Operation Manual for Small-to-Medium Scale Compost Centres Using the Takakura Composting Method

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Contents

1. Introduction

Organic waste occupies more than 50% of the municipal solid waste in Indonesia and its handling has been a big burden to municipalities who are responsible for management of waste collection, treatment and final disposal. It is wet and heavy and generates bad odour. Once it is dumped into landfill, it emits methane gas (CH_4) which has 25 times the global warming potential of carbon dioxide (CO_2). However, if separated when it is still fresh and treated appropriately, it has a good potential to be transformed into quality compost that can be used for greening of the city and agricultural productions.

This manual was developed based on the needs of on-site operators of small-to-medium scale composting centres (Input of organic waste: < 1 ton/day) in Bandung city in West Java Province to improve their composting method and to provide a hands-on manual for their daily operations. It was therefore designed to be as simple as possible with limited text and many figures and tables. In addition, to make it a practical manual, the contents were based on extensive on-site coaching and feedback during the process of upgrading the composting centre at Babakansari TPS-3R (intermediate waste management facility with a function of 3R) in Bandung city. The upgrading of composting centre was part of the "Waste Management Support Project toward a Sustainable Resource Recycling Society in Bandung, Indonesia", a city-to-city collaboration project between Kawasaki city and Bandung city, funded by Japan International Cooperation Agency (JICA)'s Grassroots Project during 2017-2020. The method applied in this manual is the "Takakura composting method" and the detailed technical guidance was provided by Dr. Koji Takakura, the inventor of the method, through multiple on-site coaching and workshops.

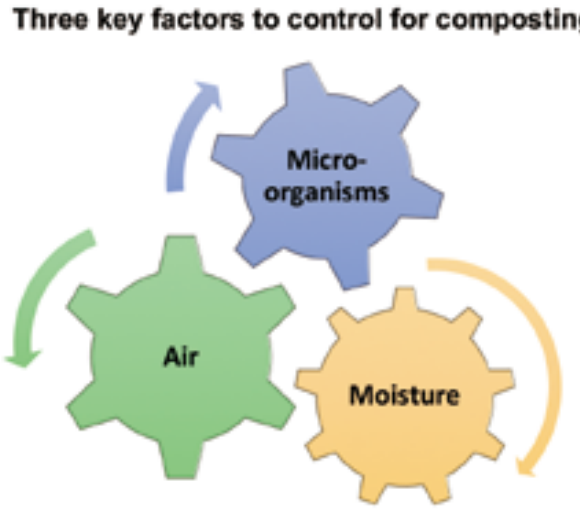
By replicating functional small-to-medium scale composting centres throughout the city, this manual is expected to contribute to the reduction of waste going to the landfill, improve sanitation and the environment, enhance greening of the city, and reduction of spending of waste management costs by the local government. It is also expected that it will contribute to reduction of greenhouse gas (GHG) emissions and hence contribute to the achievement of Indonesia's National Determined Contributions (NDCs) to the Paris Agreement. These local efforts and multiple effects are expected to contribute to the Sustainable Development Goals (SDGs).

Why Small-to-Medium Composting Centres?

In the JICA Grassroots Project 2017-2020 at Bandung city, raising the capacity of communities to separate waste at households was one of the four main components. In the programme, six target communities were selected, and source separation at households and on-site treatment of organic waste by communal composting were facilitated through mutual learnings. There were some good progresses in the source separation, while it was realized that the capacity of on-site treatment was generally limited and its stable operation was not so easy. Bandung city is dense in population, so the available space for on-site treatment in the communities and large land area for centralized processing were also limited. From these situation, developing a small-to-medium composting centres in a decentralised manner was considered to be the most appropriate strategy in treating organic waste in Bandung city.

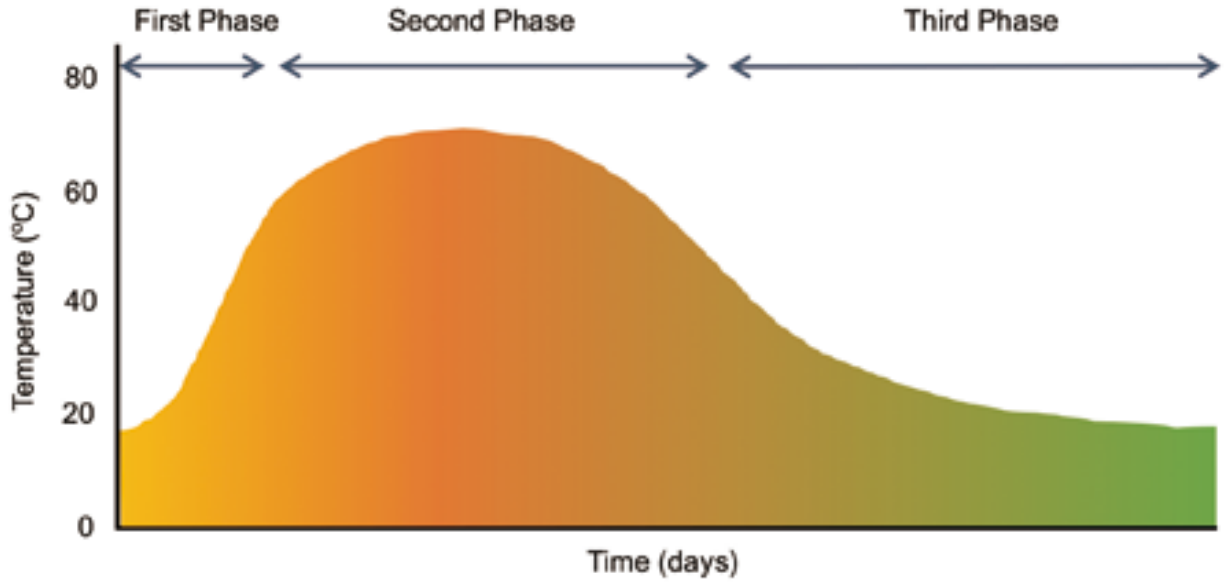
2. Basic Concept of the Takakura Composting Method

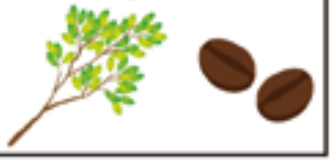
The key features of Takakura composting method is to maximize the natural degradation process of organic waste into fine compost. There are three key factors that you need to bear in mind and control in order to avoid failures in aerobic composting.



2-1. Microorganisms

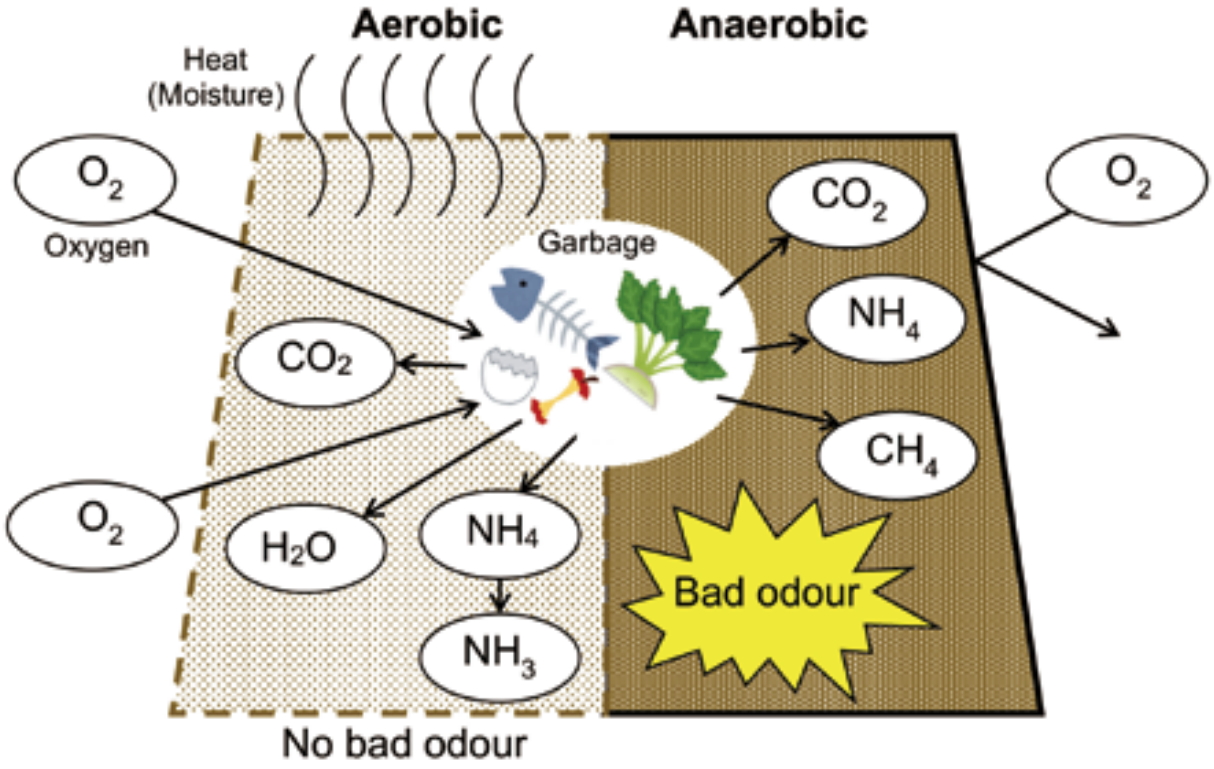
Various kinds of fermentation microorganisms are necessary to complete decomposition processes especially when organic waste consists of different kinds of materials, such as kitchen waste, market waste, garden waste and organic industrial waste. At different stages of decomposition process, different types of microorganisms become active. It is therefore important that the compost bed contains various kinds of microorganisms. You can obtain these microorganisms from locally available fermented foods, humus soil and mushrooms (better with wild mushrooms).



Phase	First Phase (< 40 °C)	Second Phase (40 – 80 °C)	Third Phase (< 40 °C)
Active microorganisms (familiar materials)	 Mesophilic bacteria and fungi Fermented foods (yogurt, tempe, tape, yeast, etc.)	Thermophilic bacteria and actinomycetes  Humus soil	Mesophilic bacteria, fungi, and  basidiomycetes Mushrooms, earthworm, soil microorganisms, and soil animals (insects)
Decomposing materials	Carbohydrate, proteins, and fat 	Hemicellulose and cellulose 	Lignin and other resistant compounds 

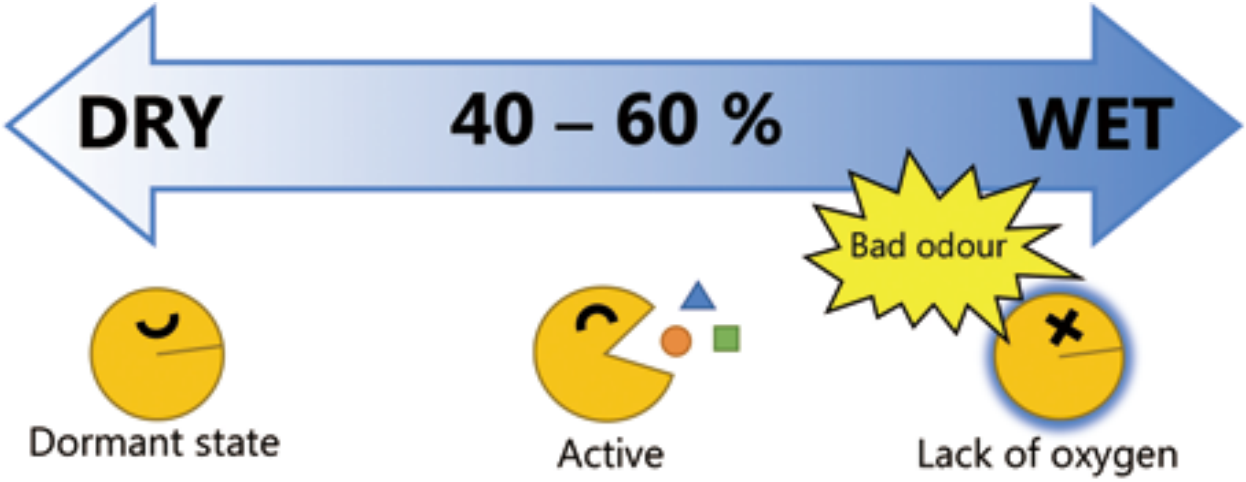
2-2. Air (oxygen)

There are two types of fermentation – **aerobic fermentation** that decompose organics by aerobic bacteria and facultative anaerobic bacteria under the presence of oxygen; and **anaerobic fermentation** by anaerobic bacteria and facultative anaerobic bacteria that decompose organics without oxygen. Under the presence of oxygen, aerobic fermentation becomes active and decompose organic waste quickly; this is often accompanied by the generation of heat that further accelerates decomposition. On the other hand, in the absence of oxygen, the activity of bacteria is slow and produces various substances through anaerobic fermentation. In other words, anaerobic fermentation is slow in decomposition of organic waste and produces bad odour. Thus, daily stirring to provide enough oxygen inside compost bed is important for enhancing decomposition of waste as well as avoiding bad odour.



2-3. Moisture

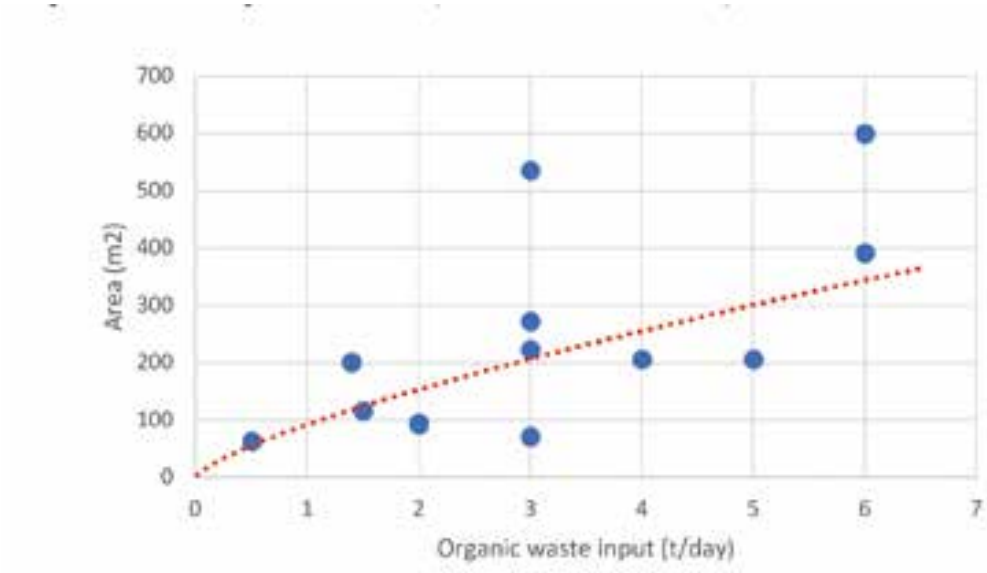
Maintaining the right moisture level will also enhance decomposition and avoid bad odour. Aerobic bacteria needs moisture to actively decompose organics and the appropriate moisture content is **40 – 60%**. Limited moisture (too dry) will slow down decomposition while too much moisture (too wet) will change the environment inside the compost to an anaerobic condition and thereby causes a shift to anaerobic fermentation which generates bad odour. The moisture content of fresh organic waste is about 80% which is too wet, so mixing with drier compost bed will bring about a shift so that there is a balance in the moisture content.



3. Facility and equipment

3-1. Space requirement

The space requirement for small-to-medium size compost centre using Takakura composting varies depending on the amount of daily input of organic waste and types of piling method applied. From the experiences in Surabaya city, space for composting centres were about **100 m² per 1 ton/day** of organic waste input. A larger space can accommodate more organic waste input; for example, 200 m² of space would be appropriate for 3 ton/day of organic waste, and 300 m² of space would be acceptable for 5 ton/day of organic waste. In general, more space will allow easier operation.

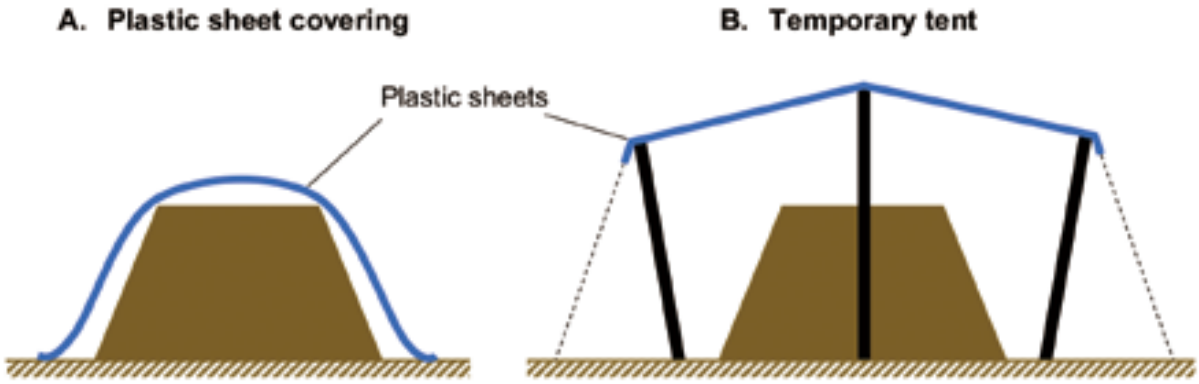


Source: Cleansing and Landscaping Department, Surabaya city

3-2. Facility construction

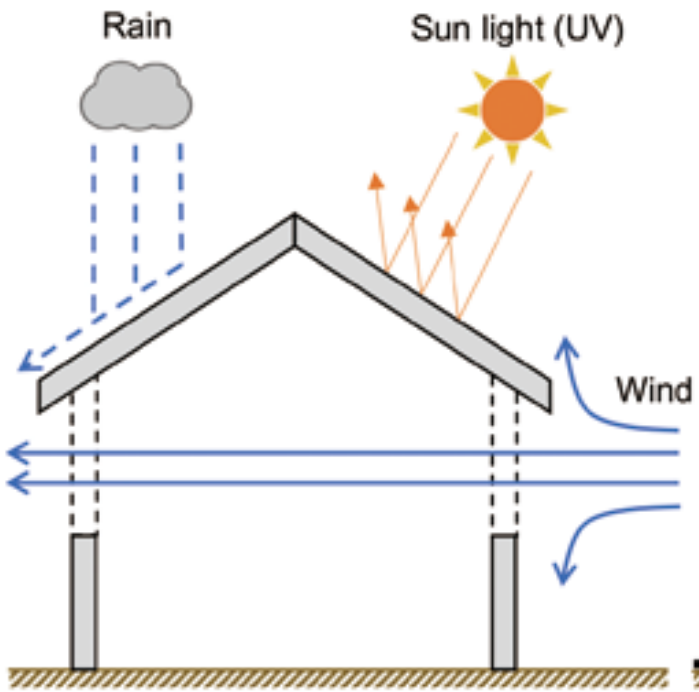
The facilities for composting shall be designed not only based on the amount of daily organic waste input but also from an operational perspective, especially in consideration of how to control the moisture and aeration of the compost beds.

