilizes petroleum refining cracking facilities to break down recovered plastics and return them to chemical raw materials.

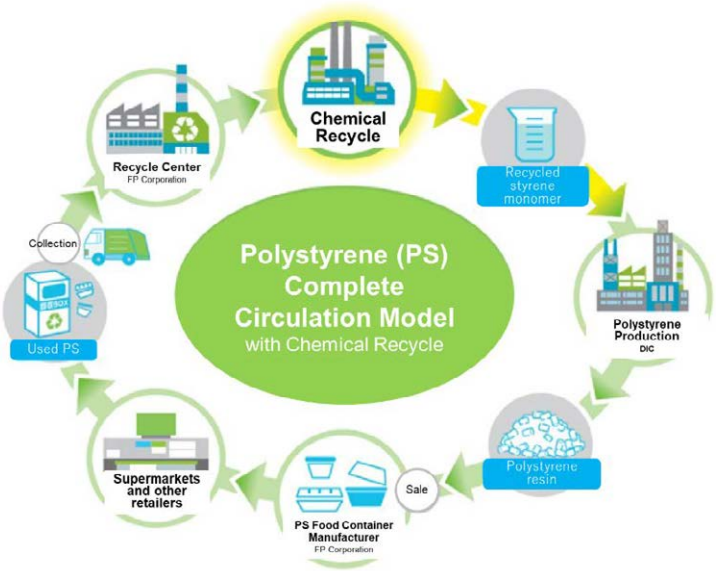
a. Complete Circular Recycling of Polystyrene by Chemical Recycling

Name	Complete Circular Recycling of Polystyrene by Chemical Recycling
Business entities	FP Corporation DIC Corporation (Former name: Dainippon Printing Ink Manufacturing Co., Ltd.)
Classification	Use of recycled materials, etc. (Chemical raw materials, monomerization) Research and Development
Target plastics	PS (polystyrene) used food containers, etc.
Summary	Details of the technology are not currently released to the public.

<Outline of efforts, (numerical) targets, results, etc.>

-PS Complete Circulation Model by Chemical Recycling-

- **PS Complete Circulation Model**
  - DIC Corporation and FP Corporation has a plan to outsource monomer reduction technology with a view to establishing a joint venture or other collaboration for chemical recycling to recycle foam PS containers with colored patterns, which have not been recycled as food packaging containers in the past, and to achieve the complete recycling of PS products.
  - The construction of a demonstration plant at DIC's Yokkaichi Plant is also being considered.
  - DIC and FP Corporation aim to achieve complete recycling by utilizing various recycling technologies for efficient utilization of used plastics and reduction of carbon dioxide (CO_2) emissions in the life cycle of food packaging containers.



Source:
https://www.fpco.jp/blog/2020/11/16/368

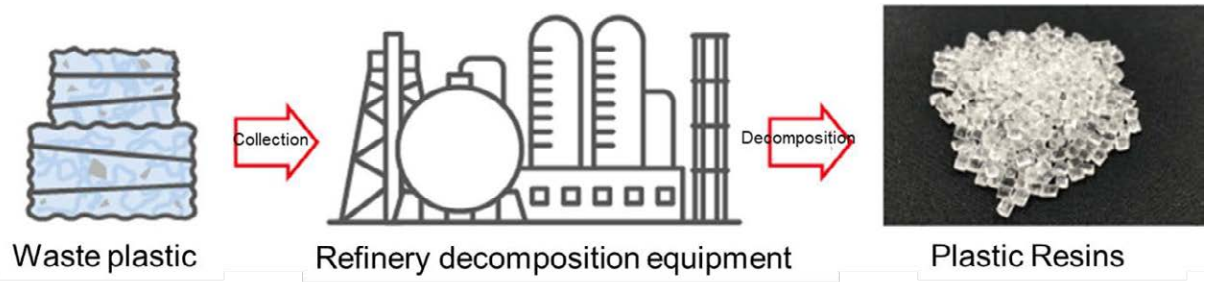
b. Waste plastic chemical recycling using oil refining cracking facilities

Name	Waste plastic chemical recycling using oil refining cracking facilities
Business entities	Idemitsu Kosan Co., Ltd.
Classification	Use of recycled materials, etc. (Chemical Recycling)
Target plastics	Plastics in general
Summary	Detailed information is not disclosed.

<Outline of efforts, (numerical) targets, results, etc.>

- Waste plastic chemical recycling using oil refining cracking facilities -

- **Chemical Recycling of Plastics**
  - The company is working on the practical application of chemical recycling, which utilizes petroleum refining cracking facilities to break down recovered plastics and return them to chemical raw materials.
  - The company positions this initiative as a next-generation circular business.



Source:
https://sustainability.idss.co.jp/ja/themes/328
https://www.idemitsu.com/jp/news/2019/191114_7.pdf

