BACK TO EARTH

COMPOSTING FOR VARIOUS CONTEXTS

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gaia

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GAIA is a global network of more than 800 grassroots groups, networks, NGOs, and individuals. We envision a just, Zero Waste world built on respect for ecological limits and community rights, where people are free from the burden of toxic pollution, and resources are sustainably conserved, not burned or dumped. We work to catalyze a global shift towards ecological and environmental justice by strengthening grassroots social movements that advance solutions to waste and pollution.

ABOUT THE AUTHOR

Shibu Nair is the India Coordinator of GAIA Asia Pacific. He is one of the pioneers of the Zero Waste movement in India. He led the Zero Waste campaigns and programs for Thanal — one of the oldest environmental organizations in South India. His expertise is in organics management, designing and developing Zero Waste systems at community level, and strategizing Zero Waste programs and campaigns. Shibu has authored several publications, among them: *Caste and Gender: The Social Barriers to Solid Waste Management in India (2015)* and *A Handbook on Solid Waste Management for Rural Tourism Areas: A Zero Waste Approach* (2008) which he co-authored with Jayakumar Chelatone. He has likewise given numerous lectures on organic waste management and Zero Waste.

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LIST OF ACRONYMS

GHG	Greenhouse Gas
FRP	Fiber Reinforced Plastic
BSF	Black Soldier Fly
MRF	Materials Recovery Facility

LIST OF FIGURES

GLOSSARY

Aerobic Digestion	The biological process through which microorganisms decompose biodegradable discards in the presence of oxygen
Anaerobic Digestion	The biological process through which microorganisms decompose biodegradable discards in the absence of oxygen
Compost	A humus-like matter resulting from decomposition process which can be used as a soil conditioner to replenish the soil carbon and micronutrients
Mesophilic bacteria	Bacteria that grow in moderate temperatures, from 20°C to 45°C
Inoculum	A balanced colony of microorganisms for composting, often cultured in solid or liquid media, that accelerate the composting process by enhancing the population and strength of microorganisms needed for composting discards
Leachate (specifically from composting)	The liquid that seeps from the decomposing organic material in the composting unit. Also called a compost tea, it can be used as fertilizer.
Microorganisms	Microscopic organisms which may exist as unicellular, multicellular, or cell clusters. There are six major types of microorganisms: bacteria, archaea, fungi, protozoa, algae, and viruses.
Slurry (specifically, biogas slurry)	A by-product of anaerobic digestion produced from a biogas plant or a biodigester that can be used to fertilize crops

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PHOTO BY VEEJAY VILLAFRANCA

CHAPTER 1

WHY COMPOST?

More than half of the waste generated in Asia is organic. This presents a good opportunity for waste managers. Just by segregating waste and managing the organic discards properly, more than 50% of the waste generated will be managed.

Municipal solid waste management is a growing challenge in Asian cities, but if we look at the composition of waste, a big percentage—typically more than 50%—is organic.[1] The high percentage of organic discards presents a good opportunity for waste managers. If organic discards are segregated properly and handled separately, that is more than 50% of the problem solved. That means we will already be halfway through to achieving Zero Waste. Fortunately, organic discards are manageable. There are numerous methods that we can use to sustainably manage organic discards. The hurdle is in overcoming a crucial step—getting people to segregate their waste at source. It is when biodegradable and non-biodegradable discards are mixed that waste management becomes a complicated undertaking.

Segregation at source is key when it comes to the handling of organic discards. Segregation alone can solve about 50-60% of the problem of municipal solid waste management. The challenge in municipal solid waste management is getting the organic discards decomposed and stabilized in a controlled manner and in a limited space without posing a nuisance to the neighborhood and without impacting environmental health. Hence, the best scenario is decentralized management where organics is managed at the source.

The reality in some places is that limited space prevents waste generators from managing their own waste. In such cases, the second best scenario is setting up composting areas closest to the source. This means that, if organic waste management cannot be done in the household (the source), then the second best place to manage it is in common spaces in the neighborhood like at the materials recovery facility, or in designated spaces in the community dedicated to managing organic discards.