In case there are no existing facilities with a roof that you can use for composting in the community, simply covering the compost bed with a plastic sheet (A) would be acceptable if the amount of daily input of organic waste is not large (eg., less than 100 kg/day). If a temporary tent (B) can be built, it will ease the operation and enhances ventilation of compost beds, and thus can accommodate larger amounts of waste (eg., about 500 kg/day).

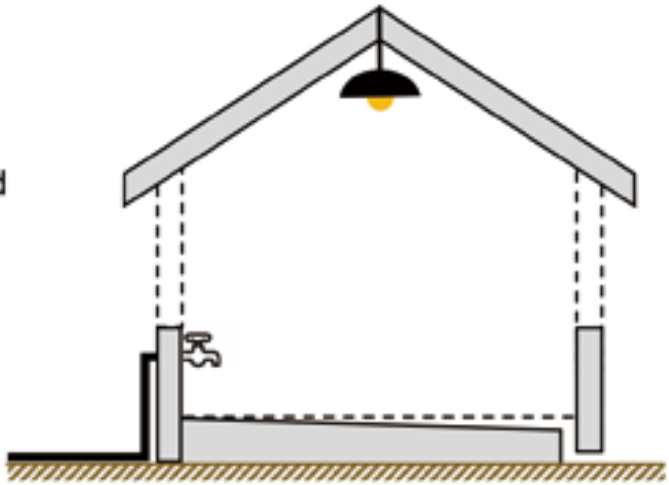


For larger amounts of organic waste processing, it would be more appropriate to have a facility with a roof where rain, strong sun, and winds can be avoided. The basement does not necessarily have to be a concrete floor – a floor made of dirt would be fine (See Figure C). In the case of concrete floor construction, it would be advantageous to have a simple flat space as much as possible to maximize the production efficiency. The building of any compartments or other construction spaces will reduce efficient stirring of compost beds and the flexibility of operation. A concrete floor can be fully flat or have a slight tilt to enable efficient drainage of excess water from the compost as well as when cleaning the floor for improved sanitation [NOTE: If the compost is in good condition, leachate is not expected to occur. The existence of leachate indicates that there is too much water]. It would also be effective if the facility is equipped with a tap of water and light (See Figure D).

C. Facility with roof with earth floor



D. Facility with roof with concrete floor, tapping water, drainage, and light



3-3. Equipment

For a small scale composting, all the process could be done manually. Equipment that would be useful for handling and managing small scale compost centres are as follows:

■ Cutting and shredding of branches and waste

Chopper

■ Mixing and shovelling of compost piles

Shovel

Hoe

■ Handling of waste and compost

Rubber gloves and

Mask

■ Measuring of volume, weight and temperature

Scale

Compost thermometer

■ Adjusting moist contents

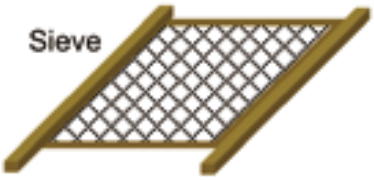
Hose

Bucket

Pail

■ Sieving compost

Sieve



■ Storage of compost

Sack

■ Covering of compost

Plastic sheet

If the amount of waste input gets larger, it would be useful to have a crusher for making the organic materials smaller to accelerate its decomposition. A trommel for sieving compost to get rid of plastics and other contaminants is also a useful tool.

Crusher

Trommel

4. Seed Compost

A seed compost is a specifically blended materials that nurtures various kinds of fermentation microorganisms that accelerates the decomposition of organic waste as a starter of compost making. In theory, once you make seed compost, you can use it repeatedly as a starter and you do not need to do it again.

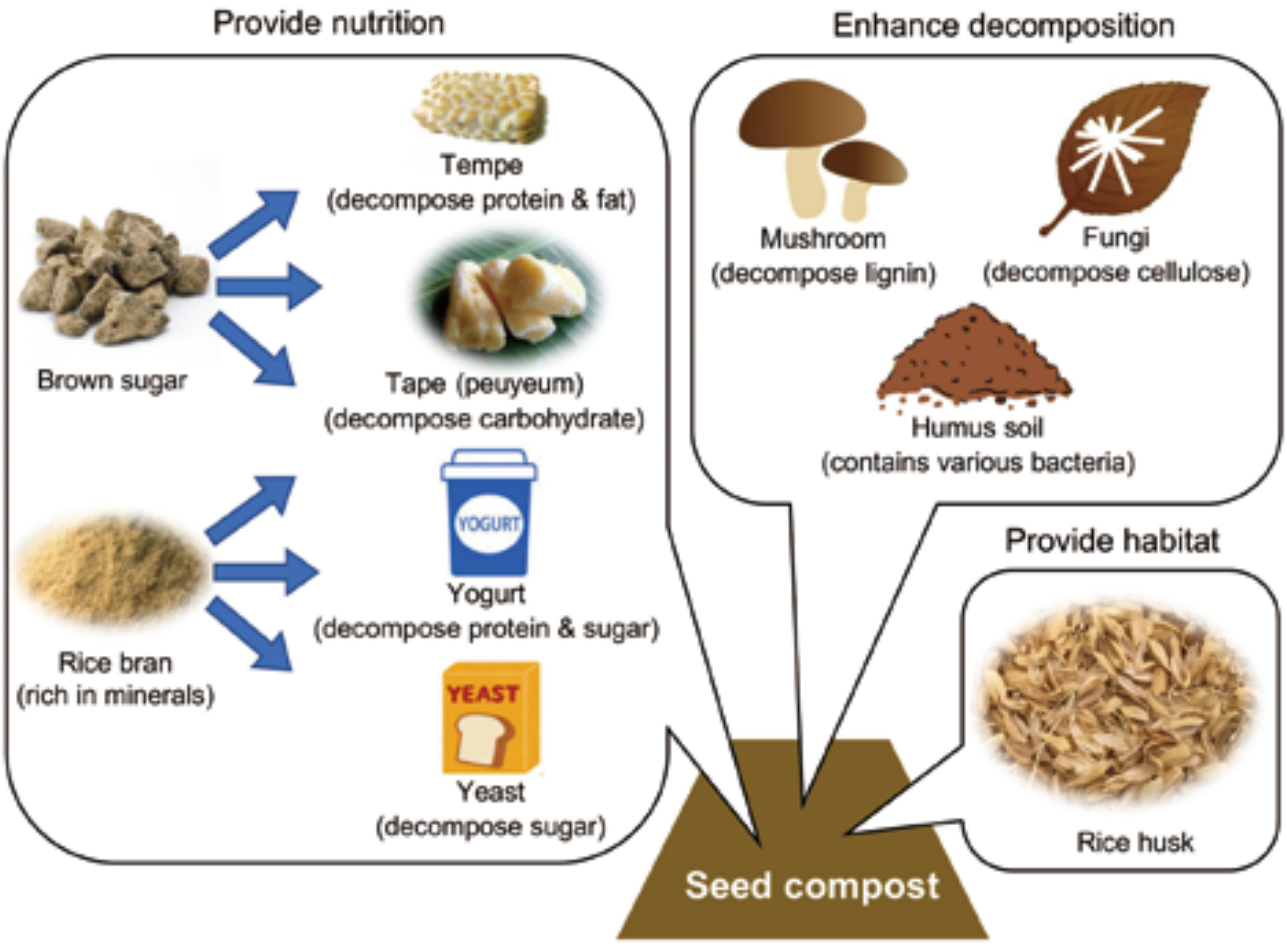
4-1. Materials for seed compost

In the Takakura composting method, a seed compost is made from locally available fermentation food and other materials that are inexpensive and/or easy to obtain. The materials for seed compost are selected considering its three major functions:

・**Provide nutrition** for proliferation of fermentation microorganisms (eg, rice bran, wheat flour, corn flour, feed for birds, etc.)

・**Provide habitat** for fermentation microorganisms and make space to enhance ventilation (eg, rice husk, wood chips, fallen leaves, corn core, rice/wheat straws, etc.)

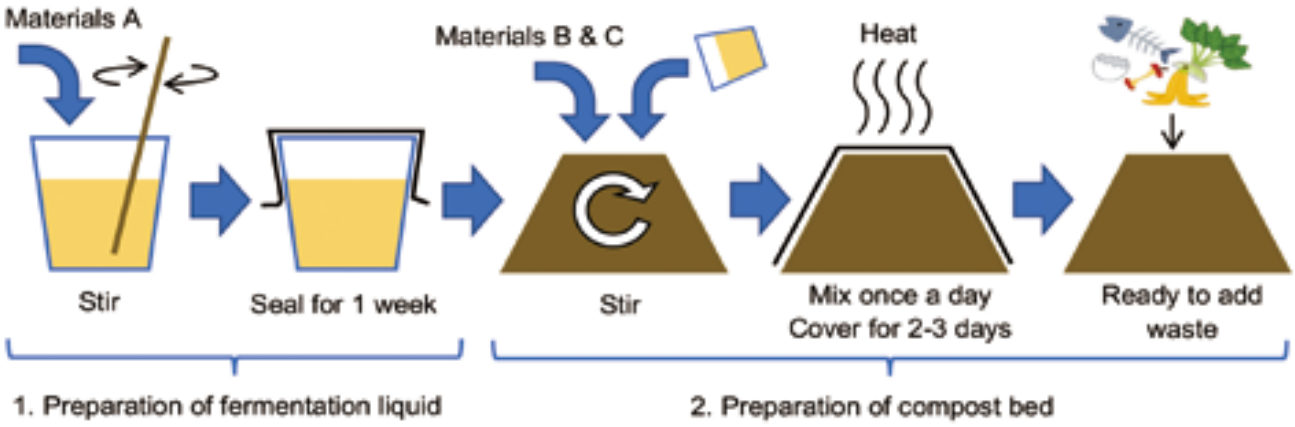
・**Enhance decomposition** especially non-perishable and resistant materials such as garden waste (eg, mushroom, fallen leaves with white fungi, humus soil, etc.)



Example of materials for making a seed compost at different size

Materials		Size of seed compost	
		1 m^3 (30 household)	5 m^3 (150 household)
A. Fermentation liquid	Drinking water (or a clean tap water)	8-10 L (2 gallons)	40-50 L
	Brown sugar	200-300 g (1 package)	1.0-1.5 kg (5 packages)
	Yogurt	300-400 ml (1 bottle)	1.5-2.0 L (5 bottles)
	Ragi tape	5 table spoons	100 g (1 package)
	Ragi tempe	5 table spoons (or 1-2 pieces)	100 g (1 package)
B. Basic materials	Rice husk	800 L (20 bags)	4,000 L (100 bags)
	Rice bran	80 (2 bags)	400 L (10 bags)
C. Other materials (if available)	Mushrooms	some	
	Leaves with white fungi	some	
	Mature compost or native soil	500 g -	

4-2. Procedure of making seed compost



A)Preparation of fermentation liquid

a. Clean buckets, pails and hands (contamination of bad bacteria into fermentation liquid may lead to failure)

b. Crush brown sugar

c. Open drinking water into bucket and mix brown sugar until it is sweet enough

d. Add Ragi tape, Ragi tempe, yogurt

e. Stir well

f. Seal the bucket with a plastic sheet (make sure there are some open space in between the plastic sheet and fermentation liquid)

g. Open after one week. If it smells good (like tape or tempe), it means it is in good condition. If it smells bad (rotten), it means it is contaminated and you need to try again.

B)Preparation of compost bed

a. Stir rice husk and rice bran (Materials B)

b. Stir fermentation liquid (Materials A) and other materials (Materials C)

c. Check moist content by hand. If it is too dry, add tapping water and adjust the moist content

d. Cover the compost bed with mesh sheets

e. Check temperature and stir compost once a day

f. When the temperature rises to about 60 degrees and the smell is good (like tape or tempe) after 2-3 days, it is a sign that fermentation bacteria have proliferated and are very active. It is also a good sign to see white fungi covering the surface of the compost bed

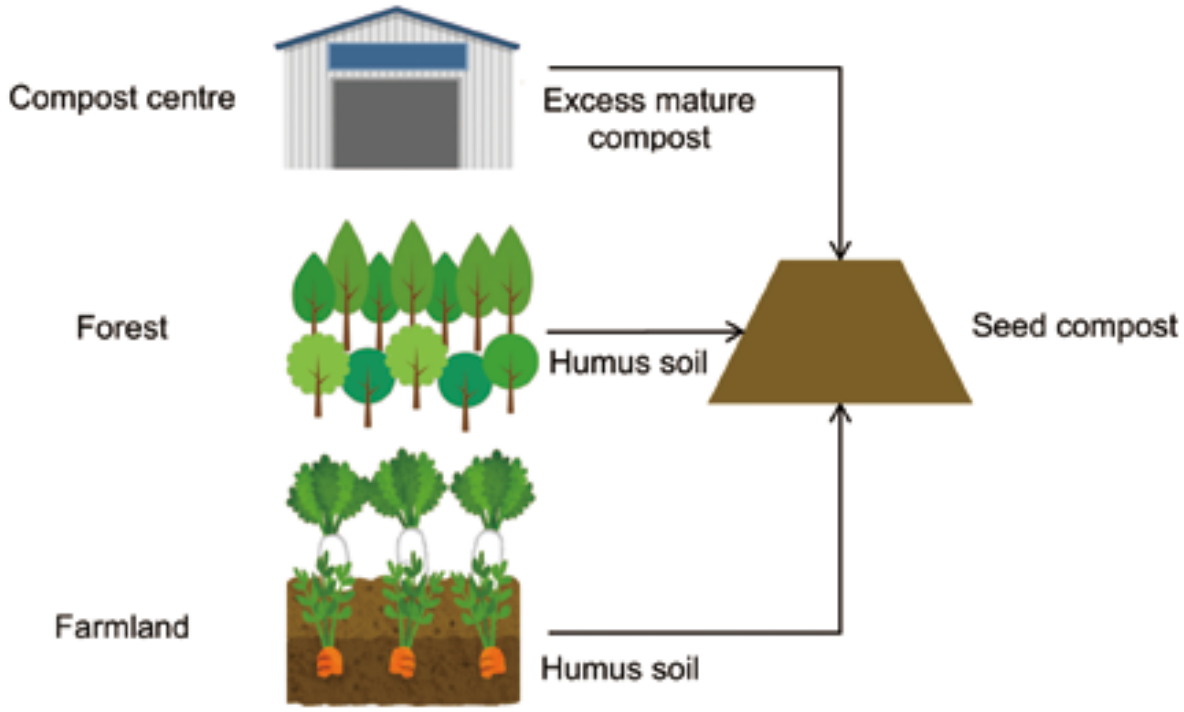
g. You can start adding organic waste.

h. If the temperature does not rise and/or the smell is bad (rotten smell), it is a sign that you have failed the preparation. Review the procedure and try again.

[NOTE: Period will be shorter when the temperature is higher and longer when temperature is lower]

4-3. Alternative seed compost

If there are enough mature compost that already contains lots of fermentation microorganisms, it can readily be used as a seed compost and it is not necessary to make new seed compost. Alternatively, humus soil from forest or farmland that contains lots of fermentation microorganisms can also be used as seed compost. Humus soil is generally dark brown and soft.

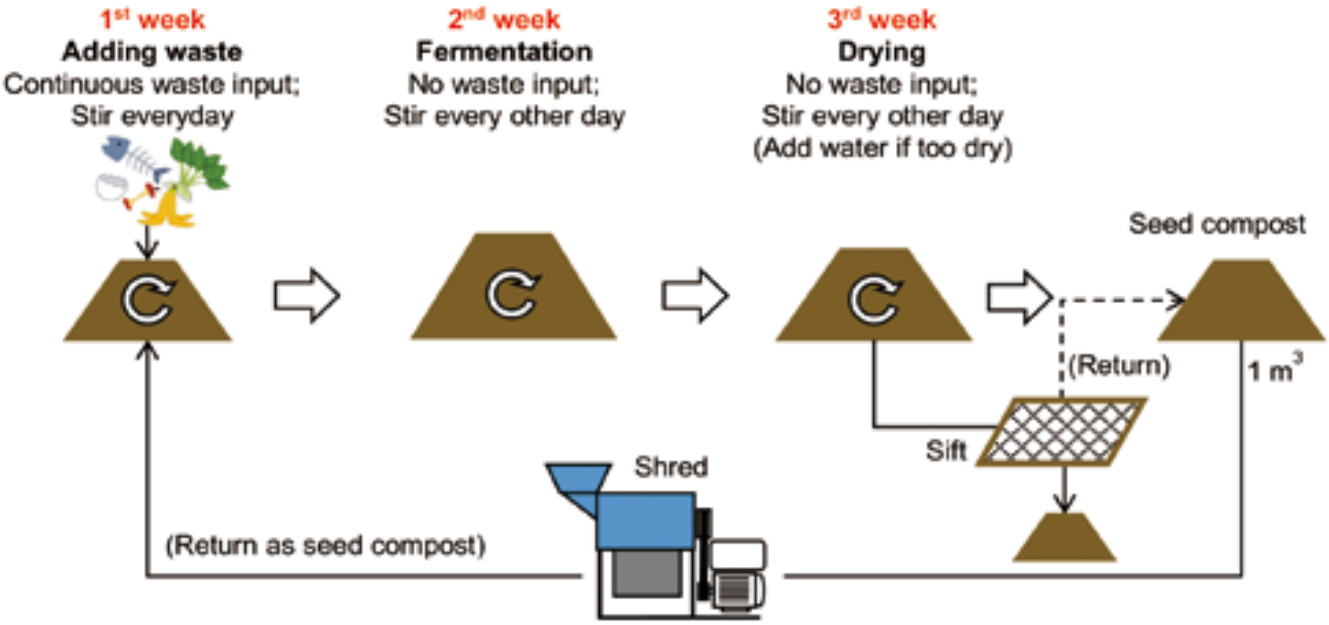


5. Type and Scale

There are various type of methods for small-to-medium size compost centre using Takakura composting method depending on the needs and circumstances of each site. In this manual, an applied version of "rotation input" type which can be applied to wide range of waste input and space availabilities will be explained. Other types are described in the **ANNEX** for reference for wider application.