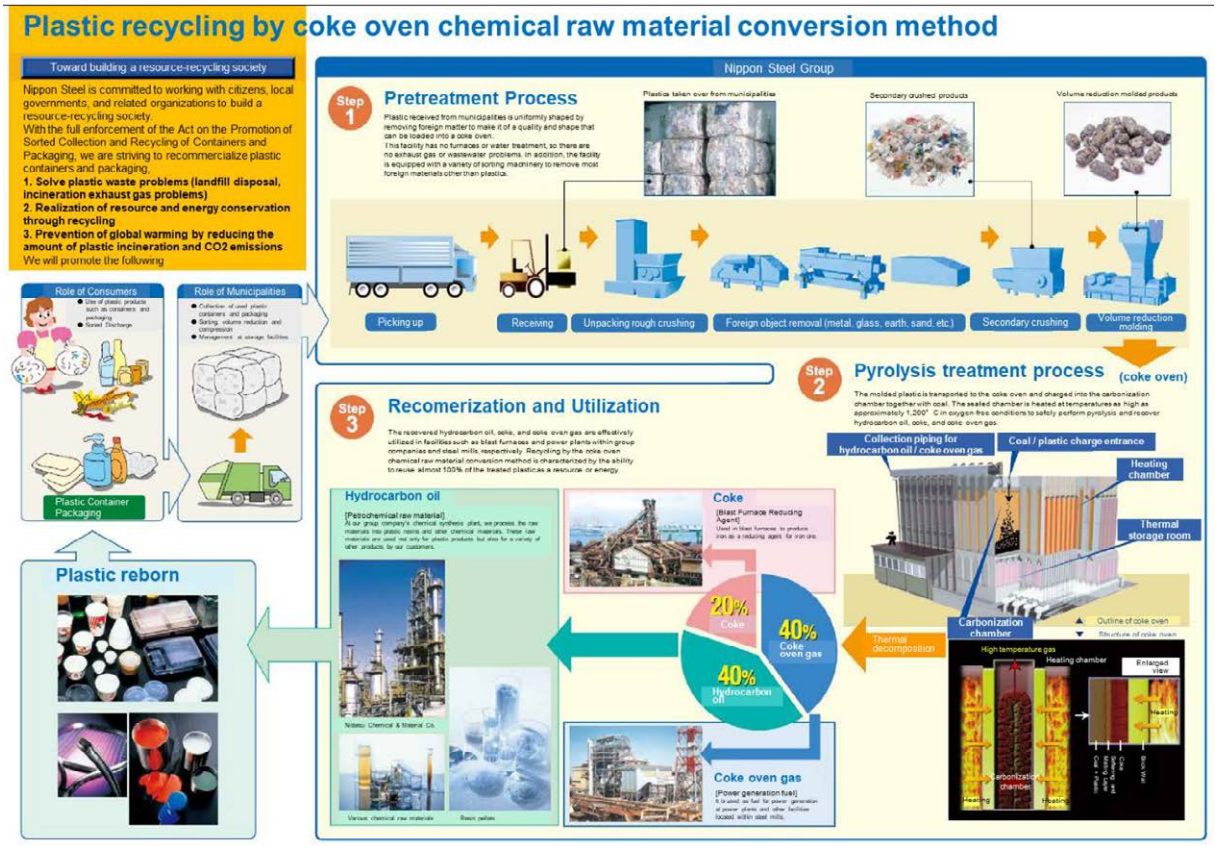
c. Nagoya Works, Nippon Steel Corporation Plastic recycling by coke oven chemical raw material conversion method

Name	Plastic recycling by coke oven chemical raw material conversion method
Business entities	Nagoya Works, Nippon Steel Corporation
Classification	-
Target plastics	All plastics, mainly plastics for recycling containers and packaging
Summary	-

<Outline of efforts, (numerical) targets, results, etc.>

- Plastic recycling by coke oven chemical raw material conversion method -

- **Coke oven chemical raw material conversion method**
  - When coal is steamed and burned, coke is formed, and from the volatile components produced, hydrocarbon oil and coke oven gas can be produced. Similarly, coke, hydrocarbon oil, and coke oven gas are produced from waste plastics. Nippon Steel Corporation established facilities to utilize waste plastics as coke, chemical raw materials, and fuel, and started operation at each of its steel mills.
  - Waste plastics collected by municipalities are crushed and foreign substances such as iron are removed. It is then heated to 100°C and processed into granules, excluding vinyl chloride. These granules are mixed with crushed and graded coal at a ratio of 1-2% and fed into the carbonization chamber of the coke oven. The carbonizing chamber is sandwiched between the combustion chambers and heated indirectly on both sides. Because of the oxygen-free conditions in the carbonization chamber, waste plastics pyrolyze after being heated to 1,200°C. The high-temperature gas produced in the process is cooled and purified together with the high-temperature coal gas and separated into high-calorie gas and oil at room temperature. This process produces 40% hydrocarbon oil as chemical feedstock, 20% coke as reducing agent for blast furnaces, and 40% coke oven gas used for power generation and other purposes.
  - Plastics are decomposed into coke, gas, and oil compounds in coke ovens and reused as reductant, fuel, and chemical raw materials in blast furnaces, respectively.
  - The coke oven chemical raw material conversion method is an advanced chemical recycling system that applies the coke oven's ability to pyrolyze organic matter (coal) at high temperatures and recover carbon, gas, and oil to waste plastics (petroleum-based polymers) recycling.



[Reference] Reception of Plastic for Containers and Packaging Recycling at Nagoya Steel Works (Bidding Results)

Accepting Factory	Emission source		By prefecture		Total number of municipalities and associations	Total amount received (t/year)
	Prefectures	Number of municipalities, associations, etc.	Volume received (t/year)	Percentage (%)		
Nagoya Plastic Recycling Plant	Hokkaido	1	1,000	4%	40	25,916
	Kanagawa	1	1,000	4%		
	Niigata	7	2,876	11%		
	Toyama	2	328	1%		
	Yamanashi	3	441	2%		
	Nagano	7	1,286	5%		
	Gifu	6	664	3%		
	Aichi	8	17,423	67%		
	Mie	5	899	3%		

Source: Containers and Packaging Recycling Association of Japan website: Based on information disclosed in the 2020 bidding results.