Fortunately, as mentioned, there are numerous ways to manage organic discards. There are composting units and methods for various contexts—even in small spaces—making the lack of space no longer an issue. Some of these methods will be presented in this publication.

When it comes to managing organic discards, the only logical, scientific, safe and affordable option is through a biological process. There are two biological processes, namely aerobic (with oxygen) and anaerobic (without oxygen). For each of the processes, there are many variants available from which a waste manager can choose to suit their scenario.

1.1 NUTRIENT RECOVERY

Planetary boundaries is a framework developed by a group of earth and environmental scientists.[2] The framework assesses the limits of the earth's systems which decides the sustainability of life on earth. Biogeochemical flows (phosphorus and nitrogen cycles) is one of the nine planetary boundaries.[3]

This team of scientists warns that we have already crossed four out of nine planetary boundaries: climate change, loss of biosphere integrity, land system change, and altered biogeochemical flows or the nutrient flow.

Nitrogen and phosphorus are the two primary biological nutrients which help living organisms to form proteins, enzymes, and organic compounds. They are important in building DNA by being exchanged and distributed throughout the biosphere. The degradation of soil due to human activities have interfered with this vital nutrient cycle.

Nitrogen gas, which is abundant in the atmosphere, is not available for organic use. It is the bacteria in soils that capture it and convert it into ammonia and then nitrate for plants to absorb. This nitrogen moves through herbivores that distribute this nitrogen throughout the ecosystem.
Phosphorus also moves in a cycle through rocks, water, soil, sediments, and organisms. Human interventions disrupted the phosphorus cycle by rampant use of synthetic nitrates and phosphates as fertilizers, which have created dead zones due to eutrophication.

Compost, which is the decayed organic material resulting from the composting process, adds organic matter and provides an ecosystem for bacteria to recover and replenish soils with nitrogen, phosphorus, and other vital nutrients that contribute to maintaining a balance in the nutrient cycles and therefore supports plant growth.

1.2 CARBON SEQUESTRATION

Carbon sequestration in soil, or the capture and storage of carbon in soil, has been recognized as one of the climate change mitigation measures by the United Nations Intergovernmental Panel on Climate Change.[4] Compost adds more organic matter into the soil and improves upon soil organic carbon. This results in better yields, better retention of water, and better defence for soil erosion. Agricultural practices liberate carbon from soil, and composting is the process which facilitates the replenishment of carbon in soil. According to Hogg and Favoino[5],

> *"... this loss of carbon sink capacity is not permanent. Composting can contribute in a positive way to the twin objectives of restoring soil quality and sequestering carbon in soils. Applications of organic matter (in the form of organic fertilizers) can lead either to a buildup of soil organic carbon over time, or a reduction in the rate at which organic matter is depleted from soils. In either case, the overall quantity of organic matter in soils will be higher than using no organic fertilizer. What organic fertilizers can do is reverse the decline in soil organic matter that has occurred in relatively recent decades by contributing to the buildup in the stable organic fraction in soils, and having the effect, in any given year, of ensuring that more carbon is held within the soil."*

Hence, composting can be your climate action, a positive step towards climate resilience.

What are Organic Discards?

Organic discards are often called wet waste due to their high moisture content. Organic discards are also termed "biodegradable discards" since they degrade according to natural biological processes.

The number of days in a biological process may vary based on the dominating characteristics of the organic discard, the methods used to manage the compost, the climate, etc. For example, if the organic waste is dominated by slow-decaying discards such as tree trimmings, bones, feathers, and hair, it may take longer for it to decompose. If it is dominated by fast-decaying discards like food leftovers, meat discards, and vegetable parts, it will decompose within a comparatively shorter period.