5-1. Basic type

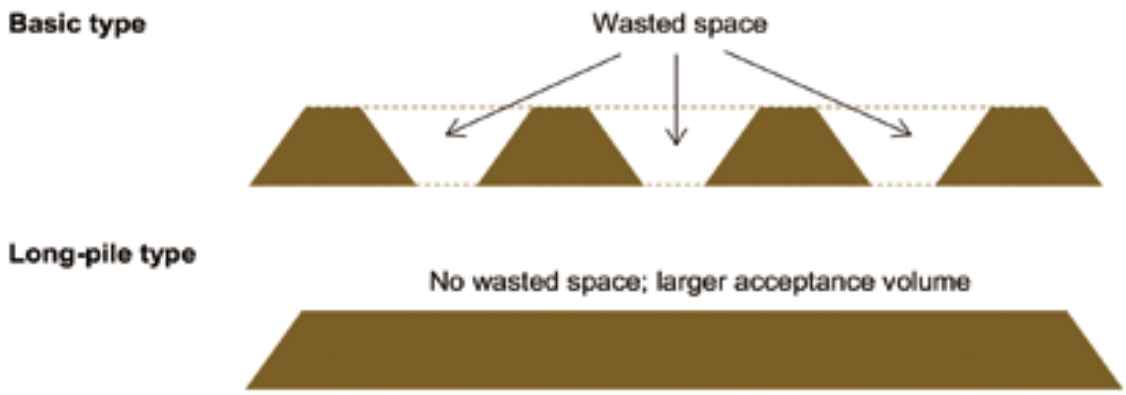
Each unit of seed compost piles will receive different treatments over a week cycle, covering a three weeks to complete the composting process. After the 3rd week, compost should be extracted and sifted for use, while the remaining compost (1 m^3) shall be shredded by a crusher and used as seed compost.

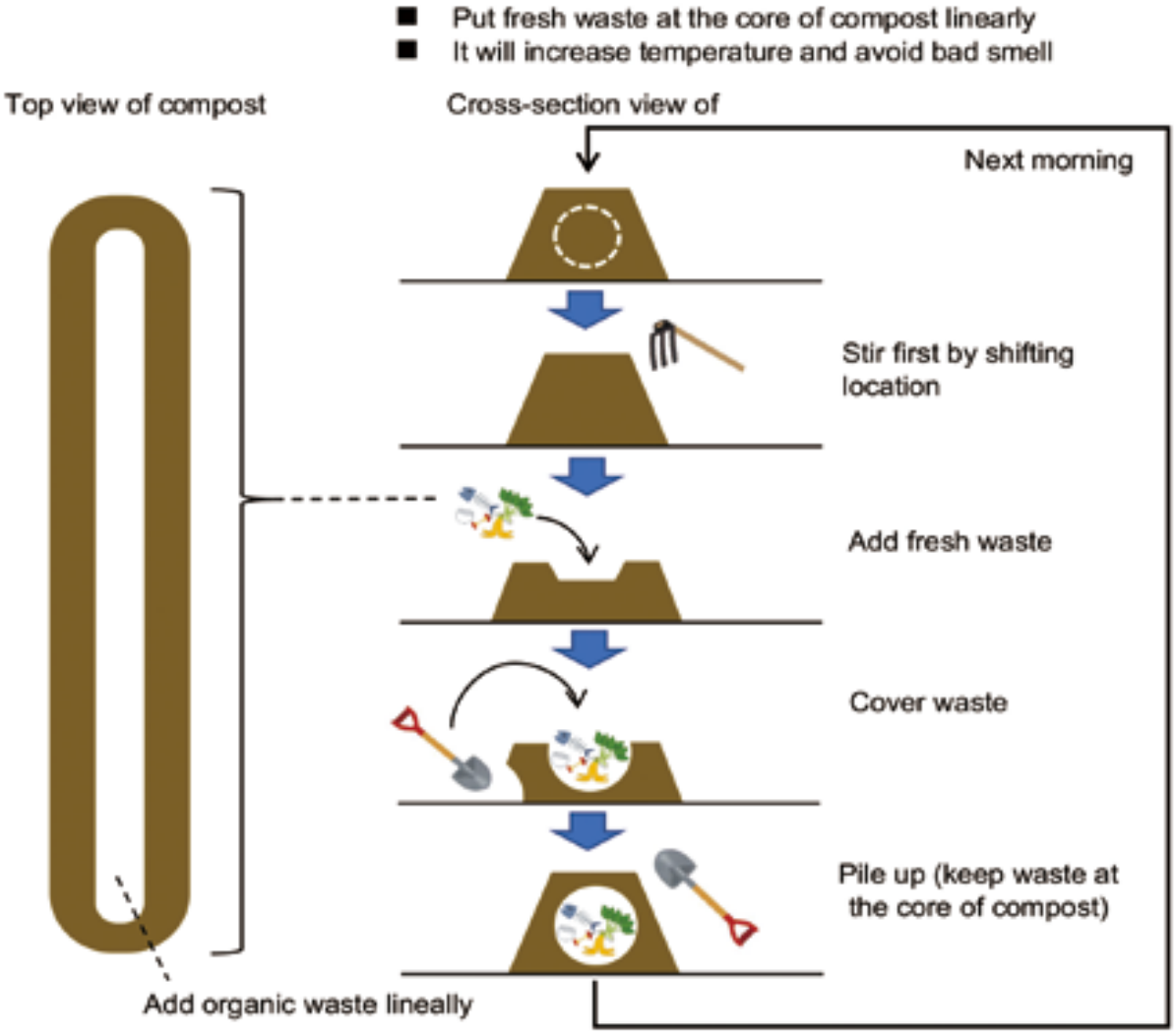


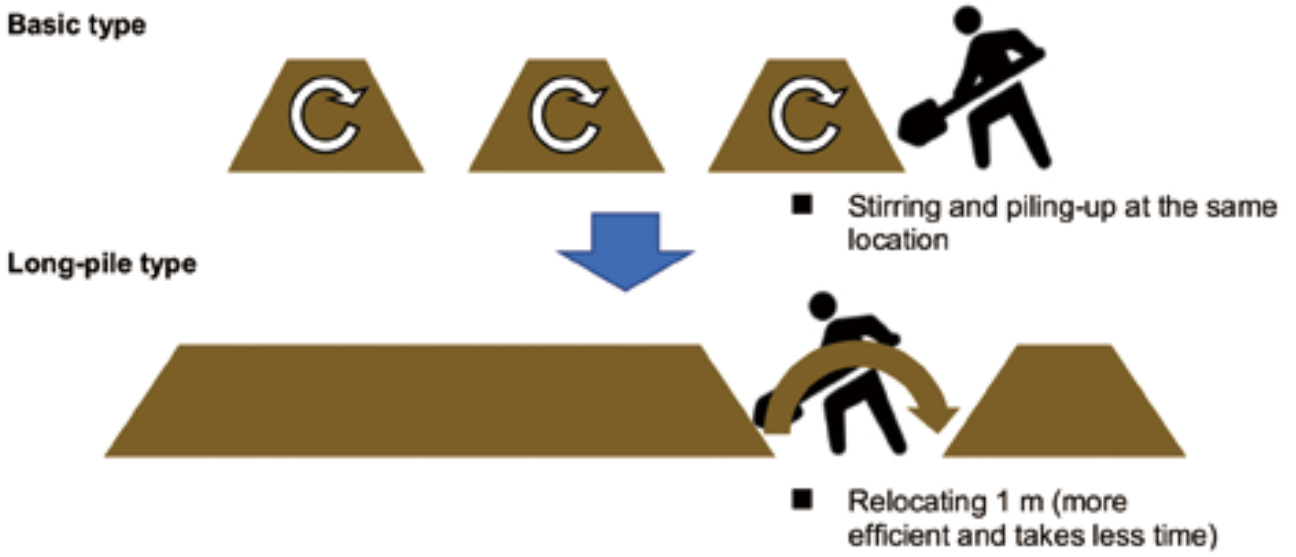
Three compost piles are considered as one unit. When there is a space for 4 units (3 x 4 = 12 piles), the rotation will look as follows:

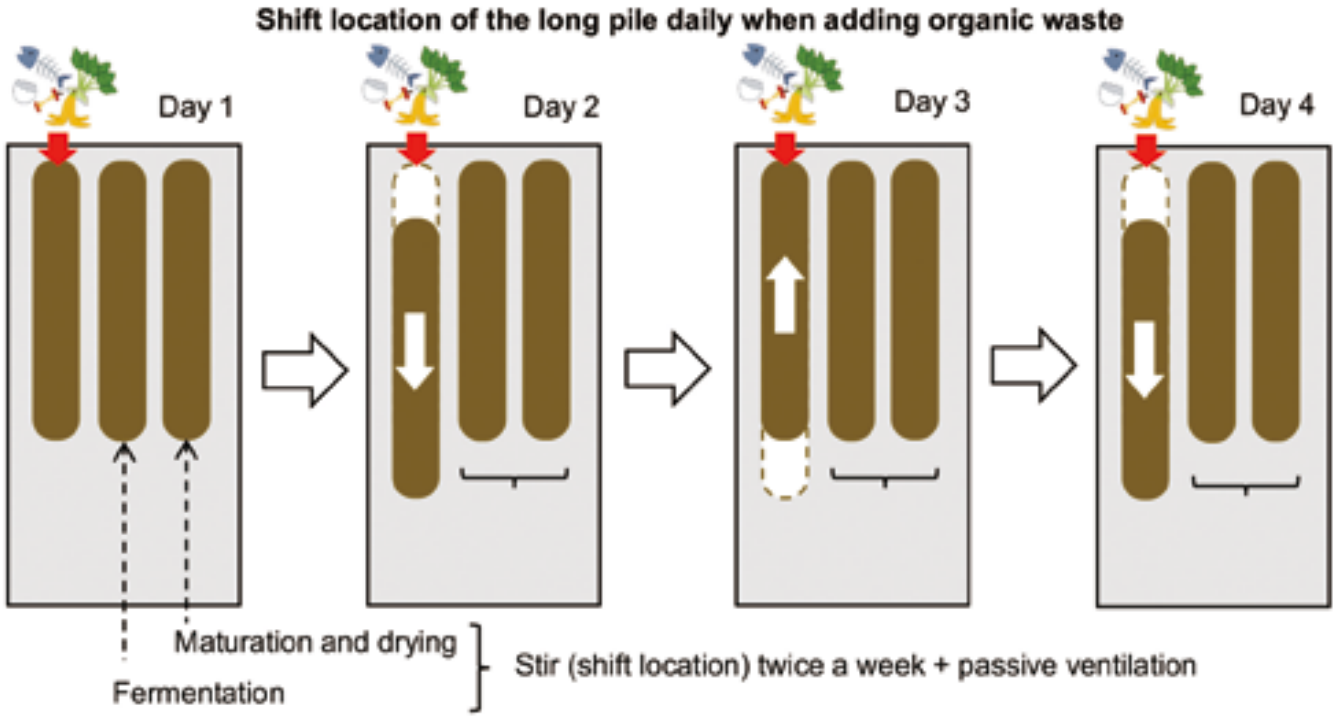
5-1. Long-pile type

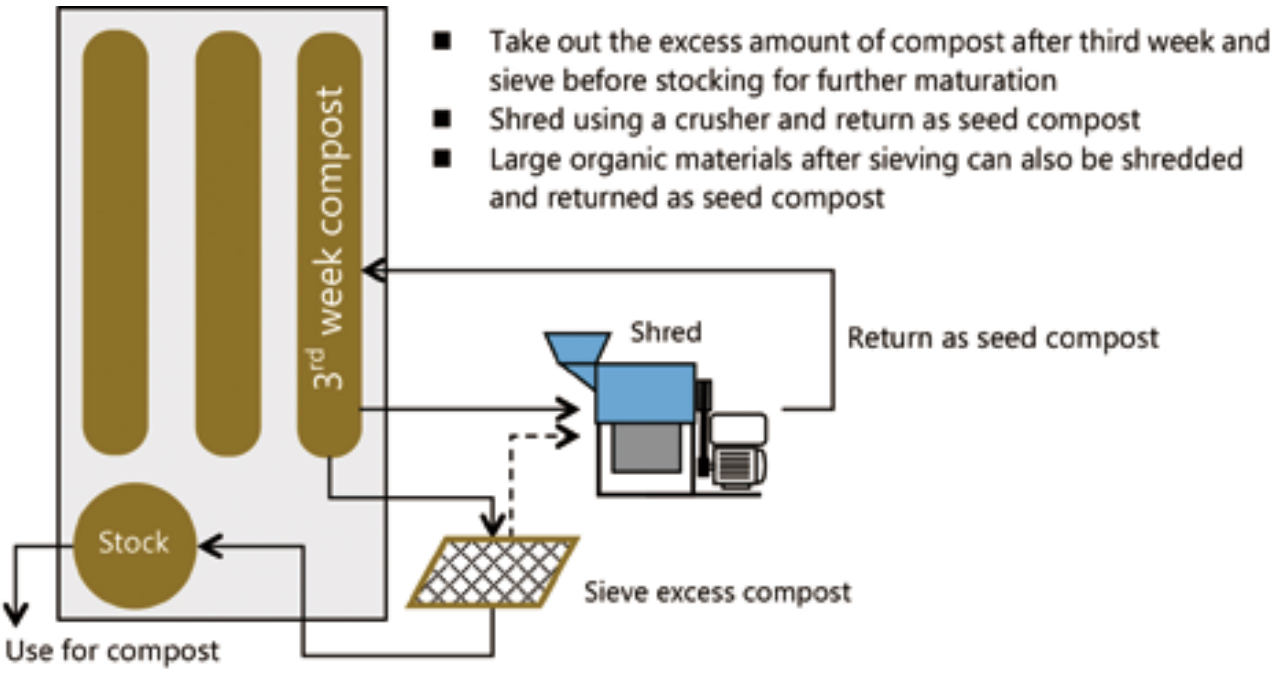
The long-pile type of composting is an applied version of the basic type that combines the piles into a long pile to increase the volume of compost and the capacity within limited space and human resources. This type of composting also goes through the same 3 weeks cycle rotation procedure as the basic type.






Basic type
Stirring and piling-up at the same location
Long-pile type
Relocating 1 m (more efficient and takes less time)


Shift location of the long pile daily when adding organic waste
Day 1
Day 2
Day 3
Day 4
Maturation and drying
Fermentation
Stir (shift location) twice a week + passive ventilation



5-3. Amount of daily waste input

The appropriate amount of daily organic waste input can be estimated from the expected moisture content of the compost. More organic waste can be added when the initial volume of seed compost is larger, while the workload for stirring will become heavier and occupy more space. It is recommended to start from smaller volume of seed compost (eg, 1.0 m^3) with less organic waste input amount (moisture content: 55%) and gradually increase the seed compost (eg, 1.5 m^3) and/or daily input amount (moisture content: 60%) if necessary. Controlling the moisture content of the compost below 60% should be a priority.

Appropriate amount of daily organic waste input (kg/day)

Expected moist content (%)	Volume of seed compost (m^3)				
	1.0 (Unit pile)	1.5 (Unit pile)	30 (10 x 3)	60 (20 x 3)	
55	30[1]	50	300 (10 x 30)	600 (20 x 30)	Safe amount (start from this amount)
60	60[2]	90	600 (10 x 60)	1200 (20 x 60)	Amount for regular operation

CHECK!

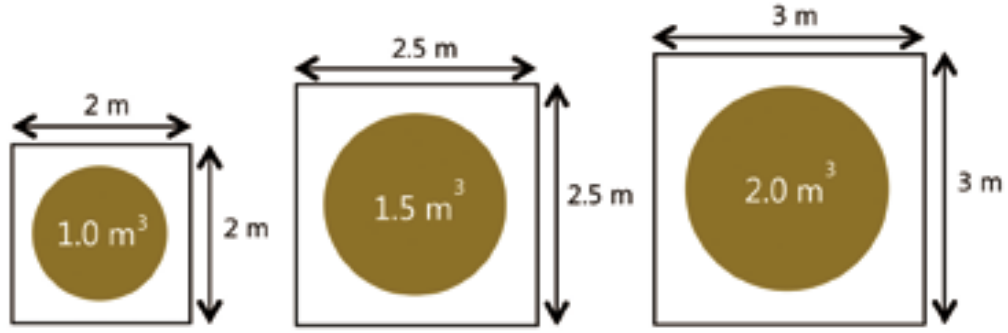
The above estimation is calculated based on the assumption that the moisture content of the seed is 40% (dry) and organic waste is 80% (wet). If the seed compost is wet, the amount of organic waste input should be reduced. If the organic waste is dry (eg, with garden waste), more organic waste can be added. Similarly, waste input should be reduced during the rainy season.