Source:
https://www.nipponsteel.com/works/nagoya/eco/recycle.html

d. Project to convert used plastics into ammonia as raw material

Name	Project to convert used plastics into ammonia as raw material
Business entities	Showa Denko Co., Ltd. Kawasaki Works
Classification	Use of recycled materials, etc. (Chemical Recycling)
Target plastics	Plastics in general
Summary	-

<Outline of efforts, (numerical) targets, results, etc.>

- Project to convert used plastics into ammonia as raw material –

- **Ammonia raw material conversion of plastics (existing facility)**
  - The facility utilizing EUP technology was previously operating in Yamaguchi Prefecture but is now operating at the Kawasaki Plant of Showa Denko Co.
  - In 2003, Showa Denko's Kawasaki Plant began a "plastic chemical recycling project" to recycle plastic containers into chemical raw materials.
  - The largest plastic and chemical recycling facility in Japan was established for the purpose of recycling plastic containers and packaging collected from municipalities.
  - The process consists of two steps: (1) crushing waste plastics to make compacted products, and (2) gasification process in which the compacted products are thermally decomposed in a pressurized two-stage gasifier at high and low temperatures to produce hydrogen and carbon monoxide synthesis gas.
  - No sorting of vinyl chloride is required, and all plastics can be processed. Chlorine and hydrogen sulfide in synthesis gas are recovered and recycled as industrial salt and sulfur, and the unburned ash is turned into granulated slag and used as raw material for roadbed material and improved soil, etc. 100% of waste plastic is recycled.
  - According to interviews with the company, it has received approximately 60,000 tons of melted riprap in FY2020.
  - On August 31, 2020, Showa Denko Co., Ltd. announced that it has started accepting crushed and moulded industrial plastic waste at its Kawasaki Works (Kawasaki City, Kanagawa Prefecture), which carries out chemical recycling by gasification. The license to conduct an industrial waste disposal activity (286 tons/day) was obtained.

Ammonia raw material conversion facility for used plastics (Kawasaki Plastics Recycling (KPR))
(Source: Showa Denko HP)

Source:
https://www.sdk.co.jp/kpr/process.html
https://www.city.kawasaki.jp/kawasaki/page/0000026792.html

5 Plastic Substitutes

5.1 Need for alternatives to plastics (biomass plastics, etc.)

In order to address a wide range of issues, such as resource and waste constraints, the marine plastic waste problem, global warming, and waste import restrictions in Asian countries, a strategy to comprehensively promote the recycling of plastic resource based on the basic principle of 3R+Renewable (substitution for renewable resources), the "Plastic Resource Recycling Strategy" was formulated in 2019.

This strategy states that one of the priority strategies for comprehensively promoting the recycling of plastic resources is to formulate a "roadmap for the introduction of bioplastics" and to aim for the maximum introduction of biomass plastics (approximately 2 million tons) by 2030.

In terms of reducing plastic emissions, the strategy states that appropriate substitution for renewable resources such as paper, biomass plastic, etc., will be promoted.

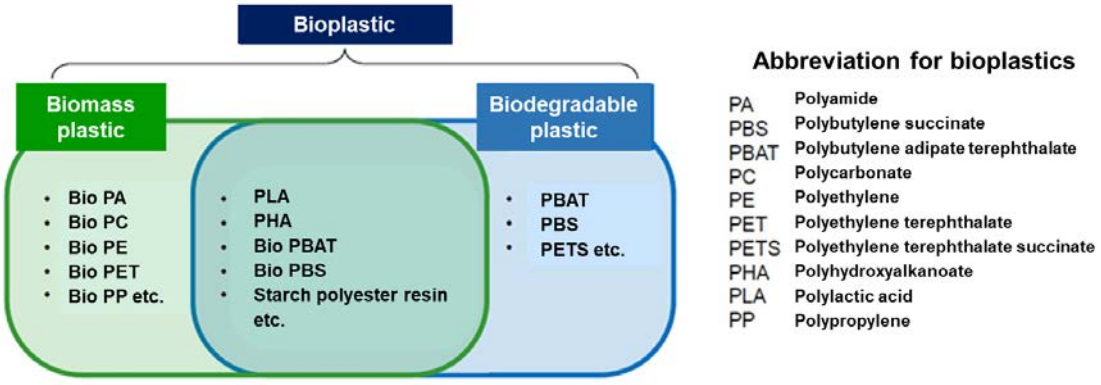
5.2 Types of alternatives to plastics (Definition)

Paper and bioplastics are the two most common alternatives to plastics.

With regard to paper, there has been a movement to replace plastic containers and packaging with paper. Typical examples include straws and candy packaging.

Bioplastics is a generic term for biomass (-derived) plastics and biodegradable plastics. Biomass plastics are plastic materials that use renewable organic resources such as plants as raw materials, and biodegradable plastics are defined as plastics that, in addition to their performance and physical properties, can decompose under certain conditions through the action of microorganisms and other organisms that are abundant in nature and eventually transform into carbon dioxide and water.

According to data from the Ministry of the Environment, the bioplastics currently introduced into the country depend on imports from foreign institutes. The report also states that approximately 70% of biodegradable plastics currently in widespread use are derived from biomass, while the other 30% are manufactured primarily from naphtha derived from fossil resources.



Source: Excerpts from Reference Material (Ministry of the Environment, 2020) of the 3rd Study Group on Roadmap for Introduction of Bioplastics

Figure 6: Definition of bioplastic

5.3 Latest technology trends in alternatives to plastics (biomass plastics, etc.)

This section outlines the technological trends related to alternatives to plastics such as bioplastics.

The main focus will be on the targets of the Ministry of the Environment's technology development support program in this field.

Table 9: Summary of Recent Technology Trends in Plastic Substitution

Project Name	Main Business Entities	Classification	Technology Development Summary/Abstract
(i) Development of biodegradable and biomass-derived new agricultural plastic films and demonstration project for their practical application	Mitsubishi Chemical Corporation	Bioplastic	・ The goal is to promote a new social system that stabilizes and improves agricultural production while reducing energy-derived CO_2 emissions. The project was expected to improve biodegradable and biomass-derived plastics, create methods to control their degradation, and demonstrate their practical application for the expansion of agricultural films that do not require disposal to more crop types and other regions.
(ii) Technological development for bio-oriented food containers and packaging using biomass PE, etc.	NISSIN FOODS HOLDINGS CO., LTD.	Alternative materials to plastics	・ To reduce the use of petroleum-based plastics in food containers and packaging and to reduce CO_2 emissions, a processing technology demonstration is planned to conduct to bioengineer the food container product.
(iii) Substitution of microplastic beads in cellulose particles	Rengo Co., Ltd.	Alternative materials to plastics	・ The goal is to promote cellulose particles that biodegrade in the natural environment (in soil, freshwater and seawater) as an alternative material to microplastic beads, which contribute to global marine pollution. The project is expected to demonstrate the pulp dissolution process and the cellulose particle size reduction process to improve productivity, diversify varieties, and lower costs.