[1] World Bank. What a Waste 2.0. http://datatopics.worldbank.org/what-a-waste/trends_in_solid_waste_management.html
[2] Nine Planetary Boundaries, Stockholm University https://www.stockholmresilience.org/research/planetary-boundaries/the-nine-planetary-boundaries.html
[3] Steffen et al. 2015. Planetary Boundaries: Guiding human development on a changing planet. Science Vol. 347 no. 6223
[4] Assessment Report 5. Climate Change 2014.Mitigation of Climate Change, IPCC. (https://www.ipcc.ch/report/ar5/wg3/) Pg 829, Chapter 11.3
[5] Faviono, Enzo and Dominic Hogg. The Potential Role of Compost in Reducing Greenhouse Gases https://www.researchgate.net/publication/5513046_The_potential_role_of_compost_in_reducing_greenhouse_gases
[6] Uses bacteria that grows in moderate temperature, from 20°C to 45°C
[7] Uses bacteria that thrives at relatively high temperatures, between 41°C and 60°C

CHAPTER 2

AEROBIC COMPOSTING

Aerobic composting is a simple natural process of decomposing biodegradable discards. It needs two things for it to happen: oxygen and microorganisms.

PHOTO BY THOMAS VARGHESE

The biological process through which microorganisms decompose biodegradable discards in the presence of oxygen is called aerobic digestion. The resultant is called compost, a humus-like matter which can be used as a soil conditioner to replenish the soil carbon and micronutrients.

Composting happens in nature with the help of microorganisms like bacteria, actinomycetes, fungi, rotifers, protozoa, etc. Aerobic digestion is completed through repetition of two major stages in a cyclical manner: mesophilic and thermophilic.

In the first stage, mesophilic bacteria (bacteria that grow in moderate temperatures, from 20°C to 45°C) initiate the digestion process, generating heat. They decompose simple and ready-to-decay compounds under 40°C, and as the temperature increases, they become inactive. The thermophilic bacteria (bacteria that thrive at relatively higher temperatures, between 40°C and 60°C) take over from this point and decompose complex compounds such as lignin, cellulose, and proteins. The temperature rises to 60°C, making it difficult for any microorganism to thrive. Once the thermophilic bacteria become inactive, the temperature goes down. When it cools down, the mesophilic bacteria get re-activated. They look for leftover materials to be decomposed and as they act on these leftover materials, the temperature rises again. The mesophilic bacteria get deactivated once more while the thermophilic bacteria come back to finish anything left behind. This cycle continues until there is nothing left to decompose. Once all organic material has been digested by the two major bacteria, the product of this cycle cools down to form compost.

Understanding these process helps us to control the aerobic composting process to manage organic discards in a more efficient way.

2.1 HOW TO COMPOST

Perhaps even without knowing the exact science and process of composting or decomposition, we may still be applying the science of composting in our daily life, either to prevent or slow down the composting process or to speed up the decomposing process. For example, when we do the following to preserve some materials and food from disintegrating or rotting:

- Keep wooden furniture dry and coated with paint
- Brush and polish leather shoes, bags, and coats
- Preserve vegetables and fruits in salt or vinegar
- Sun dry or smoke meat

Through all these processes, we are trying to delay or slow down the decomposition of materials. Adding salt or vinegar prevents the growth of microorganisms; keeping objects completely dry makes the microorganisms inactive; and adding paint coatings or polish keeps the microorganisms out.

We do the following to speed up the process of decomposition to get a desired result:

- Adding mother curd to warm milk to get it fermented to form curd
- Adding yeast to get dough fermented to make breads
- Adding jaggery to get fruits fermented to make wine

We know all these. So, let us apply this knowledge to organic discards to get them composted.

2.2 FACTORS AFFECTING COMPOSTING

There are four main factors that determine the process of composting: (1) microorganisms, (2) moisture, (3) oxygen, and (4) carbon-to-nitrogen ratio.

2.2.1 Microorganisms Composting is a biological process mainly assisted by microorganisms like bacteria, fungus, rotifers, protozoa, yeast, and so on. Presence of a healthy colony of microorganisms with sufficient strength will ensure efficient composting. The major sources of microorganisms include cow dung, curd, rotten vegetables and fruits, and topsoil collected under the shadow of a tree. Matured compost harvested from an existing heap of compost can also be used as a starter to initiate a new composting process.