[1] Moisture content when adding 30 kg/day of waste to 1 m^3 compost bed for 1 week: (400 x 0.4 + 30 x 7 x 0.8)/(400 + 30 x 7) x 100 = 53.8

[2] Moisture content when adding 60 kg/day of waste to 1 m^3 compost bed for 1 week: (400 x 0.4 + 60 x 7 x 0.8)/(400 + 60 x 7) x 100 = 60.5

5-4. Required space

The required space for composting depends on the basic size of seed compost and number of units (one unit = three compost piles). An extra open space is also needed for placing a shredder, sieving and stocking the mature compost. For one compost pile, an indicative required space depends on the volume as shown in the following diagrams:



Required space for one compost pile: 1.0 m^3: 2.0 m x 2.0 m; 1.5 m^3: 2.5 m x 2.5 m; 2.0 m^3: 3.0 m x 3.0 m

Example of 4 units (3 x 4 piles) layout and expected performance

Size of seed compost	Number of household (0.5 kg per household)	Daily input of organic waste (kg/day)	Expected output (compost) (kg/day)	Compost piles	Example of layout (one unit represents one compost pile; shade is extra open space for sieving and stock)	Required space
1.0 m^3	480	240	48	1 m^3 x 4		10 m x 6 m (84 m^2)
1.5 m^3	720	360	72	1.5 m^3 x 4		12.5 m x 7.5 m (93.75 m^2)
2.0 m^3	960	480	96	2 m^3 x 4		15 m x 9 m (135 m^2)

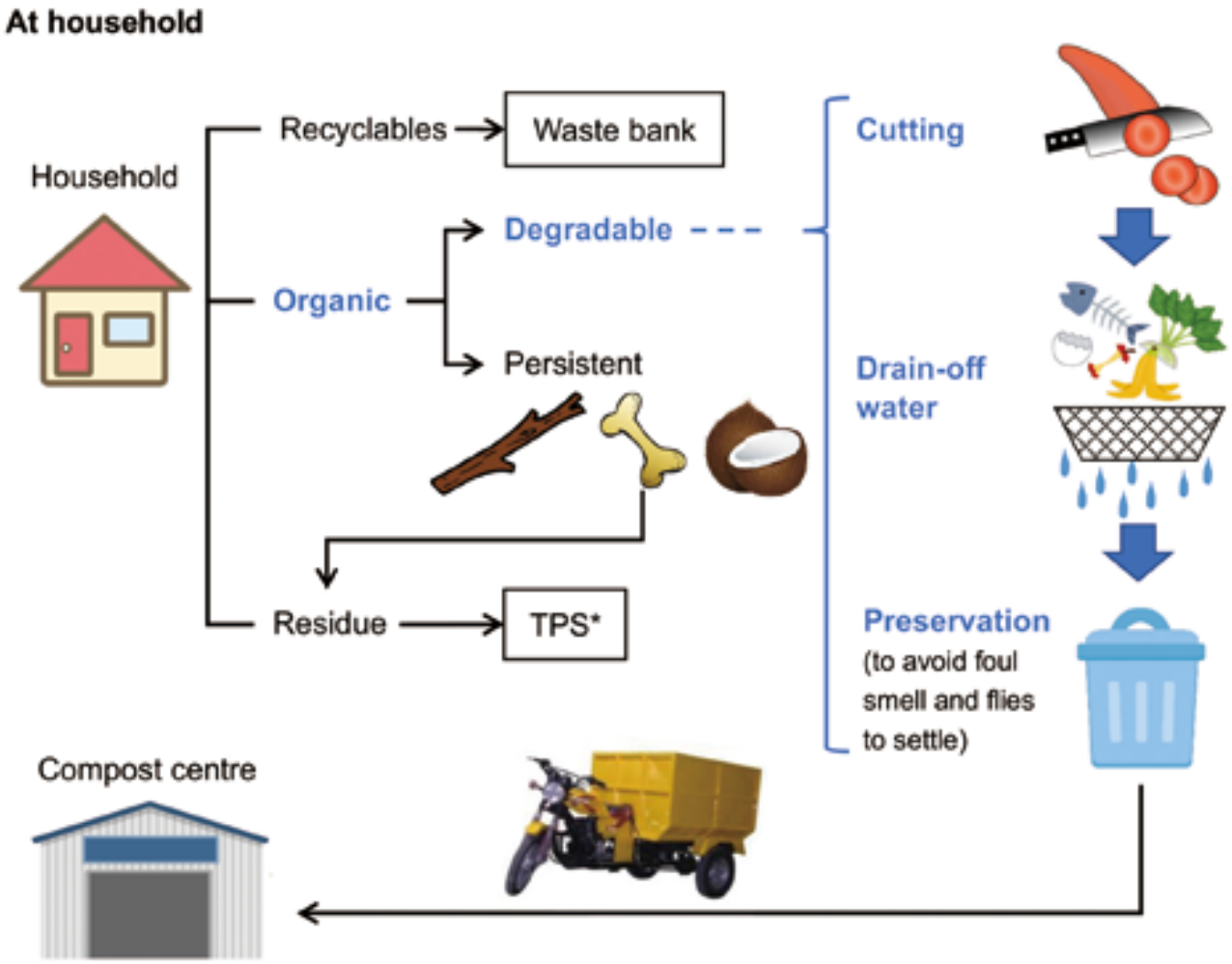
Example of 6 units (3 x 6 piles) layout and expected performance

Size of seed compost	Number of household (0.5 kg per household)	Daily input of organic waste (kg/day)	Expected output (compost) (kg/day)	Compost piles	Example of layout (one unit represents one compost pile; shade is extra open space for sieving and stock)	Required space
1.0 m^3	720	360	72	1 m^3 x 6		14 m x 6 m (84 m^2)
1.5 m^3	1,080	540	108	1.5 m^3 x 6		17.5 m x 7.5 m (131.25 m^2)
2.0 m^3	1,440	720	144	2 m^3 x 6		21 m x 9 m (189 m^2)

6. Daily Operation

6-1. Pre-treatment of organic waste

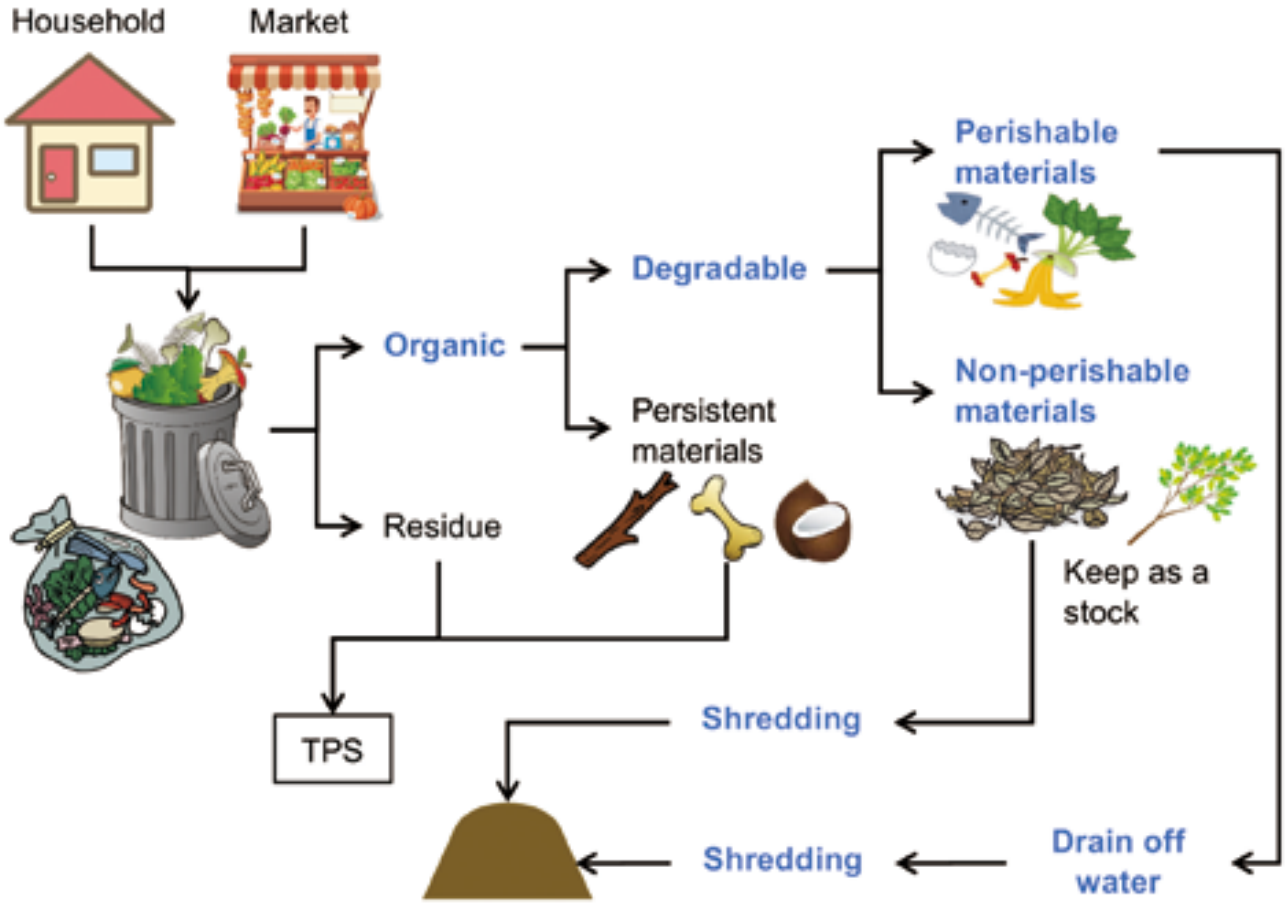
In order to enhance the effectiveness of composting, pre-treatment of organic waste before mixing it into a compost pile is very important. In addition to source separation, removing persistent materials, shredding of large organic waste, and removing excess water will enhance decomposition and avoid failures.



*TPS (*Tempat Pengelolaan Sampah*): Intermediate waste treatment facility

At compost centre

Pre-treatment of waste before processing for compost production is also important. If the compost is contaminated with foreign materials such as plastics, it will be of poor quality. It is therefore critical that those creating and managing the compost to check and put only materials that are readily degradable to the greatest extent possible.



CHECK! In case the incoming waste is a mixed waste, it is not necessary to separate thoroughly as it will take lot of time and efforts. Pick up only degradable organic waste from mixed waste and use it as compost materials.

6-2. Quality and quantity of waste input

6-2-1. Quality of waste input

A proper carbon to nitrogen ratio in the compost is an important parameter to enhance plant growth. This is difficult to measure and control. However, from past surveys and experiences, compost generated from food waste from household, market waste, and garden waste proved to satisfy the good balance of carbon to nitrogen ratio.

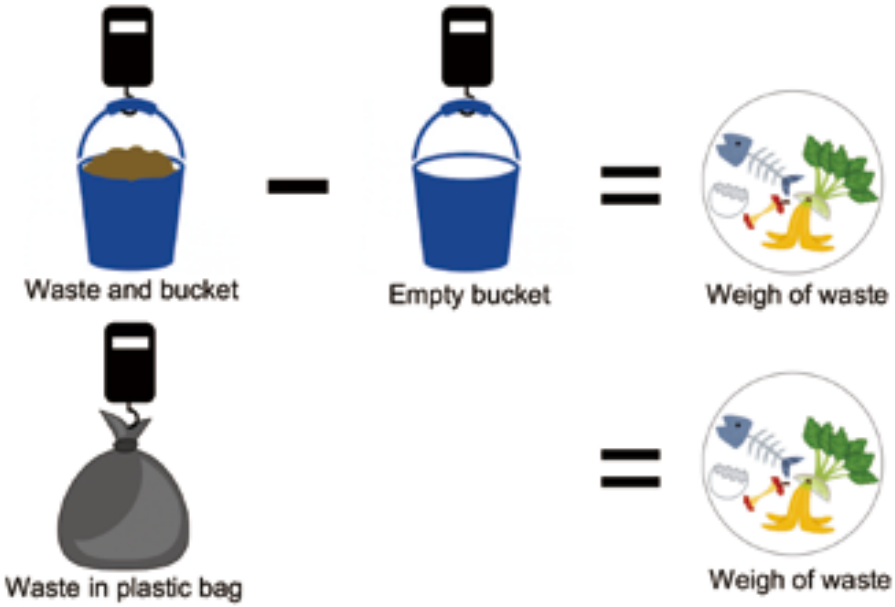
Garden waste takes more time for decomposition.
Mixture of food waste and garden waste is also good.

Avoid too high a concentration of same materials. High concentrations of sour fruits will increase acidity and hinder decomposition.

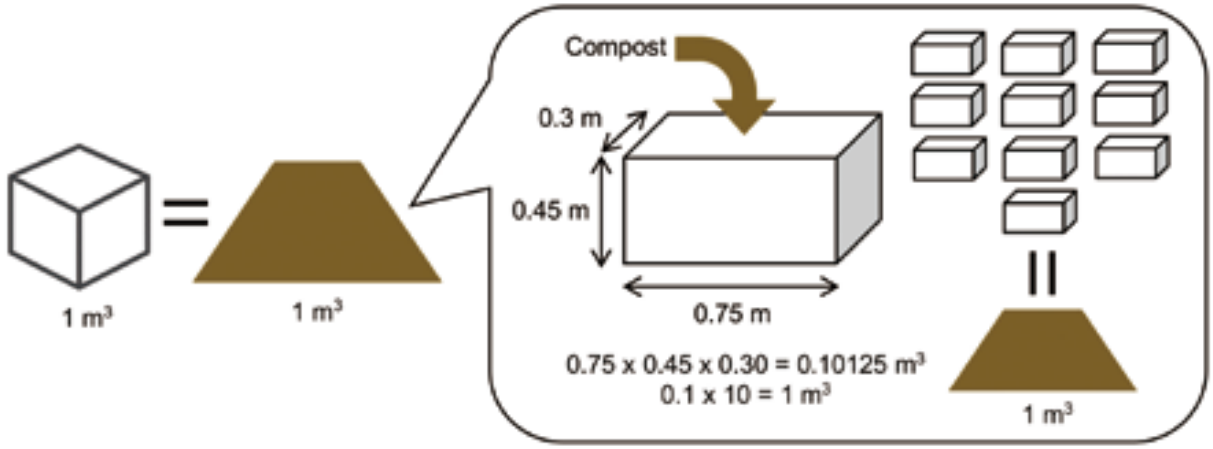
6-2-2. Quantity of waste input

The appropriate quantity of organic waste to be added to compost bed is determined from the moisture content of the compost. In other words, amount of organic waste should be adjusted to keep the optimal level of moisture content for aerobic fermentation (ie., 40-60%). As moisture content is subject to changes depending on the temperature, humidity (eg, dry season or wet season), type and conditions of waste, etc., it requires daily adjustment based on experience and monitoring.

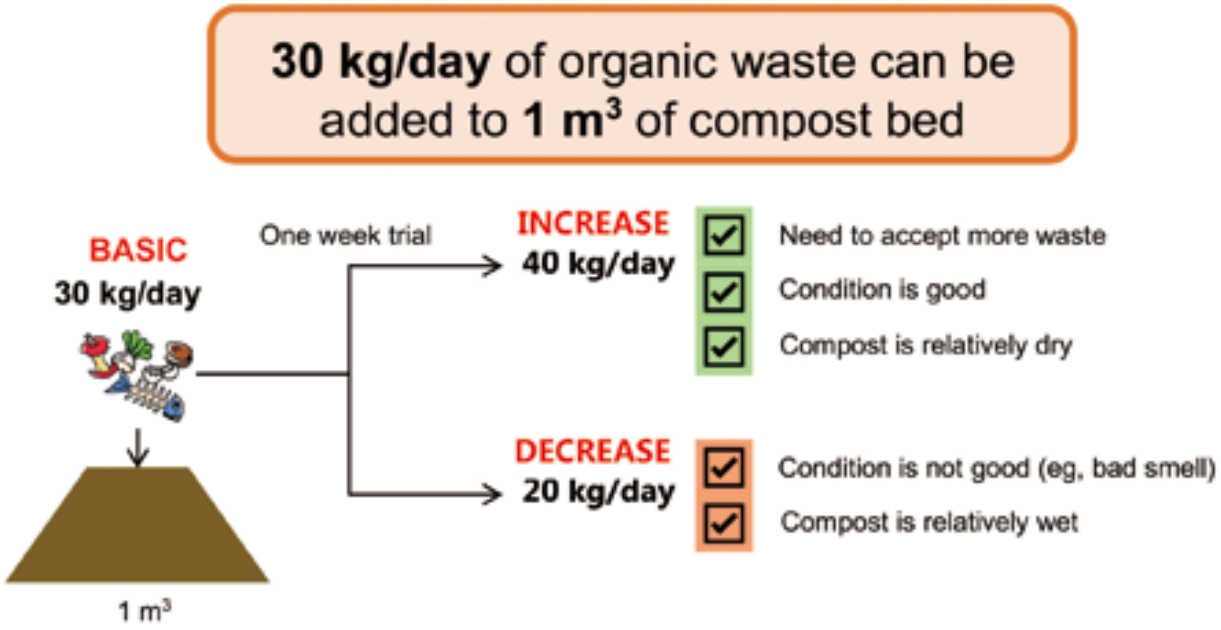
The weight of organic waste input needs to be measured and recorded every time. The weight of a bucket should be deducted from the measurement data. If the organic waste is contained in a plastic bag, the weight of plastic bag can be ignored as it is not likely to weigh much.



The amount of seed compost does not have to be measured every time, but it is recommended to initially understand the approximate volume of compost equivalent to 1 m^3 (or other target volume). For example, 1 m^3 of volume can be measured using an existing box container (or bucket) as follows:



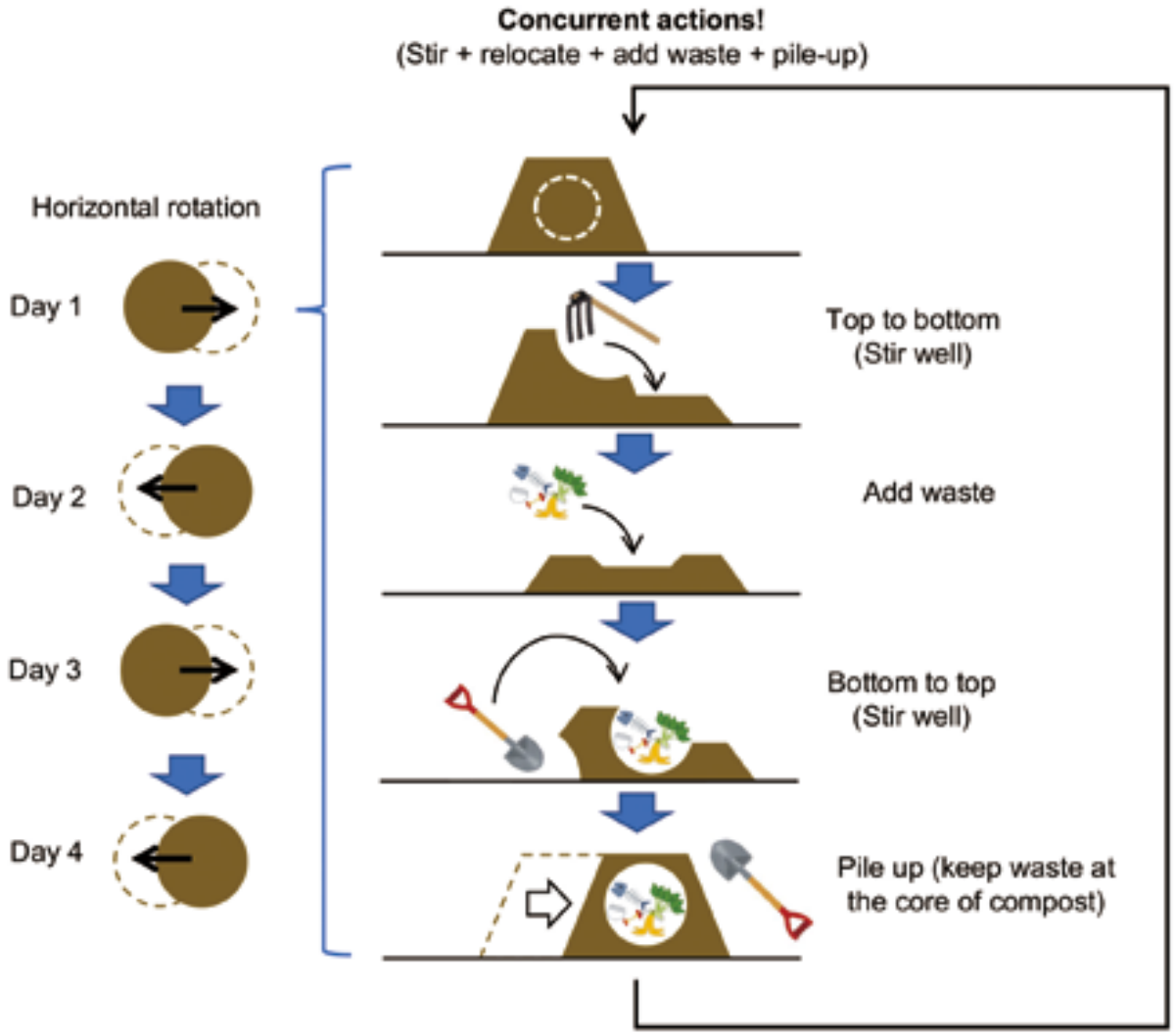
Experiences in various locations and conditions suggests that it is safe to add 30 kg of organic waste daily to 1 m^3 of compost bed. This should be considered as a rough indicator to determine the initial input amount and be adjusted depending on the needs and conditions of the compost through a series of trials.