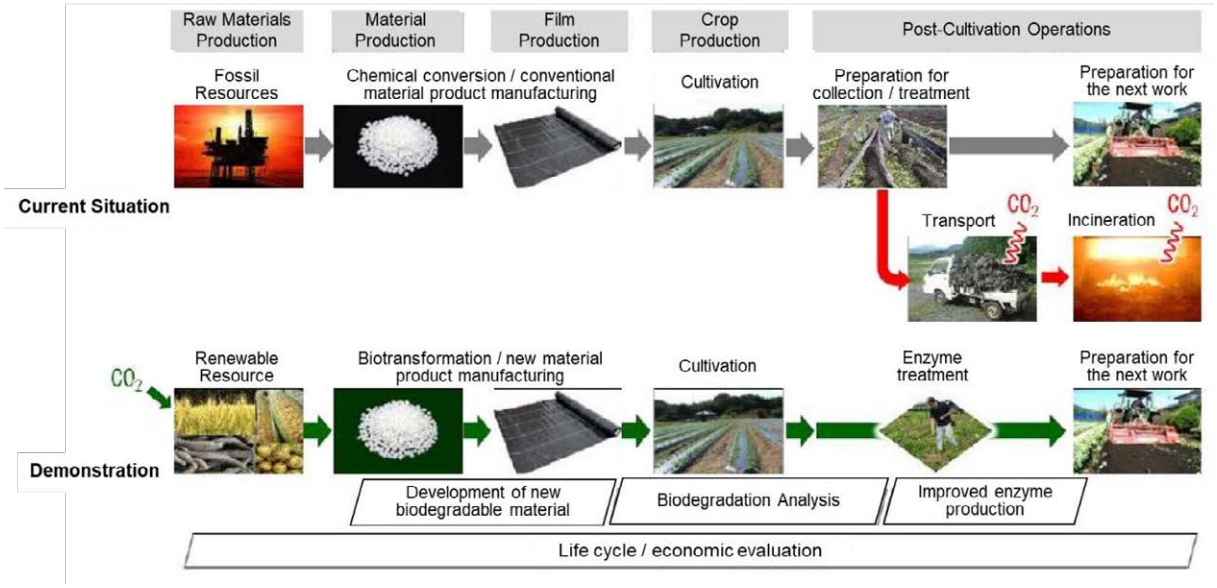
a. Development of new biodegradable and biomass-derived agricultural plastic films and demonstration project for their practical application

Name	Development of new biodegradable and biomass-derived agricultural plastic films and demonstration project for their practical application
Business entities	Mitsubishi Chemical Corporation
Classification	Utilization of bioplastics (biomass / biodegradable plastics)
Target plastics	Bio PP (development of alternatives)
Summary	Demonstration project for the construction of circulation systems for plastics and other resources to support a decarbonized society in fiscal year 2019

<Outline of efforts, (numerical) targets, results, etc.>

-Development of new biomass-derived agricultural plastic films -

- **<u>Demonstration of practical application of a new agricultural plastic film derived from biomass</u>**
  - The goal is to promote a new social system that stabilizes and improves agricultural production while reducing energy-derived CO_2 emissions. Mitsubishi Chemical Corporation has developed a method to improve and control the degradation of biodegradable and biomass-derived plastics to conduct a lab-scale operation for their practical application with the aim of promoting agricultural films that do not require disposal to more crops and regions.



Conceptual Diagram of the Demonstration Project

- **<u>FY 2019 Outcomes</u>**
  - To produce new materials that will enable the expansion of mulch film applications, the company attempted to identify several new material candidates that outperform existing biodegradable plastics in terms of physical properties required for agricultural films, and as a result, narrowed down the number of new material candidates they considered for development to three. Small quantities of these materials were produced and subjected to material evaluation tests. From the results of this evaluation, one new material

candidate was selected, a formulation suitable for agricultural films was devised, and a prototype film was made with this formulation and subjected to film evaluation testing.

- With the objective of obtaining materials and processing methods that reduce the cost of film production, the company attempted to improve the efficiency of material production by modifying production equipment. By examining in detail the conditions of the material production stage related to pelleting, they devised modifications to the production conditions. The company then tested the production of new materials at a commercial production facility under the new production conditions and confirmed that materials with the prescribed performance could be produced.
- For the purpose of life cycle assessment and economic evaluation of films from manufacturing to final disposal, a study on evaluation methods to be implemented in the future was conducted. The results of various past LCAs were analyzed to determine the evaluation areas and baselines, respectively.