Inoculums, a balanced colony of microorganisms for composting, often cultured in solid or liquid media, accelerate the composting process by enhancing the population and strength of microorganisms needed for composting the discards. Inoculums are often cultured in biological laboratories in large quantities and made available for sale in the market. Inoculums can also be made at home, but the efficiency and precision of home-made inoculums will not be as good as that of laboratory-made inoculums.

Making Inoculums at Home

Materials Needed

Overripe banana
Overripe pumpkin
Overripe papaya
Jaggery
Green gram flour (or flour from any protein rich pulses) 250 grams each
2 glass jars or PET containers, 2L or bigger
2–3 eggs

1. Slice the pumpkin, banana, and papaya into small pieces.

2. Mix the banana, pumpkin, papaya, and flour in one container.

3. In the other container, add one liter of water to the jaggery to make a solution.

4. Pour the jaggery solution into the container with the mixed ingredients. Mix it well.

5. Pour the white and yolk of the egg on the top of the mixture to form a layer to prevent bacteria from getting in.

6. Close the container with an airtight lid and keep it in a dark corner for 15 to 20 days.

7. After 20 days, open the container and stir the mixture and strain it to get the liquid.

8. Take 100 ml of the solution. Add a liter of water to the 100-ml solution. Mix well and apply as inoculum for composting.

9. Store the rest of the liquid for future use. The liquid may be stored for three months.

2.2.2 Moisture

Moisture provides a conducive environment for microorganisms to thrive. For efficient composting, the moisture level should be maintained somewhere near 50%. Organic discard that is neither dry nor leaching is assumed to have 50% moisture. If the materials in the compost pile are too wet, air circulation will be poor, leading to anaerobic digestion. This will result in bad odor due to the formation of hydrogen sulphide. On the other hand, if the materials in the compost pile are too dry, the bacteria will become inactive, and the composting process will slow down. To maintain a balanced moisture level, mix the wet materials with dry materials like dry leaves, rice husk, saw dust, wood chips, etc. These materials will absorb extra moisture, thus enabling a more effective environment for composting.

2.2.3 Oxygen

Aerobic bacteria need oxygen for the composting process to happen. The compost pile should be managed in a way that ensures air penetration to all parts of the compost pile. In a normal tropical condition, the air penetration at natural atmospheric pressure is limited to a depth of 60 centimetres. Any compost material kept beyond that may not get adequate aeration. In such conditions, it is important to provide aeration using an air compressor or by turning the compost pile once a week.

Layering the compost materials with spongy materials like dry leaves and wood chips in between the layers of organic discards will provide for air columns required for aerobic composting. This method will avoid the need for turning the discard and/or artificial aeration.

2.2.4 Carbon/Nitrogen Ratio

The bacteria require a tremendous amount of energy for breaking down the organic materials in the compost pile. Carbon forms the source of energy for them, hence a compost pile should maintain a carbon-to-nitrogen balance. For every single part of nitrogen, about 30–40 parts of carbon need to be supplied for an efficient composting process.