6-3. Stirring of compost

6-3-1. Stirring and relocation of compost

It is important to stir the compost daily. Stirring will provide oxygen to microorganisms inside the compost for active decomposition and will keep the compost homogenous. Without stirring, oxygen will be lacking inside the compost and anaerobic digestion will occur, which will create a bad smell. It will also result in uneven decomposition, leaving behind some undecomposed materials. In order to reduce time and energy, four actions (stir, relocate, add waste, and pile-up) can be done concurrently. Stirring beforehand and keeping waste fresh at the core of the compost over one night will also avoid a bad smell.


Concurrent actions!
(Stir + relocate + add waste + pile-up)
Horizontal rotation
Day 1
Day 2
Day 3
Day 4
Top to bottom
(Stir well)
Add waste
Bottom to top
(Stir well)
Pile up (keep waste at
the core of compost)

6-3-2. Frequency of stirring

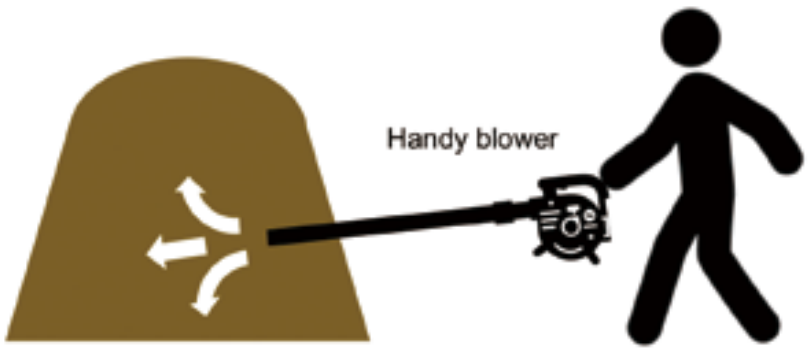
Appropriate frequency of stirring the compost differs depending on the situation.

Parameters	Recommended frequency of stirring		
	Everyday	Once per 2-3 days	Once a week
Frequency of organic waste input	Everyday	Once per 2-3 days	Once a week - None
Ratio of waste and compost	Waste > Compost	Waste < Compost	Waste << Compost
Dominant type of organic waste	Soft food waste	Soft food waste and/or resistant garden waste	Resistant garden waste
Moist content	High	Intermediate - Low	
Features	• Provide oxygen but will lower the internal temperature • Soft food waste will generate water, so it is necessary to evaporate it by stirring	• Less frequent stirring will lower the oxygen level inside the compost while keeps the internal temperature high • Garden waste provides space for better ventilation inside the compost and requires high temperature for decomposition, so a less frequent stirring would be appropriate	

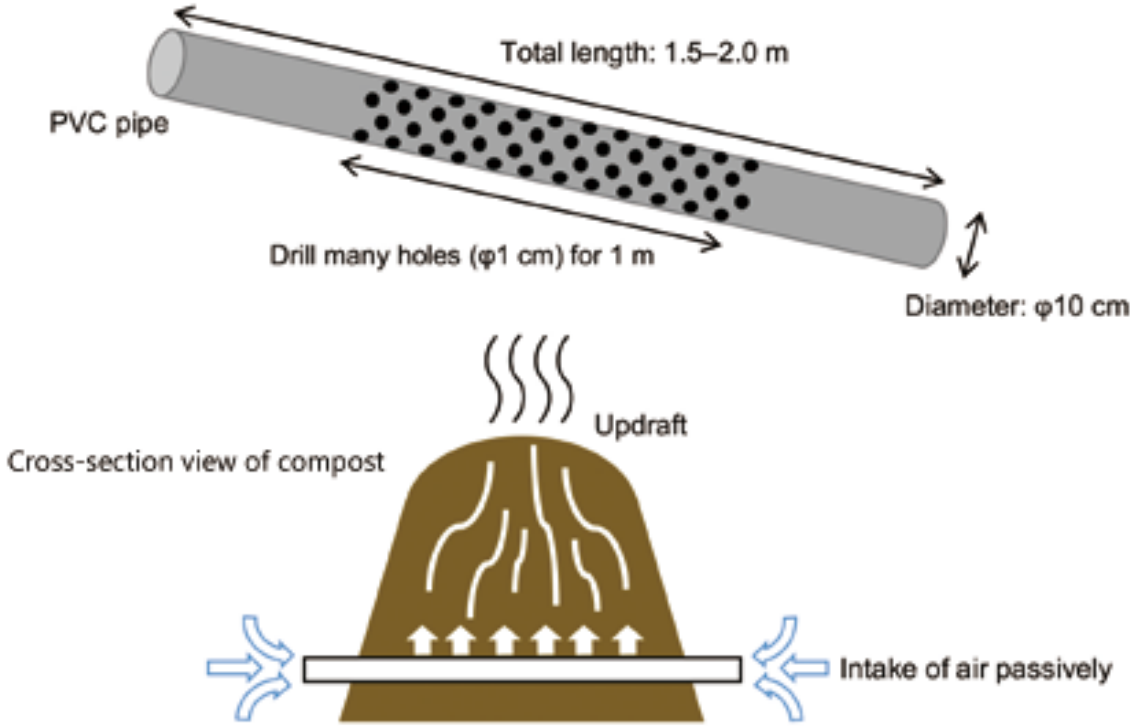
6-3-3. Mechanical and passive ventilation

Stirring of compost manually has the advantage of the through mixing of waste and compost but requires hard work. When the compost piles gets larger (eg, 1.5 m^3 or 2.0 m^3), the piles will be a lot heavier and turning over the compost will take a lot of time. In such a case, mechanical ventilation using a handy blower would be effective. Another cost-effective option is a passive ventilation system using PVC pipes.

Mechanical ventilation



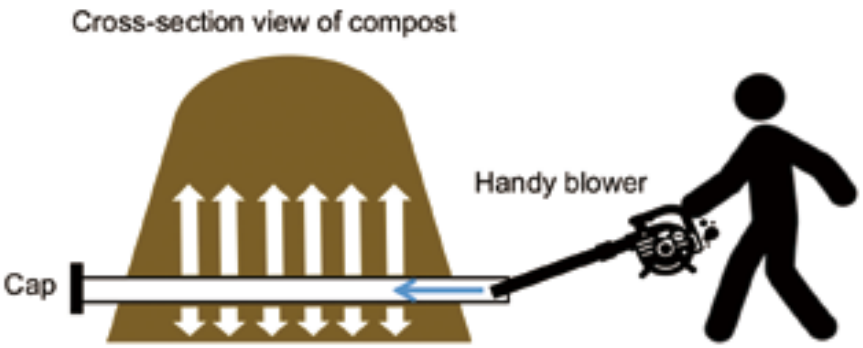
Passive ventilation



When the temperature inside the compost increases (eg, 60 oC), an updraft of air is formed in the compost bed, so the air will be slowly inhaled into the compost bed through the ventilation pipe. However, the suction volume is very small so it should be considered as complementary method for ventilation.

Mechanical ventilation with ventilation pipe

A combination of handy blower and ventilation pipe can enhance efficient ventilation inside the compost bed. In this case, it is important to close the other end of the pipe in order to maximize the supply of the blower air inside the compost bed.



6-4. Shaping the compost piles

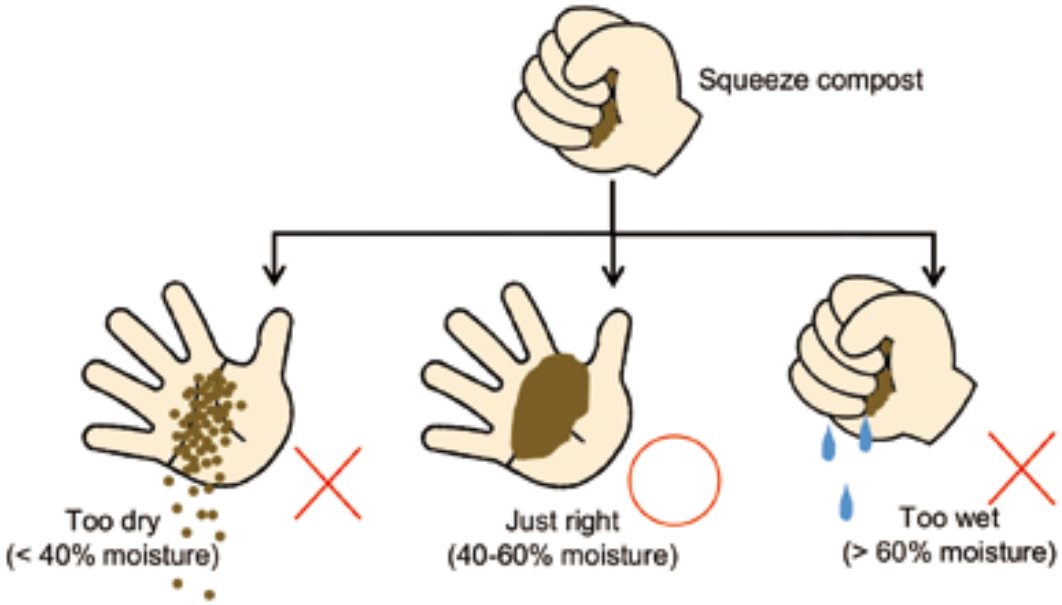
The decomposition of organic waste is faster at higher temperature. So the decomposition will become most efficient when the compost will be piled-up in a cylindrical shape due to efficient heat storage. Thus, by placing the fresh organic waste in the core of the compost bed, it will generate heat by fermentation, and the heat will be trapped inside. High temperatures will not just enhance decomposition of waste but also sterilize pathogenic bacteria (eg, E. Coli, Salmonella sp.), eggs of flies, etc.

6-5. Controlling moist content

Moisture content is a key parameter to understand the condition of compost bed and should be monitored everyday. Maintaining the appropriate moisture content (50-60%) will accelerate decomposition of waste and keeps the compost in a good condition. Please be careful not to exceed 60% moisture.

6-5-1. How to check moist content

You can easily check the moist content by using your hand. When you squeeze compost in your hand, and the compost becomes like a ball, it is a sign that the moist content is just right. If the compost does not stick together and drops easily, it indicates that it is too dry, while if water can be squeezed out of the compost, it is too wet.

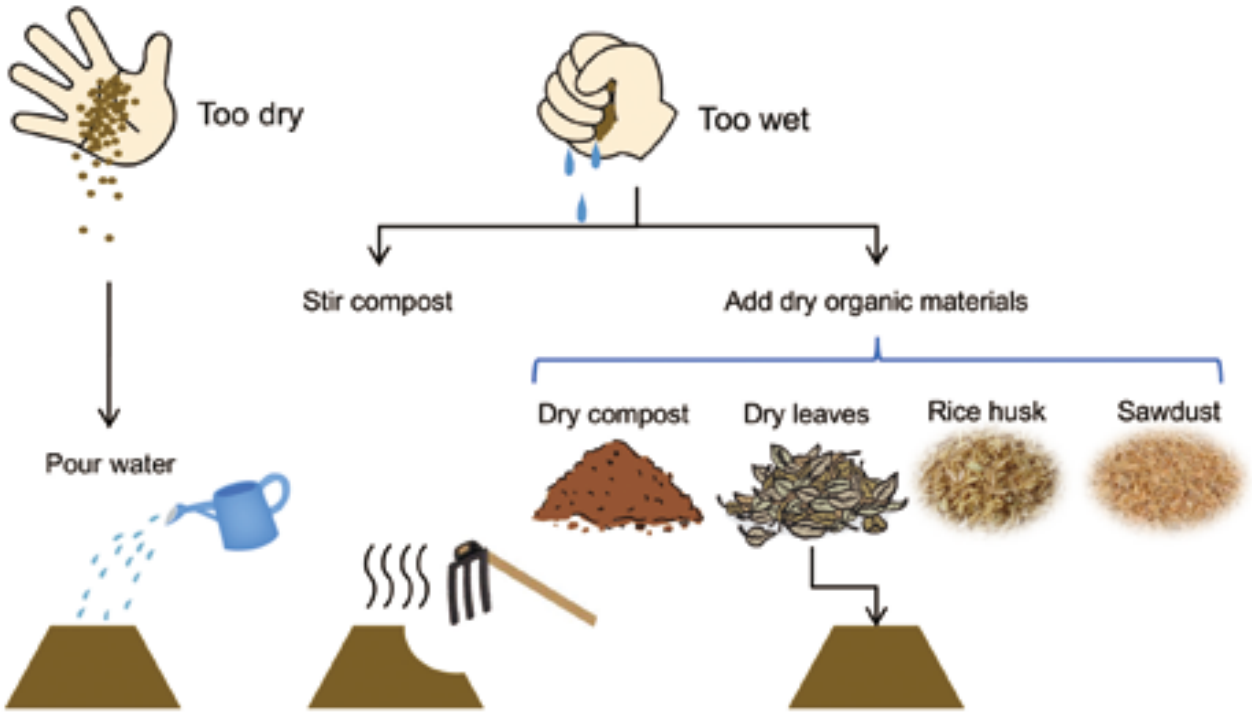


CHECK!

Between 50-60% moisture content is best for bacteria to actively decompose organic waste and generate heat. However, at the stage of maturation after the organic waste has sufficiently decomposed, you can reduce the moisture content to slightly lower levels (eg, at 40-50%). And if you want to extract compost for use, you don't need to maintain this moisture level. By naturally drying the compost, the moisture content will decrease (< 40%), and the bacteria becomes dormant (inactive) which allows the compost to be preserved stably.

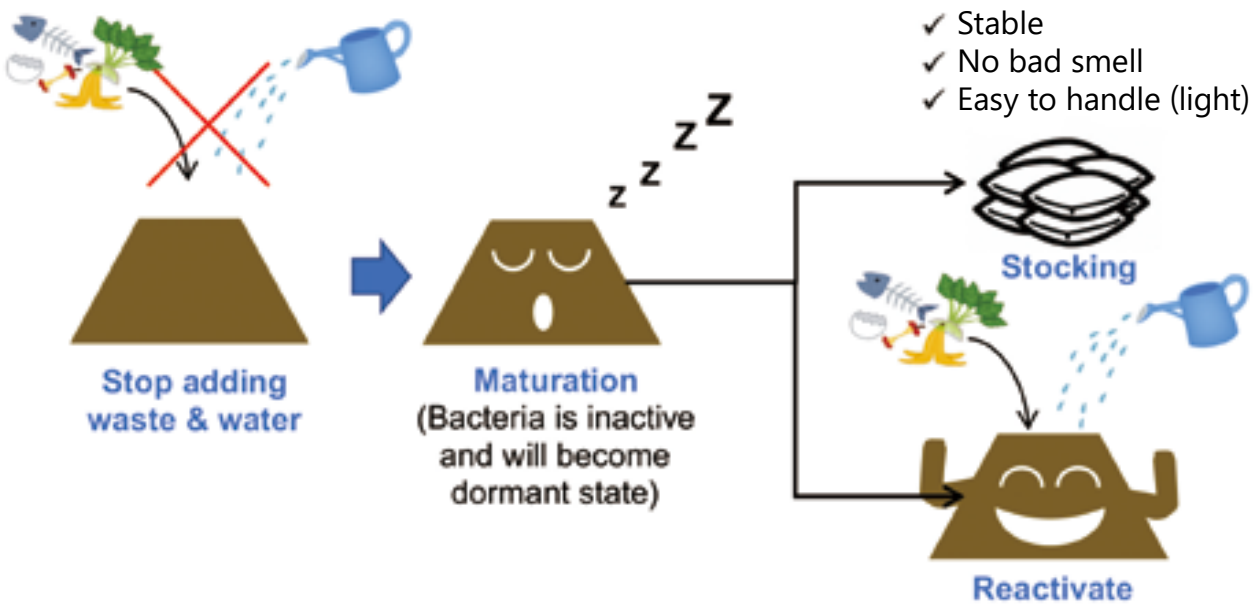
6-5-2. How to adjust moist content

If the compost is too dry, you can adjust the moisture content by pouring water. If it is too wet, the first thing you should do is to stop adding organic waste. The next thing you should do is to stir the compost well which will enhance the decomposition of waste, generate heat, and evaporate the moisture. You can also adjust the moisture content by adding dry organic materials. It would be useful to have a stock of some dry organic materials for adjusting the moisture content.