Biodegradable mulch film prototype

Testing biodegradable mulch film in test plots

Source:
https://www.m-chemical.co.jp/news/2019/1207422_7467.html
https://www.env.go.jp/press/107210.html
http://www.env.go.jp/recycle/post_67.html

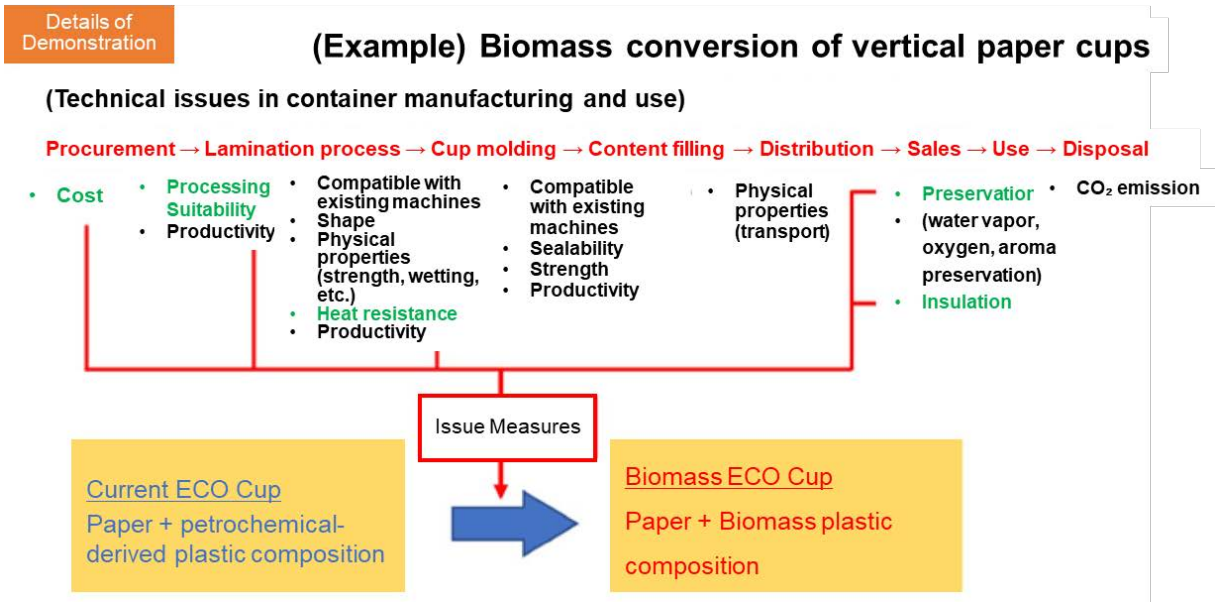
b. Technological development for bio-oriented food containers and packaging using biomass PE, etc.

Name	Technological development for biomass-derived food containers and packaging using biomass PE, etc.
Business entities	NISSIN FOODS HOLDINGS CO., LTD.
Classification	Other utilization (paper products as plastic substitutes, etc.)
Target plastics	Bioplastics (utilization of alternatives)
Summary	(Ministry of the Environment) Technology demonstration project for the transition from petroleum-derived plastics to alternative materials made from renewable resources and social implementation

<Outline of efforts, (numerical) targets, results, etc.>

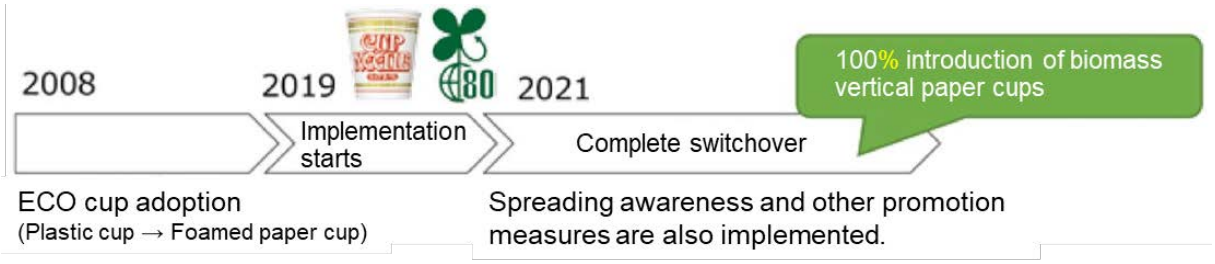
-Technological development for biomass-derived food containers and packaging using biomass PE-

- **Aims of the Demonstration**
  - Biomass materials and petrochemical-derived plastics are used as materials for food containers and packaging, but petrochemical-derived plastics are planned to be replaced by plastics made from biomass materials.
  - The transition to food containers and packaging made from biomass feedstock raises various issues, such as strength, heat resistance, cost, etc. In this demonstration project, the company plans to develop a processing technology for containers and packaging to solve these issues.



- **Subsequent Developments**
  - In order to strengthen its efforts to address the CO_2 problem, the company switched to an eco-friendly container, the "Biomass ECO Cup," which is a further evolution of the "ECO Cup." The "Biomass ECO Cup" maintains the heat insulation and aroma retention properties of the conventional "ECO Cup," but by partially replacing the petrochemical-derived plastic used for the container with a plant-derived biomass plastic, the biomass content has been increased to 81%. Compared to the conventional "ECO CUP," the amount of petrochemical-derived plastic used per cup is almost halved, and the amount of CO_2 emitted during incineration is reduced by approximately 16%.

- The transition to the “Biomass ECO Cup” began at the end of 2019, and all “Cup Noodle” containers switched to the “Biomass ECO Cup” by the end of FY2021, when “Cup Noodle” celebrated its 50th anniversary.