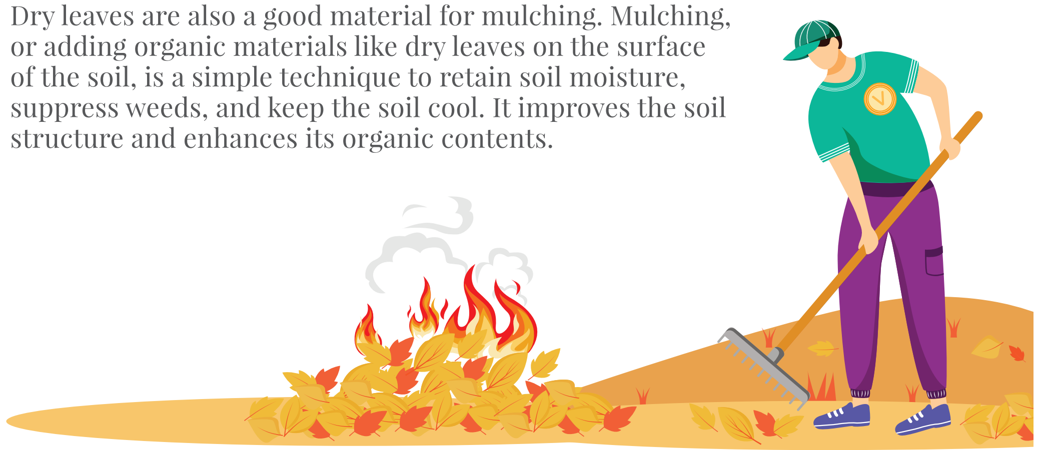
The organic material contains both carbon and nitrogen, but some materials are nitrogen rich and some are carbon rich. Cooked food, meat discards, and wet vegetable discards are nitrogen rich. Dry leaves, wood chips, paper, grass cuttings, and twigs are carbon rich. Based on the nature of feedstock for composting, adequate carbon-rich materials need to be mixed for effective composting.

Don't Burn Dry Leaves

Burning dry leaves remains a common practice even in countries and communities where it is illegal to do so. Besides being a fire hazard, burning dry leaves is also bad for the environment and to human health. It causes air pollution and produces irritating particles and gases that can exacerbate asthma and cause other breathing disorders.

Dry leaves are an important resource, thus burning them does not make sense. Leaves contain nutrients which are best returned to earth via composting. Dry leaves are a good component in composting as they are carbon rich.

Dry leaves are also a good material for mulching. Mulching, or adding organic materials like dry leaves on the surface of the soil, is a simple technique to retain soil moisture, suppress weeds, and keep the soil cool. It improves the soil structure and enhances its organic contents.



2.3 DESIGNING A COMPOSTING UNIT

The number of days to get organic material composted is dependent upon the nature of the material, its size, volume, and the type of composting process you want to implement. In a tropical condition, it may take 40–60 days to compost organic discards from households. Tree trimmings and grass cuttings will take longer—up to 90 days. The number of days can be brought down to 15–20 days by reducing the size of materials using slicers or shredders and adding materials that are rich in microorganisms such as cow dung and curd, among others.

The daily average quantity of organic discards needs to be assessed before designing a compost facility. The rule of the thumb is that one kilogram of segregated organic discards is almost two liters in volume. About 80% of organic materials are made up of water. When composted, this water content is lost and the material gets reduced to 20%. For example, a household generating 1 kg of organic discards daily that adopts a composting method which requires 40 days to compost must hold discards for 40 days at any given point of time. The discards fed on day 1 will have composted on day 40. Hence, the volume or space required for composting organic materials daily can be calculated on the basis of the number of days required for composting and average daily feed stock.

For efficient, continuous, and easy management of composting and compost harvesting, it is advised to use a minimum of two containers for composting. Each one should have a capacity to hold organic materials for half of the cycle of the composting process. For example, a composting process that takes 40 days to decompose (composting cycle) requires two bins to hold organic materials for 20 days each. Once the first bin is full on the 20th day, it is left to "sleep" to allow the compost to mature while the other one is used for feeding. When the second one is full on the 40th day, the first bin will have completed the full cycle of composting and will be ready to be harvested. Empty the compost on the first bin and use it for feeding while the second bin is left for sleeping.

Figure 1. Volume of Waste Before Composting and After Composting

After composting, the volume of the resulting compost will just be 20% of its original volume.

2.3.1 Calculating Space Requirement for a Composting Unit

As mentioned, organic discards are made up of about 80% water which will be lost in the composting process. Hence, the quantity of discards at the end of the composting process will be 20% of the discards fed on day 1. For practical purposes, we assume that if the daily intake of the quantity of organic discards is d and the number of days required to compost is n, at the end of the composting cycle, the total quantity will be 20% of d. The reduction of weight assumed here is equally distributed in n days. It forms an arithmetic progression series which starts at 'd' and ends at '0.2d' and the count of series is n.