6-5-3. Dry compost for stocking

After terminating the addition of organic waste, the temperature will decrease gradually and will reach a maturation stage. After that, the compost will gradually get dry if you do not add water. The bacteria will be inactive and reach a dormant state which is stable for stocking the compost. You can reactivate whenever you add organic waste and/or water.



6-6. Controlling the temperature

Temperature is another key parameter to understand the condition of compost bed and should be monitored everyday. Adding organic waste and maintaining appropriate conditions will raise internal temperature and keep the compost in a good condition.

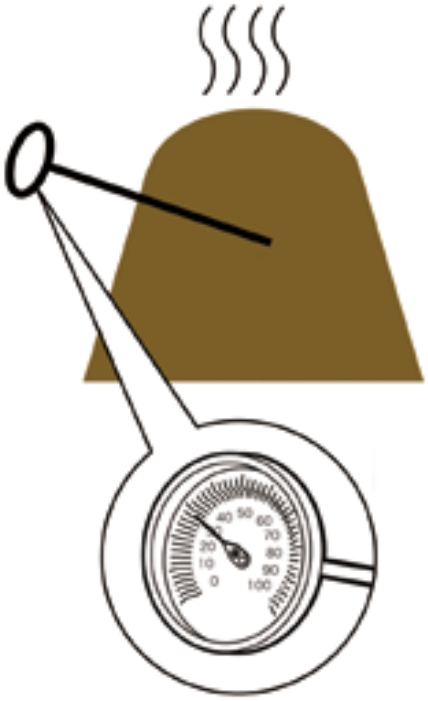
6-6-1. How to check temperature

A compost thermometer is a useful tool to check the temperature inside the compost. If you cannot afford a thermometer, you can roughly identify approximate temperature inside the compost bed. After inserting a large knife into the compost bed, touch it with your hand. Or put your hand directly into the compost bed. Extra care should be taken when touching the compost to avoid burning your hand.

Keep above **65 °C** for more than 3 days
to sterilize pathogenic bacteria and eggs of flies

By hand

By compost thermometer



Very very hot (with vapour): **70 °C <**

Very hot (intolerable): **50 °C <**

Hot (tolerable): **30 - 40 °C**

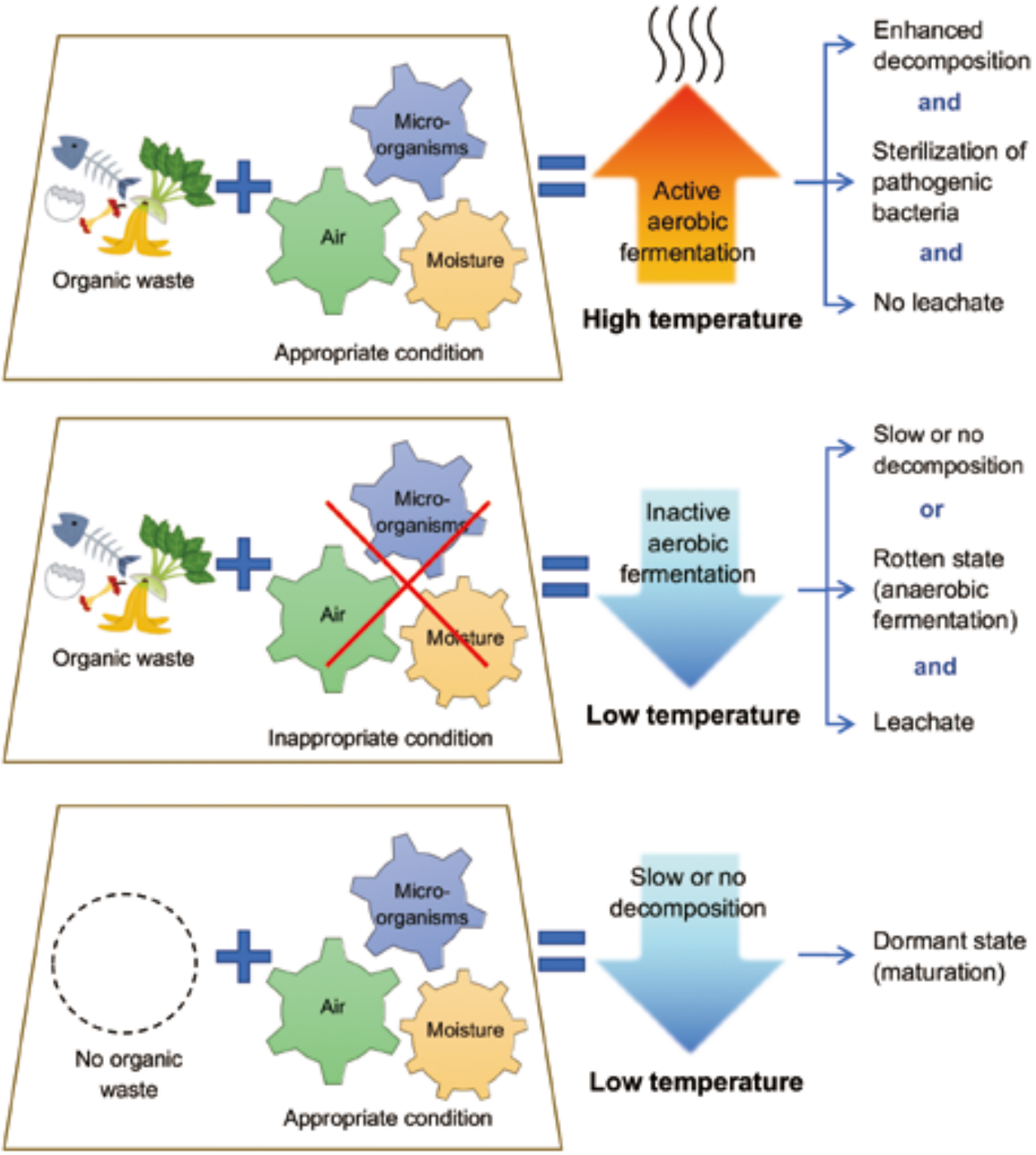
Not hot: **< 30 °C**

CHECK!

Make sure to check the temperature at around the centre of compost

6-6-2. Understanding temperature (What does it indicate?)

Active aerobic fermentation accompanies the generation of heat and keeps compost bed a high temperature (above 60 °C). On the other hand, low temperature indicates that the compost is either in a bad condition or in a dormant (maturation) state.



6-6-3. Understanding temperature (Difference in transition)

The changes in temperature in the compost bed differs depending on how you operate the bed. Generally, the temperature of the compost bed will decrease as you add organic waste and/or stir the compost. However, if the organic waste is easily degradable organic waste (eg, kitchen garbage), the temperature of the compost bed will rise rapidly after a while (if it is a garden waste, the rise of temperature will take more time). If you do not add waste and repeat stirring, the temperature will gradually decrease and fade out, which is a sign of maturation (dormant) state. So you need to bear in mind these dynamics.

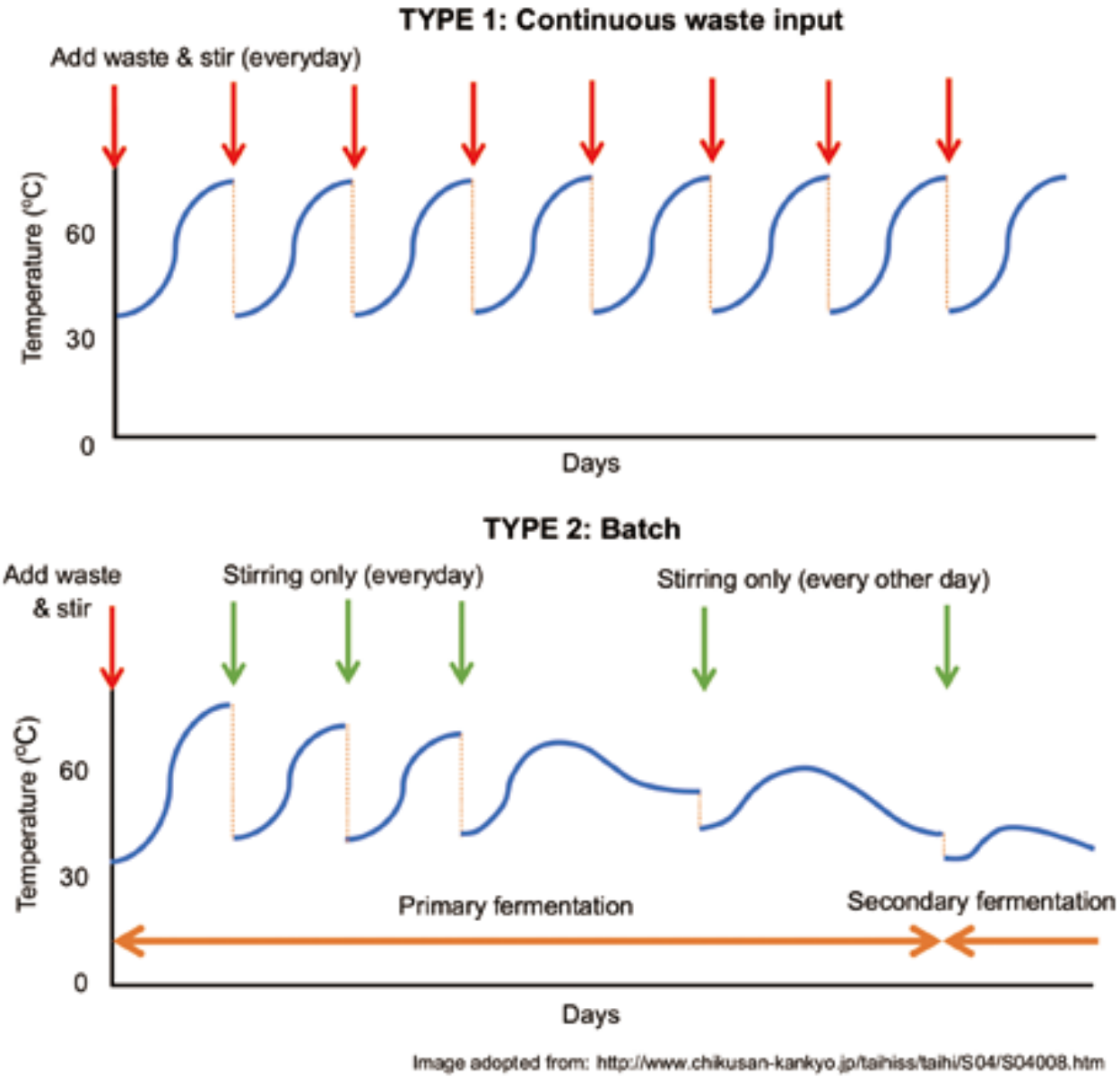
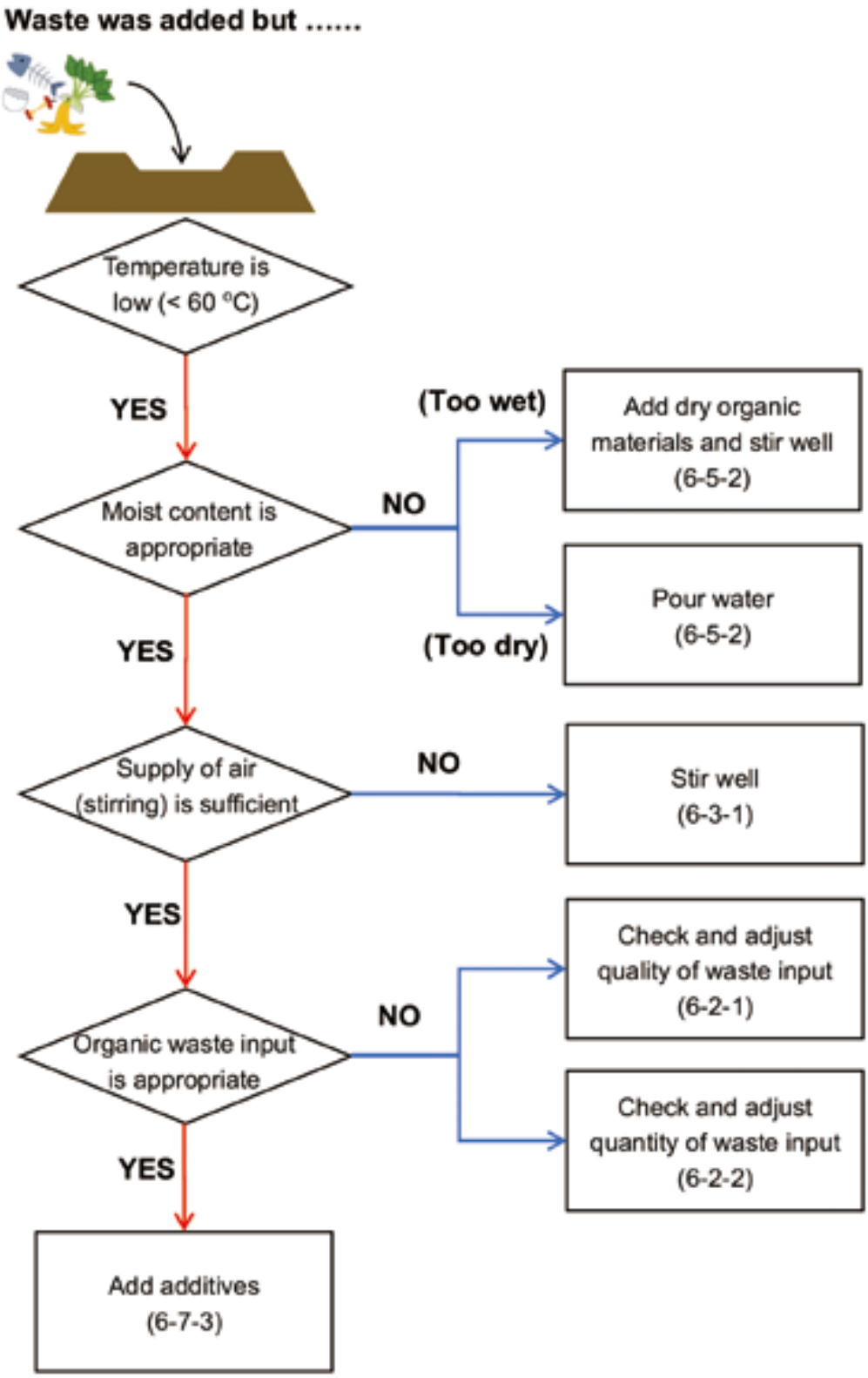


Image adopted from: http://www.chikusan-kankyo.jp/taihiss/taihi/S04/S04008.htm

Make sure to check the temperature before adding organic waste and/or stirring the compost bed, because the temperature differs depending upon when you monitor.

6-6-4. How to control temperature

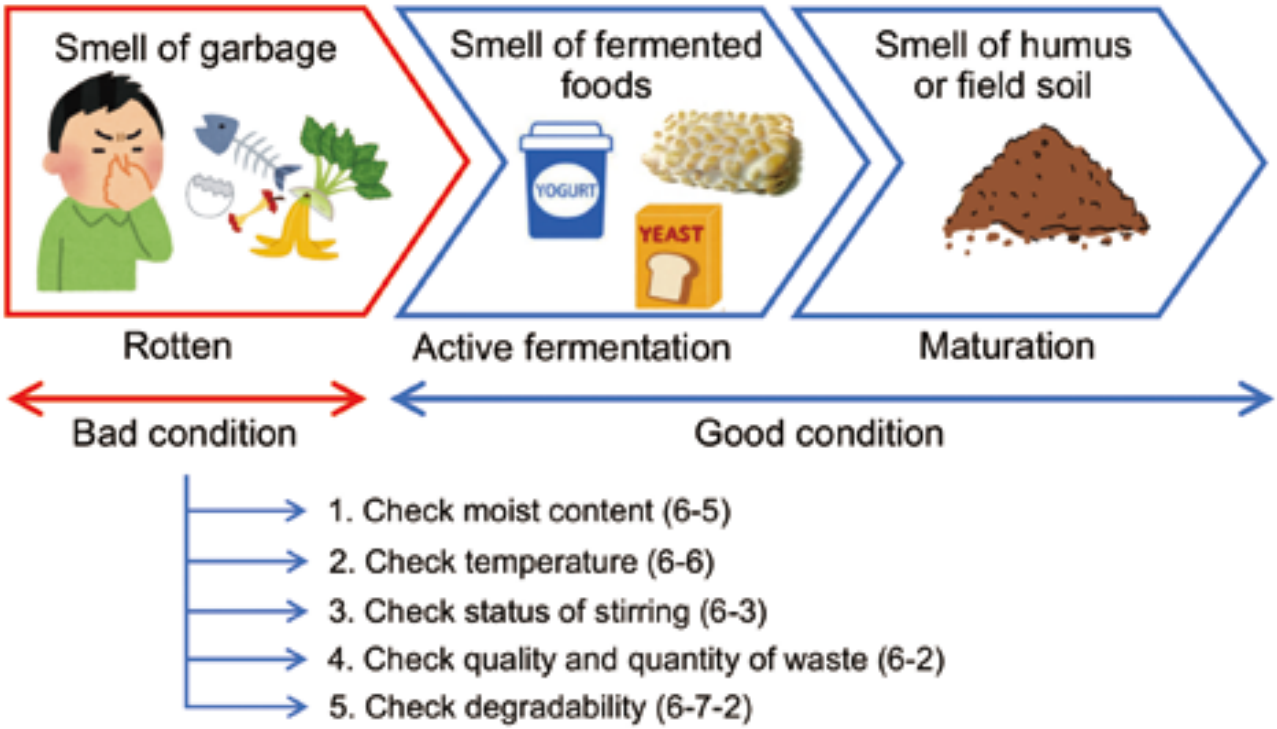
To maintain high temperature is a key strategy to enhance decomposition of organic waste and sterilizes pathogenic bacteria and eggs of flies and other insects. In other words, if the temperature is low, it is a sign that the compost bed is not in a good condition unless it is shifting to maturation status. Here are some tips that you may try when temperature is not getting high.



6-7. Controlling other factors

6-7-1. Checking smell

The smell of compost is also a useful parameter to understand the condition of compost. If active fermentation is taking place, the compost smells like fermented foods (such as tempe, tape, yeast, etc.) and it suggests that the condition is good.



6-7-2. State of decomposition of organic waste

The appearance of the surface of compost will also indicate the condition of compost. If it is dominated by dark-brown fine particles (soil), it suggests that the organic waste is degrading well and is in good condition. While if it is dominated by undecomposed organic waste, it suggests that the amount of waste input is exceeding the ability of compost to decompose. In this case, you could either: (a) crush large materials with a crusher, (b) add more seed compost, or (c) stop adding waste (eg, for one week) and decrease the amount of input.