Source:
https://www.env.go.jp/press/107210-print.html
https://www.jora.jp/19datsutanso/pdf/200302pamphlet_all.pdf
https://www.nissin.com/jp/news/7874

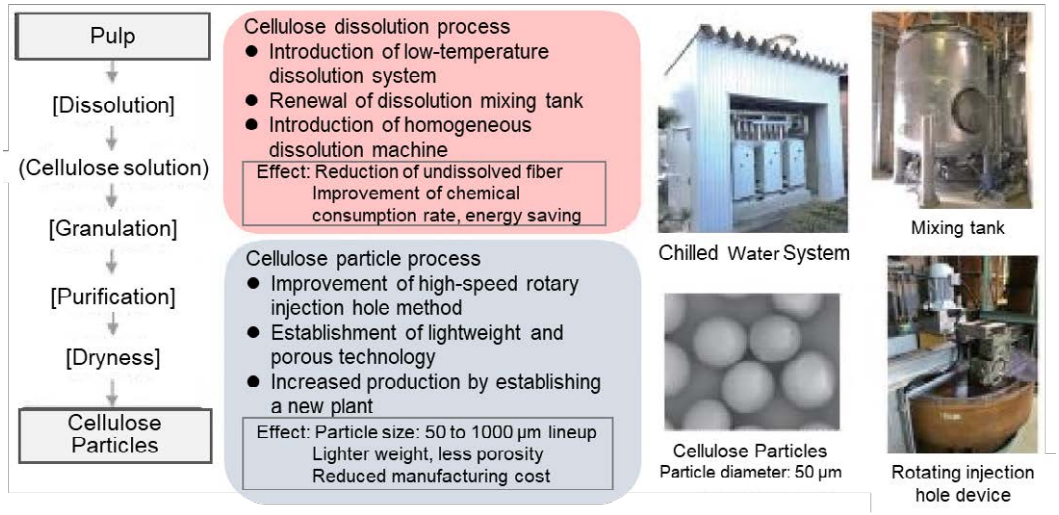
c. Substitution of microplastic beads in cellulose particles

Name	Substitution of microplastic beads in cellulose particles
Business entities	Rengo Co., Ltd.
Classification	Other utilization (paper products as plastic substitutes, etc.)
Target plastics	Development of alternatives to microplastic beads (acrylic, polystyrene, polyethylene, polyamide, silicone, polyurethane)
Summary	Technology demonstration project for the transition from petroleum-derived plastics to alternative materials made from renewable resources and social implementation.

<Outline of efforts, (numerical) targets, results, etc.>

- Alternative materials for microplastic beads that contribute to global marine pollution -

- **Development Demonstration of Alternative Materials**
  - The goal is to promote cellulose particles that biodegrade in the natural environment (in soil, freshwater and seawater) as an alternative material to microplastic beads, which contribute to global marine pollution. The project aims to demonstrate the pulp dissolution process and the cellulose particle size reduction process to improve productivity, diversify varieties, and lower costs.

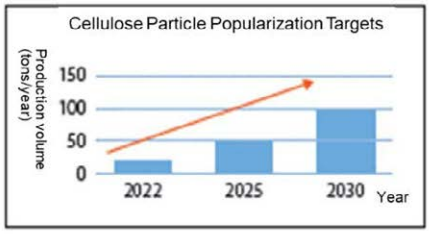


- **Improvement of the cellulose dissolution process**
  - Since the properties of cellulose solution fluctuate over time, a major manufacturing challenge is to control this fluctuation and stabilize quality. One of the major causes of property fluctuations is undissolved pulp remaining in the cellulose solution, and one method to reduce this undissolved pulp is to lower the temperature of the pulp dissolution process. The conventional melting temperature of 20°C is reduced to 15°C, which improves pulp solubility and reduces the amount of undissolved pulp.
  - Improved solubility of pulp results in cost reductions by reducing the amount of chemicals added and the energy load of the mixing process.

- **Improvement of the cellulose particle manufacturing process**
  - Cellulose particles are produced by spraying a cellulose solution into a coagulation bath by rotating a cylindrical vessel with tens of thousands of small holes (several hundred μm) at high speed to obtain particles with a narrow particle size distribution. Decreasing the amount of undissolved pulp in the raw material is effective in preventing nozzle blockage. Smaller cellulose particles are adjusted by reducing the diameter of the discharge hole of the cylindrical vessel and by increasing the rotation speed. The key points of cost reduction are the demonstration of mass production technology at the new plant and the reduction of unit volume cost by making the fine particles more porous and lighter.

- **Introduced Products / Usage**
  - Product introduced: Cellulose particles (particle size: 50 μm - 1000 μm).
  - Usage: Cosmetic raw materials, resin additives, paints, filter materials, abrasives, lightening agents, porosity agents, water and oil absorbents, agricultural materials, and fishery materials.

- **Dissemination Target**
  - The company aims to sell 100 tons per year of biodegradable cellulose granules by FY2030.
  - Manufacture and expand sales of 50μm to 1000μm particles and even smaller diameter particles for the demonstration project.



Fiscal year	Assumptions of dissemination
2020	Operation of small grain size reduction equipment at the current plant Product variety setting, market launch, demand cultivation
2021	Started operation of new plant
2025	Annual production of 50 tons for alternative plastic applications
2030	Annual production of 100 tons for alternative plastic applications

Source:
https://www.jora.jp/19datsutanso/pdf/200302pamphlet_all.pdf
https://www.rengo.co.jp/news/2019/19_news_024.html

5.4 Advanced cases of alternative materials to plastics

This section outlines some of the leading examples of alternative materials to plastics.

Table 10: Summary of Advanced Practices on Plastic Substitution

Project Name	Main Business Entities	Classification	Technology Development Summary/Abstract
(i) Efforts by Major Convenience Stores to Promote and Expand Use of Biodegradable Polymer Straws	Seven & i Holdings Co., Ltd. KANEKA CORPORATION	Utilization of biodegradable polymers	・ KANEKA CORPORATION, in collaboration with Seven & i Holdings Co., Ltd., has developed products using the biodegradable polymer PHBH, and planned to begin using straws made of PHBH in Seven Cafe iced coffee and iced cafe lattes from November 5, 2019. The target stores were approximately 10,000 stores in Hokkaido, Hokuriku, Kansai, Chubu, Shikoku, Kyushu, and Okinawa.
(ii) Introduced straws made of plant-derived biodegradable plastic	Keikyu Corporation	Utilization of biodegradable plastics	・ Keikyu Group's restaurants, department stores, stores, hotels, etc. (68 facilities operated by 13 companies) replaced the approximately 160,000 plastic straws used annually with plant-derived straws that are biodegradable and less harmful to the natural environment.
(iii) Recyclable tableware "edish" that can be reborn over and over again	Marubeni Corporation	Tableware derived from biomass resources	・ Food waste materials such as food peels and cores are transformed into tableware using proprietary technology and provided to restaurants. After use, the tableware is collected, crushed, and dried at the plant. The company then processes them into feed, fertilizer, etc., and provides them to livestock producers and fertilizer companies, aiming to realize an upcycling process.