Calculation of volume is dependent upon the nature of organic discards. The volume factor has to be derived after studying the discards. The volume factor changes with the pre-treatment of discards. For example, it is generally assumed that 1 kg of assorted and untreated municipal organic discards will occupy a maximum 2 liters of space. In this case, the volume factor is 2. But in some places, there is a pre-treatment system for organic discards before sending it for composting. This pre-treatment is generally shredding or grinding. This reduces the volume of discards below 2 liters and slightly above 1 liter. In this case, the volume factor may vary from 1 to 2 depending upon the shredder or grinder used.

Hence $V = n(0.6d)\,f$

V = Total volume
n = Number of days
d = Daily intake of discards
f = Volume factor

Example

Let's calculate the volume required for a composting bin where daily intake is 15 kg and number of days required for composting is 30 and the volume factor is 2 (1 kg of discards is 2 liters in volume)

n = 30, d = 15kg, f=2

$$\begin{aligned} V &= n(0.6d)f \\ &= 30\,(0.6 \times 15)\,2 \\ &= 30 \times 9 \times 2 \\ &= 540 \text{ liters} \end{aligned}$$

Once we get this volume, we can design the bin, tank, or pit or windrow. To ensure efficient aeration, limit the depth of the pit/bin/tank to 50 cm and the width to 1.5 m if they are built below ground level. If the bin or tank is built above ground with provision for aeration from bottom to top, then limit the height and width to 1.5 m.

With the above example, the size of the pit can be calculated as follows:

Scenario 1. Below Ground
Depth 0.5 m, Width 1.5 m,
Length = Volume (m^3) / Depth x Width
0.54 m^3 / 0.5 m x 1.5 m = 0.72 m.

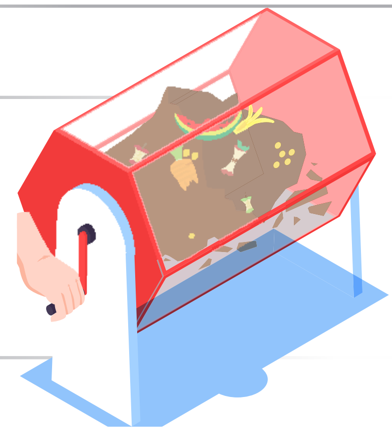
Scenario 2. Above Ground
Height 1.5 m, Width 1.5 m, Length = Volume (m^3) / Height x Width)
0.54 m^3 / 1.5 m x 1.5 m = 0.24 m.

2.4 THINGS TO REMEMBER: GOOD PRACTICES IN COMPOSTING

Size matters. The smaller the size of organic materials, the larger will be the surface area. This will help bacteria to break down the material in a faster way. Slicing, mincing, shredding, or grinding organic discards before feeding them to the compost facility yields better quality compost in a shorter period of time.

Mix it well to get it well. Mixing or layering of dry or carbon-rich organic materials with wet nitrogen-rich organic discards helps to retain desirable moisture level, carbon-to-nitrogen ratio, and aeration.

Turn it. Turning organic materials in a compost pile or bin at regular intervals speeds up the process of composting and prevents the production of bad odor.



No antibacterial agents. Composting is a bacterial process. The presence of any antibacterial substances will slow down the process of composting. Excess salt, lotion, detergent, oil, deodorants, pesticides, and the like will kill or hinder the microorganisms in the composting process.

Right diet. Like us, composting requires the right diet. There has to be a balance of nitrogen-rich materials and carbon-rich materials in the compost.