6-7-3. Use of additives

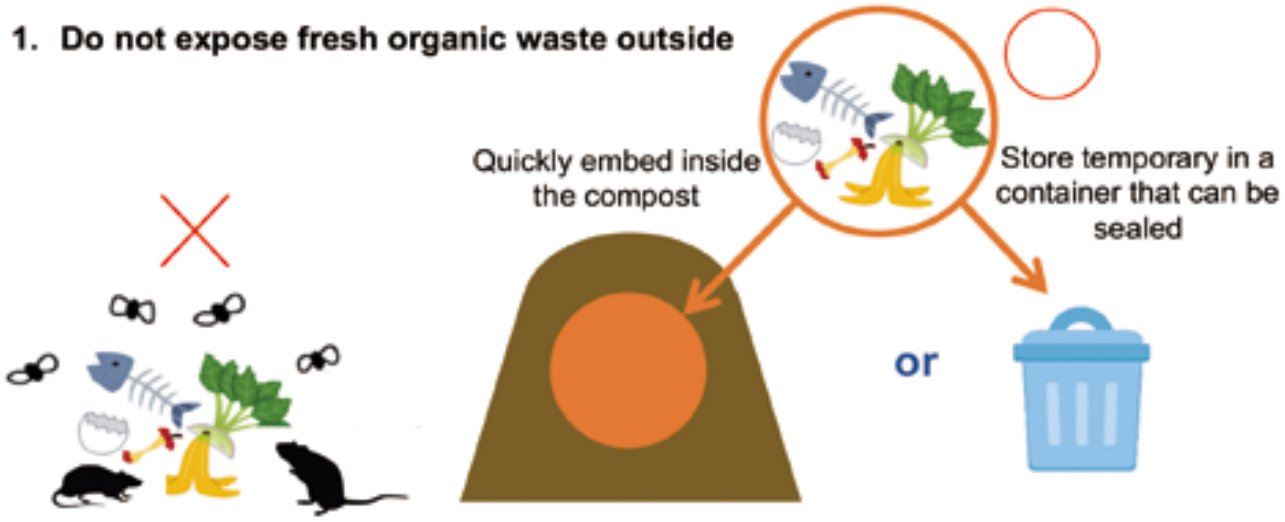
If the condition of compost is not good, you may try to activate the compost by using some additives depending on the situation. It is not necessary to buy special additives. Rather, left-over fermentation food or other materials that are easy to obtain can be used.

Symptoms	Additives	Expected effects
• Compost is wet and heavy	 Dry leaves  Rice husk  Sawdust	Enhance ventilation and absolves moisture
• Temperature not high (fermentation not active) • Smell is not good	 Tempe  Tape  Yogurt / Yakult  Yeast	Enhance decomposition of food waste
	 Rice bran	Provide nutrients to bacteria
	 Humus soil or field soil	Provide various bacteria and functions as a neutralizer
• Decomposition of garden waste is slow	 Mushroom  Fungi	Enhance decomposition of resistant materials (eg, lignin, cellulose)

6-7-4. How to avoid flies and rats

Organic waste generates rotten smells and attracts flies and rats. It would be difficult to completely avoid flies and rats, but the best strategy to avoid pests is to keep the compost centre clean and well-maintained to the greatest extent possible. That will also contribute to keeping the quality of compost, limit complaints from neighbouring communities, and maintain the health of workers.

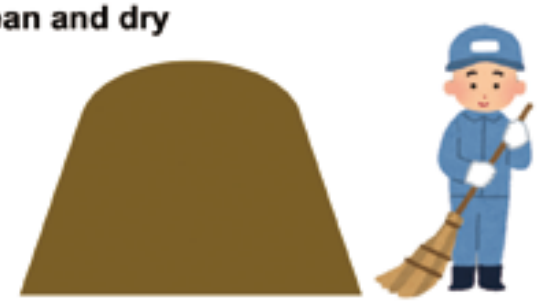
1. Do not expose fresh organic waste outside



2. Keep fresh waste at the core of the compost

Keeping fresh waste at the core of the compost will raise the temperature of compost and kills fly eggs and other pathogenic bacteria.

3. Keep the floor clean and dry



6-8. Monitoring

Daily monitoring is an important activity for operating the compost centre. It is a useful source of information whenever there is a problem and necessary measures needs to be identified and taken. It also keeps track of the performance of the compost centre. The following basic parameters should be monitored on a daily basis.

Examples of daily monitoring data

Parameters	Pile 1	Pile 2	Pile 3
Date / Time	3/4, 9:15	3/4, 9:20	3/4, 9:25
Moist content	√	√	Add water
Temperature (°C)	67	70	60
Stirring of compost	√	√	√
Amount of waste input (kg)	52	55	54
Remarks			

The daily monitoring data should be transferred to digital data that can be used on a personal computer (EXCEL file) immediately and necessary back-ups should be made to avoid a data loss. The accumulated data at each compost centre should be shared with the responsible government agency on a regular basis or through online and analysed for sharing and decision making.

7. Compost Extraction

After the temperature drops and sufficient time has passed for maturation, the compost is ready for use as an organic fertilizer or can be used as a seed compost.

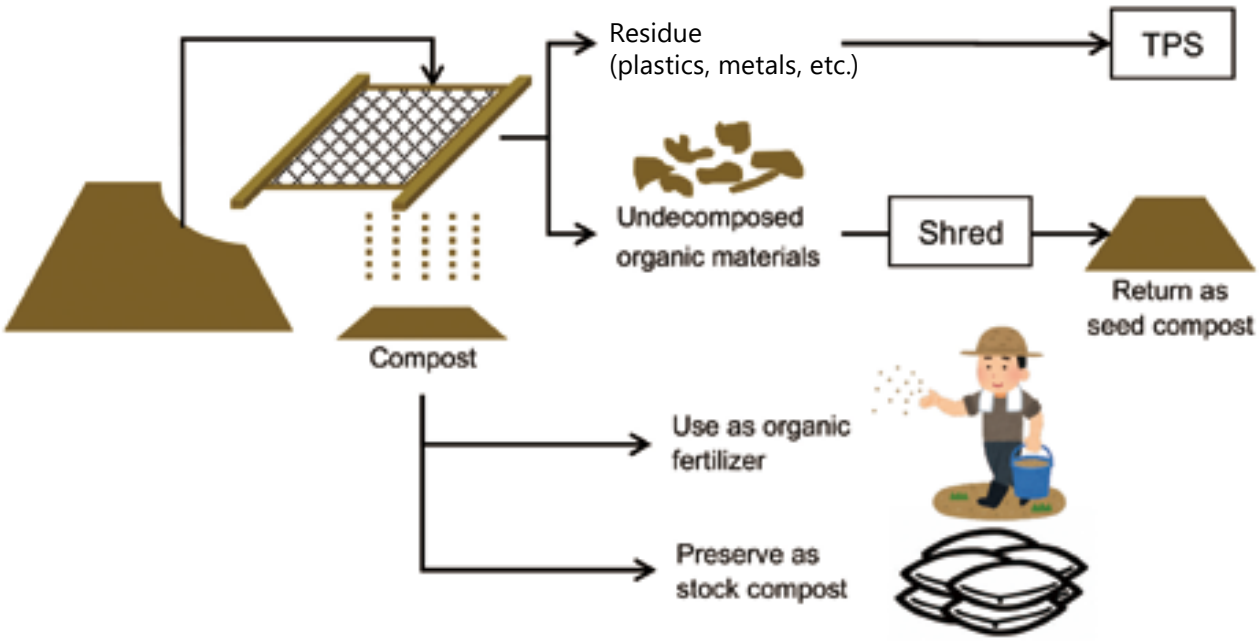
7-1. How to determine maturation of compost

Aside from the indicated time for compost maturation, you should check the temperature, colour, looks, and smell of compost to determine whether it is mature enough to be used for organic fertilizer or not.

☑ **Temperature:**	Low - about 30 °C (room temperature)
☑ **Colour:**	Dark brown
☑ **Moist content:**	Dry (below 30%)
☑ **Looks:**	Looks like a soil with limited undecomposed organic materials
☑ **Smell:**	Smells like a humus soil or a field soil (no smell of garbage and/or fermented foods)

7-2. Sieving and preservation

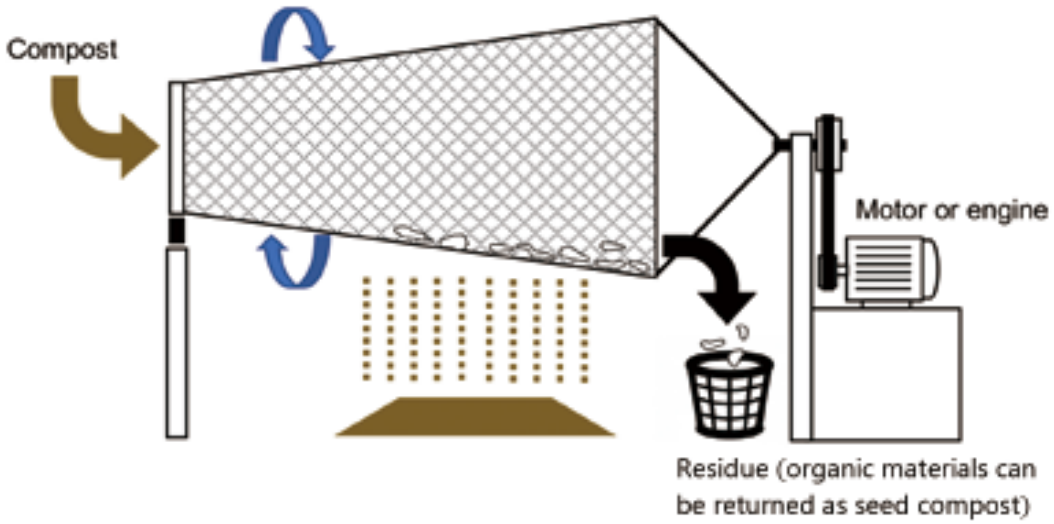
The mature compost should be sifted through mesh (about 4-5 mm) to get rid of inorganic materials and undecomposed organic matter. To preserve the compost, the moisture content should be low and dry. Undecomposed organic materials can be returned and used as seed compost to be further decomposed and as an agent to provide microorganisms.



7-3. Type of sifting

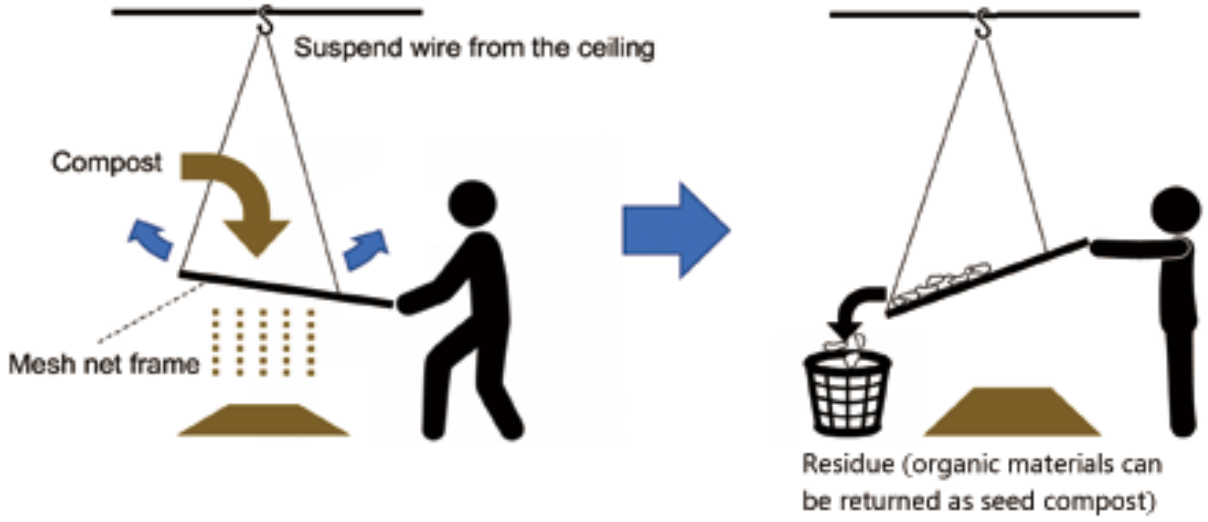
Mechanical sifting

"Trommel" is a mechanical sifting machine to separate compost (fine particles) and residue (large particles). When the production capacity is large (eg, 1-2 ton/day of organic input), it is advantageous to introduce trommel to reduce the work load and increase work efficiency. However, this requires an initial investment, fuel and other running costs.

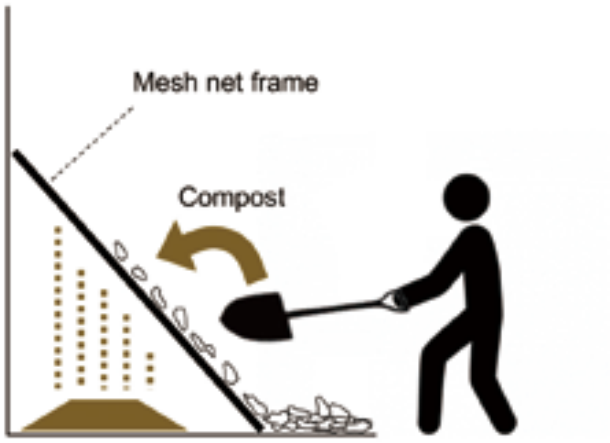


If the production capacity is not so large and/or trammel is not affordable, manual sifting is also possible. By suspending the mesh net (about 4-5 mm) frame on the ceiling or throwing the compost to the mesh net frame that is leaning obliquely to the wall, efficiency of sifting can be increased while the workload can be reduced.

Manual sifting (Suspension type)



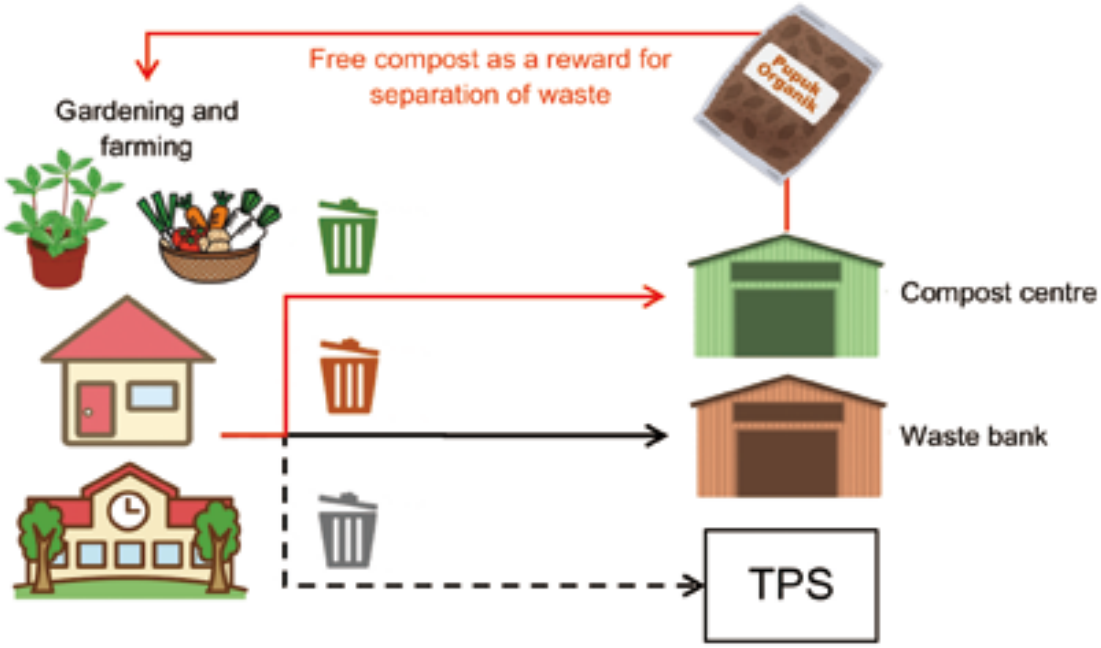
Manual sifting (Throwing type)



8. Use and Distribution of Compost

The sales of compost in retail markets in Indonesia requires formal licencing from the central government. The license is needed to comply with the technical standard of the Indonesia National Standard (SNI) on domestic organic compost (SNI: 19-7030-2004). However, self-consumption or free contract between the producer and consumer does not require a SNI certificate. The most cost-effective way to use compost is self-consumption by the community for gardening and farming or by the city's landscaping department for greening of parks and streets. Use of commercial fertilizers for landscaping public works can be replaced by the compost and hence contribute to saving the city budget.

The compost could also be used effectively as a tool to incentivise source separation. For example, providing free compost to household, schools, and/or other social entities as a reward for contribution to source separation and/or other green activities could increase awareness and can motivate more communities to participate.



When there are more than enough compost production for self-consumption and reward purposes, extended use and distribution of compost could be explored. Bilateral contracts could be exchanged between the city and some reliable entities that require large amount of organic fertilizer and are willing to contribute to the city's greening efforts. In exchange for accepting the compost at a reasonable price, the city could provide certificates to recognize the entity's social contribution. The entity can then use the certificate to increase their corporate image and further enhance corporate responsibility. As such, it is expected that the reliability and branding of compost will increase.


Pupuk Organik
Certificat
✓ Acquisition of cost-effective fertilizers
✓ Increased corporate social responsibility
Kota Bandung
• Agriculture organizations
• Plantations
• Public works agencies
• Universities
• Industries, etc.
Branding of compost
More commitments and contributions

Acknowledgement

This manual was prepared as part of capacity building activities in the “Waste Management Support Project Toward a Sustainable Resource Recycling Society in Bandung, Indonesia”, a city-to-city collaboration project between Kawasaki city and Bandung city, funded by Japan International Cooperation Agency (JICA)’s Grassroots Project during 2017-2020. We would like to especially thank the Department of Environment and Hygiene (DLHK) of Bandung City who led and supported this initiative; facilitators of Kawasan Bebas Sampah (KBS) for encouraging and assisting the communities to separate waste at source; and all the community members in the six targeted communities (Balonggede RT03 RW 06, Gempolsari RT 04 RW 04, Cibangkong RT02 – RW1, Mengger RT6 - RW1, Batununggal Cluster Permai, and Batununggal Cluster Jelita) who contributed in the source separation of waste which were used in the compost centre at the Babakansari TPS-3R.