a. Efforts by Major Convenience Stores to Promote and Expand the Use of Biodegradable Polymer Straws

Name	Efforts by Major Convenience Stores to Promote and Expand the Use of Biodegradable Polymer Straws
Business entities	Seven & i Holdings Co., Ltd. KANEKA CORPORATION
Classification	Utilization of bioplastics (biomass / biodegradable plastics)
Target plastics	Utilization of biodegradable polymer product straws (plastic substitute)
Summary	

<Outline of efforts, (numerical) targets, results, etc.>

- Promote and expand the use of biodegradable polymer straws –

- **Promote and expand the use of biodegradable polymer straws**
  - KANEKA CORPORATION, in collaboration with Seven & i Holdings Co., Ltd., has developed products using the biodegradable polymer PHBH® and sequentially began using straws made of PHBH® in Seven Cafe iced coffee and iced cafe lattes from November 5, 2019. The target stores were approximately 10,000 stores in Hokkaido, Hokuriku, Kansai, Chubu, Shikoku, Kyushu, and Okinawa.
  - Straws for Seven Cafe using PHBH® were first introduced in 7-Eleven stores in Kochi Prefecture in August 2019. The area was then expanded to promote greater environmental responsiveness.

- **About PHBH**
  - It is a 100% plant-derived biopolymer with excellent biodegradability in a wide range of environments.
  - It is certified as “OK Biodegradable MARINE*” which is biodegradable in seawater, contributing to the reduction of marine pollution.
  - * OK Biodegradable MARINE: Certification of biodegradability of at least 90% within 6 months in seawater (30°C).

Source:
https://www.7andi.com/company/news/release/201904151500.html
https://www.kaneka.co.jp/topics/information/in20191031/

b. Introduction of straws made from plant-derived biodegradable plastic

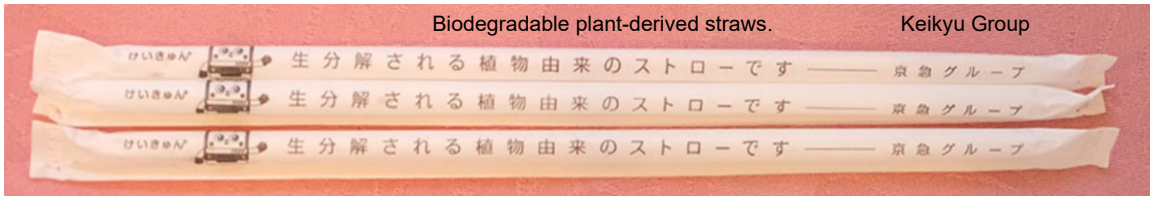
Name	Introduction of straws made from plant-derived biodegradable plastic
Business entities	Keikyu Corporation Mitsubishi Chemical Corporation
Classification	Utilization of bioplastics (biomass / biodegradable plastics)
Target plastics	Straws made of biodegradable plastic (plastic substitute)
Summary	

<Outline of efforts, (numerical) targets, results, etc.>

- Introduced straws made from plant-derived biodegradable plastic -

- **Introduction of straws made from biodegradable plastic**
  - Keikyu Group's restaurants, department stores, stores, hotels, etc. (68 facilities operated by 13 companies) replaced the approximately 160,000 plastic straws used annually with plant-derived straws that are biodegradable and less harmful to the natural environment.
  - The company aimed to reduce fossil resource consumption and plastic waste by introducing these products for internal use as well.

- **Biodegradable plastic "BioPBS™"**
  - A plant-derived biodegradable plastic developed and patented by Mitsubishi Chemical and manufactured by PTT MCC Biochem Company Limited (Head office: Bangkok, Thailand), a 50-50 joint venture between Mitsubishi Chemical and PTT Global Chemical of Thailand.
  - In addition to being decomposed into water and carbon dioxide by microorganisms present in nature after use, the product reduces the consumption of petroleum-derived resources and thus has a low impact on the natural environment. Mitsubishi Chemical worked with customers to develop applications and expand into a variety of fields, including food packaging and cutlery (disposable tableware), in addition to straws.



"Biodegradable straws" made with Mitsubishi Chemical's BioPBS™

Source:
https://www.keikyu.co.jp/company/news/2018/20190325HP_18257KK.html

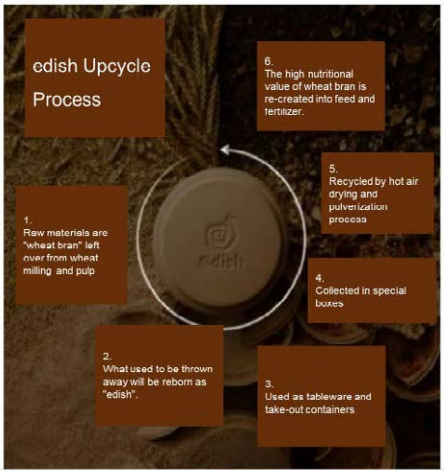
c. Recyclable tableware “edish” that can be reborn over and over again

Name	Recyclable tableware “edish” that can be reborn over and over again
Business entities	Marubeni Corporation
Classification	Utilization of bioplastics (biomass / biodegradable plastics)
Target plastics	Manufacture and sale of tableware derived from biomass resources (plastic substitute)
Summary	

<Outline of efforts, (numerical) targets, results, etc.>

- Recyclable tableware “edish” that can be reborn over and over again-

- **Features of edish**
  - Food waste materials such as food peels and cores, which until now have had few uses, are transformed into tableware using proprietary technology and provided to restaurants. After use, the tableware is collected, crushed, and dried at the plant. The company then processes them into feed, fertilizer, etc., and provides them to livestock producers and fertilizer companies, aiming to realize an upcycling process.
  - The initiative enables re-circulation of biomass resources by using surplus wheat bran, which is distributed as livestock feed, and pulp, which is composed of cellulose, as well as coffee, tea, mandarin oranges, etc. as raw materials.
  - After use, the food is collected directly from the collection box and processed into feed or compost, so there is no need to wash dishes, and even if there are leftovers, the food can be processed directly, leading to a solution to food loss.