References

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[髙倉弘二（2019） コンポストの基本理論～高倉式コンポストを活用して廃棄物マネジメントの改善を目指す～. https://jica-net-library.jica.go.jp/]

Takakura Environment Research Institute (2018) Composting Manual - Let’s Start Organic Composting. Institute for Global Environmental Strategies.

Shunrokuro Fujiwara (2003) How to make and use compost – From theory to practices. Rural Culture Association Japan. [藤原俊六郎（2003） 堆肥のつくり方・使い方　原理から実際まで. 農山漁村文化協会.]

ANNEX

Based on various field testing and feedback in many cities, methods for small-to-medium size compost centre using the Takakura composting method could be divided into following four types depending on the amount of organic waste input, availability of space for processing, and other conditions. The types described in the main text of this manual is an applied version of the rotation input type. All types can be flexibly adjusted to various conditions, therefore, there is no definitive rule on which type should be used under which circumstances.

Types	Suitable scale	Characteristics
TYPE 1: Continuous input	RT[3] to RW[4] scale (< 500 households)	• Requires only small space • Can be flexibly adjusted depending on the amount of organic waste input
TYPE 2: Rotation input	RT to RW scale (< 500 households)	• Requires double space compared to TYPE 1 • Easier to extract compost
TYPE 3: Batch	Kelurahan[5] scale (500 - 1,000 households)	• A simple one-way process • Allows to treat relatively large amount of organic waste
TYPE 4: Container	RT to RW scale (< 500 households)	• Can be performed in a very limited space • Location can be moved flexibly

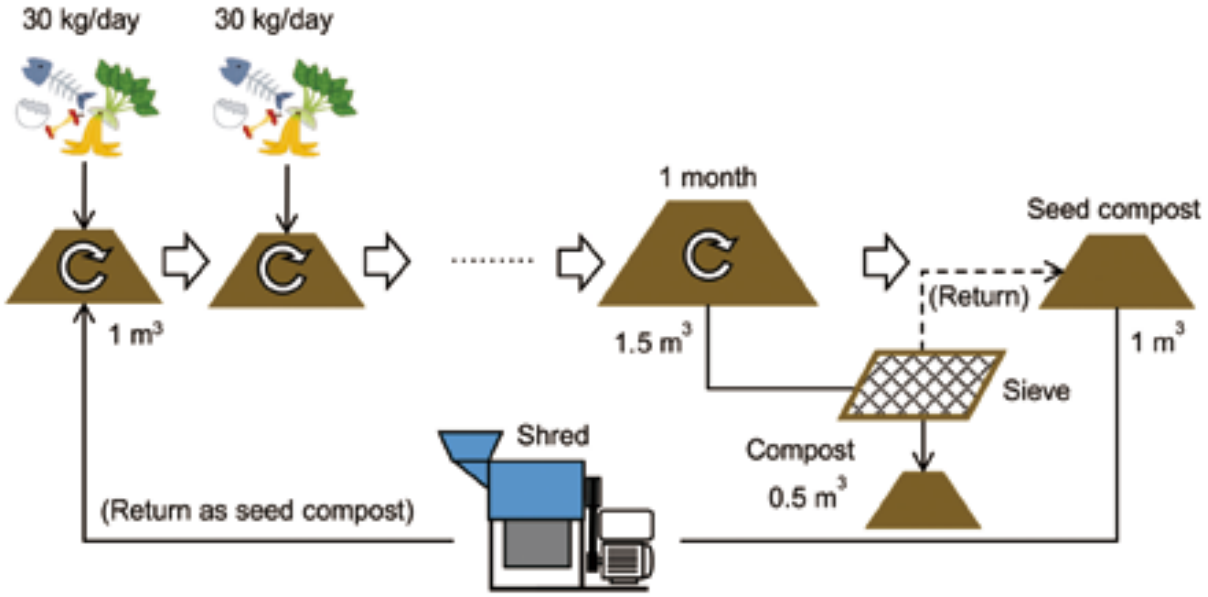
[3]RT (rukun tentangga): Neighbourhood association; Lowest level administrative hierarchy for local governance in Indonesia which typically consists of 30-50 households

[4]RW (rukun warga): Community association; Administrative hierarchy above RT for local governance in Indonesia which typically consists of 100-150 households

[5]Kelurahan: Administrative villages under the sub-districts (kecamatan) for local governance in Indonesia which typically consists of 500-1,000 households

TYPE 1: Continuous input

A pile of seed compost with a size of 1 m^3 will be prepared and 30 kg/day (Max: 50 kg/day) of organic waste will be continuously added and stirred daily. After 1 month, an excess amount of compost can be extracted, leaving behind 1 m^3 for continuous use as a seed compost. The extracted compost will mature for about 2 weeks (frequency of stirring can be reduced to once per 2-3 days).

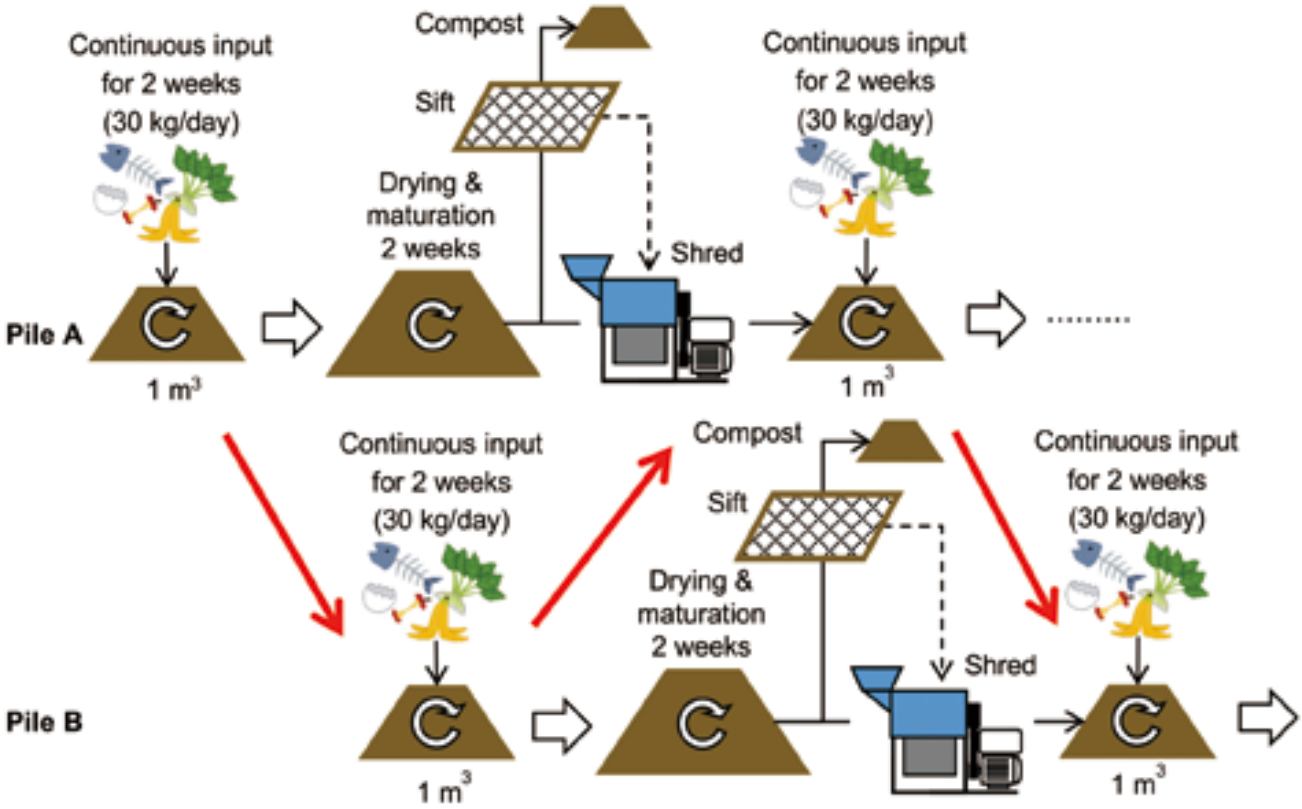


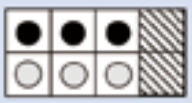
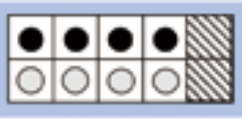
Type	Household (0.5 kg per household)	Daily input of organic waste (kg/day)	Expected output (compost) (kg/day)	Compost piles	Example of layout (one unit represents 2 m^2 of compost piles)	Required space (m^2)
TYPE 1: Continuous input	60-100	30-50	6-10	1 m^3 x 1		8
	120-200	60-100	12-20	1 m^3 x 2		12
	180-300	90-150	18-30	1 m^3 x 3		16

One unit pile of compost (1 m^3) Extra open space

TYPE 2: Rotation input

This is a modified version of TYPE 1 (Continuous input). Two sets of seed compost piles with a size of 1 m^3 will be prepared. First, 30 kg/day (Max: 50 kg/day) of organic waste will be added and stirred continuously in one pile (Pile A) for 2 weeks. Then, stop adding waste and compost will mature, while start to add waste to another pile (Pile B). After 2 weeks of drying and maturation (frequency of stirring to be reduced to once per 2-3 days), excess amount of compost will be extracted and shredded, leaving behind 1 m3 for continuously adding waste. As such, adding waste and maturation will take place alternately between the two piles.

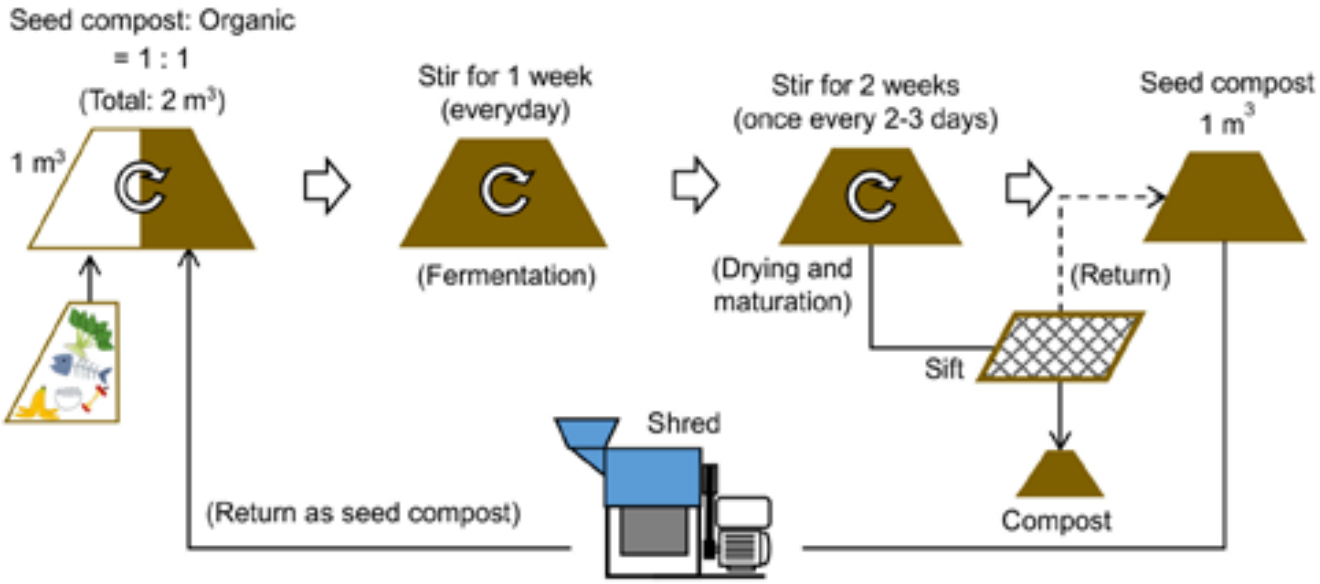


Type	Household (0.5 kg per household)	Daily input of organic waste (kg/day)	Expected output (compost) (kg/day)	Compost piles	Example of layout (one unit represents 2 m^2 of compost piles)	Required space (m^2)
TYPE 2: Rotation input	120-200	60-100	12-20	1 m^3 x 4 (2 active; 2 maturation)		24
	180-300	90-150	18-30	1 m^3 x 6 (3 active; 3 maturation)		32
	240-400	120-200	24-40	1 m^3 x 8 (4 active; 4 maturation)		40

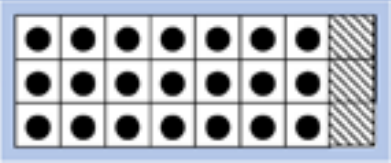
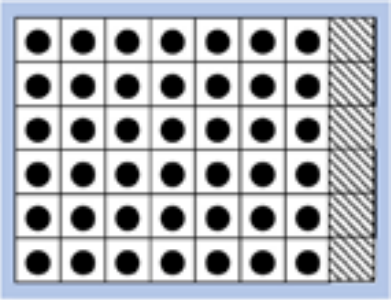
One unit pile of compost: active (1-2 m^3) One unit pile of compost: maturation (1-2 m^3)
Extra open space

TYPE 3: Batch

A compost pile with a size of 1 m^3 will be mixed with organic waste of about 1 m^3 (about 500 kg). This 2 m^3 pile will be mixed everyday for 1 week without any additional input of waste. After that, the frequency of stirring can be reduced to once per 2-3 days for the next two weeks. During the process, organic materials will be decomposed and excess moisture will evaporate, thus the volume of compost bed will gradually decrease. After 3 weeks, part of the compost will be shredded and sifted for compost use, and the remaining 1 m^3 will be returned to the process as seed compost to be mixed again with fresh organic waste.



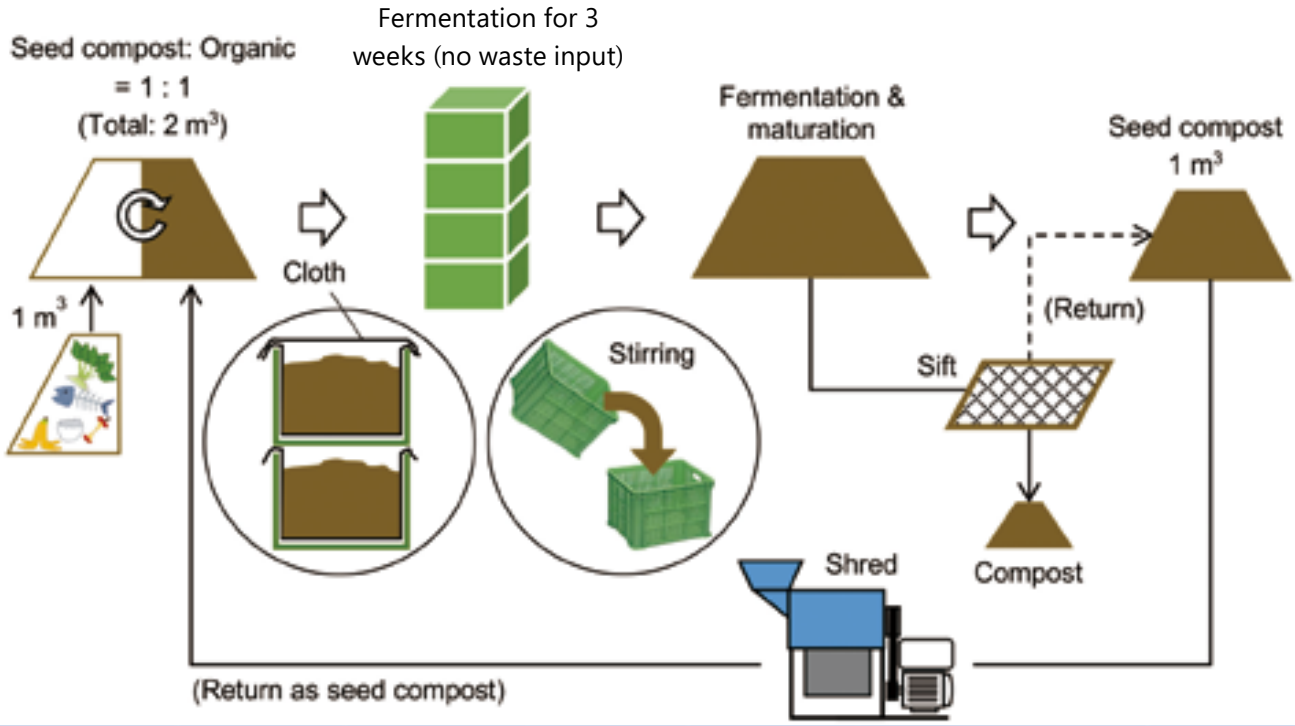
The maturation period is 2 weeks, so you will need a space for 14 piles. If the organic waste will not be collected everyday but 5 times per week, the necessary space will be reduced to 10 piles.

Type	Household (0.5 kg per household)	Daily input of organic waste (kg/day)	Expected output (compost) (kg/day)	Compost piles	Example of layout (one unit represents 2 m^2 of compost piles)	Required space (m^2)
TYPE 3: Batch	500	250	50	1 m^3 x 21		96
	1,000	500	100	2 m^3 x 21		
	1,500	750	150	1 m^3 x 42		192
	2,000	1,000	200	2 m^3 x 42		

One unit pile of compost (1-2 m^3) Extra open space

TYPE 4: Container

When the space is limited and/or there is a specific need for flexibly moving the location, a method using a plastic container may be introduced. The same volume of compost and organic waste (1 : 1) will be mixed, and put into mesh containers (40 L) covered with a cloth for preventing compost leaking and attracting flies. After stirring the contents of containers for three weeks, sift the compost for use and the remaining 1 m^3 will be shredded and returned to the process as a seed compost to be mixed again with a fresh organic waste. For ease of operation, opening up the contents to an empty container will have a same effect as stirring. Due to good ventilation in a mesh container, fermentation and drying can be enhanced, and therefore the frequency of stirring of compost could be reduced to once per 2-3 days, or even be omitted.



Type	Household (0.5 kg per household)	Daily input of organic waste (kg/day)	Expected output (compost) (kg/day)	Containers	Number of stacks (4 containers per stack)	Required space (m^2)
TYPE 4: Container	80	40	8	40 L x 4	1 stack	0.5
	160	80	16	40 L x 8	2 stacks	1.0
	240	120	24	40 L x 12	3 stacks	1.5

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