The upcycling process that edish aims for

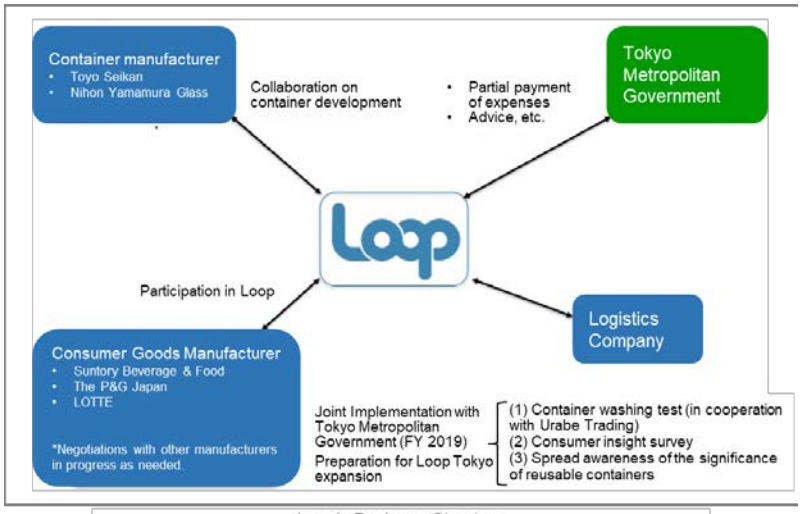
  - Regarding the manufacture of tableware, the shape is highly flexible and can be easily adapted to various needs. In addition, sauces and dressings do not soak into the tableware, and there is no worry about leakage, so the tableware can be used with peace of mind.

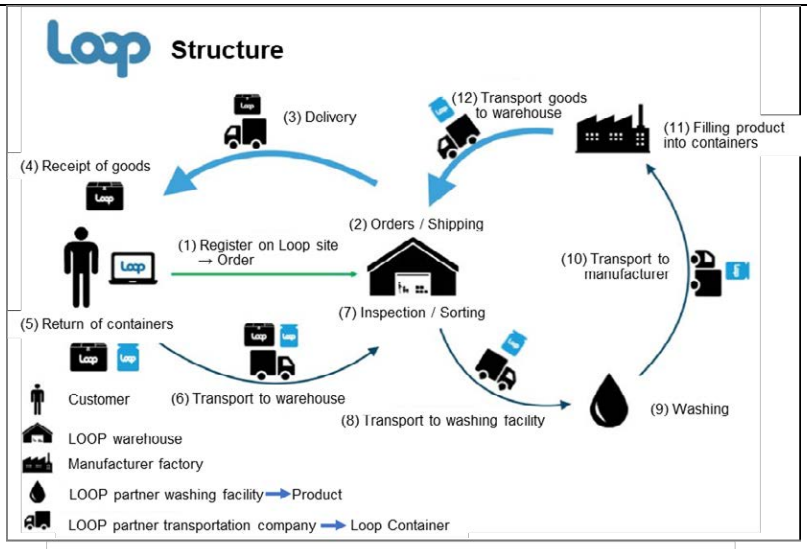
- **Further Development**
  - Currently selling flatware, bowl containers, etc., and improving products and services while obtaining feedback from purchasers.
  - The company plans to process the material into tableware such as tumblers, forks, and spoons, and is currently conducting experiments.

Source:
https://edish-jp.com/

6 Others

Tokyo Metropolitan Government's "Zero Emission Tokyo Strategy: Declaration of Action to Confront the Climate Crisis" Initiatives

Name	Zero Emission Tokyo Strategy "Plastic Reduction Program"
Organization	Tokyo Metropolitan Government
Outline of Efforts	**<Product provision platform using reusable containers (Loop)>** On the mail order platform (Loop), all products are offered in reusable and durable containers, eliminating the use of disposable packaging. Loop is responsible for sales delivery of products, collection and cleaning of empty containers, and operation of the overall platform infrastructure. Each product manufacturer is responsible for filling the products and delivering them to Loop. Consumers are able to purchase products through Loop's website or the manufacturer's dedicated Loop page, with future plans to work with retailers to sell products. Purchased items are packaged and delivered in special Loop bags (reusable), and used containers are placed in the same bags for collection. Collected containers are sorted by shape and product, sterilized, and cleaned, and sent to the manufacturer for re-filling. In Japan, the company conducted a verification test in the Tokyo metropolitan area with a target date of October 2020.  Loop's Business Structure



Product flow of the Loop system

Container prototypes for food and commodity related products

Negotiations with other manufacturers are in progress, and the number of participating companies is increasing. Specific projects to be implemented include the development of durable containers that can be recycled as reusable containers at Loop, as well as durability and cleaning tests of the containers. In parallel, the company planned to secure distribution channels and create a website. In FY2020, AEON launched an official website and service targeting 5,000 households as a mail-order sales model, and at the same time, AEON Retail Co. started this business with their supermarkets in Tokyo.

Source:
https://www.kankyo.metro.tokyo.lg.jp/policy_others/zeroemission_tokyo/strategy.html