2.5 DIFFERENT METHODS OF SETTING UP COMPOSTING

2.5.1 Windrow Composting (Composting Cycle 40–50 Days; Best for Municipal Setting)

Windrow composting is one of the most popular composting methods at municipal/city level for composting large quantities of organic discards (500 kg to several hundred tonnes per day) at centralized plants. Organic materials are piled up on the floor or ground in the shape of a long rectangular pyramid against the wind direction. This setup allows for maximum aeration. The width of the base of windrows and its height varies from place to place based on the availability of land and machinery for turning the discards. Windrows need turning at frequent intervals for aeration and temperature regulation to maintain optimum moisture levels for effective composting. In tropical climatic conditions, it will take 40 days to complete the composting process. Batch processing is followed in windrow composting where a day's organic discards will be considered as one batch and is formed into one windrow. A batch should have a minimum 500 kg of organic discard to ensure volume to maintain the heat. So, a typical compost facility will have 40 windrows at any given point of time. The windrows need to be turned once in 10 to 15 days to maintain the optimum aeration, heat, and moisture. Every day, a windrow will be created while one will simultaneously be eliminated in the form of compost.

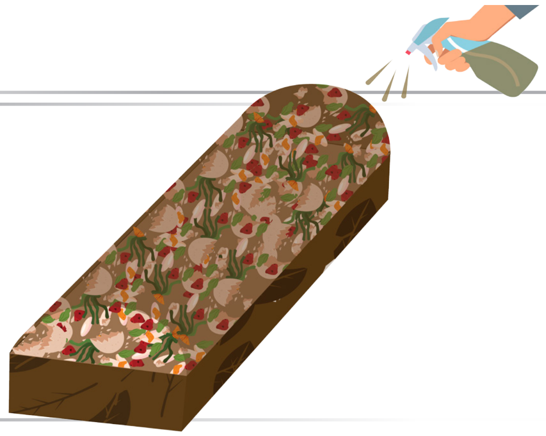
Steps

1. Find a leveled ground which is not a water logged area. The place should have adequate air circulation and preferably a roof to prevent rain from getting inv.

2. Spread dry leaves, saw dust, wood chippings, residuals from composting or any other slow-decaying, carbon-rich materials in 4 to 6 inch (10 cm to 15 cm) thickness to form a cushion bed. The width should be limited to 2 meters and there is no limit to the length. It depends upon the availability of space and quantity of discards generated.

3. Make a layer of shredded organic discards on the top at a thickness of 4–6 inches (10 cm to 15 cm). The width should be narrower than that of the first layer.

4. Sprinkle the first layer with inoculum or old compost.



5. Add another layer of dry leaves, saw dust, wood chippings, etc. Ensure that the width is narrower than that of the previous layer. In short, every layer added should be narrower than the last. Continue this alternate layering until the setup reaches a height of 1 to 1.5 meters.

6. The first windrow is ready. The next day, make another windrow next to it at a minimum distance of 2 meters. Continue the process of making up to 40 windrows.

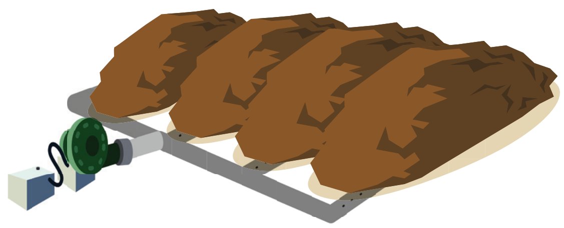
7. On the 41st day, the oldest windrow will be ready for harvesting. Take it out and sieve it to get fine compost. The residuals are often reused as layering material in the composting process.

Note: In places where windrow composting is done outdoors and where there are no water bodies, it is okay to leave the leachate (the liquid) from the compost for the soil to absorb. However, it is always preferred to have a constructed platform with adequate seepage holes and collection channels to drain, collect, and treat the leachate formed in the compost piles during the composting process. In places where humidity is high, the quantity of leachate will be higher. Since leachate is highly active with microorganisms, it can be recycled in the compost piles to speed up the composting process. The leachate can also be used for agricultural purposes as a fertilizer after diluting it with 3–10 times of water. If the daily quantity of leachate is less than 5 liters, a soak pit on the ground is enough. For large-scale composting facilities where daily intake of organic discards is above 1 tonne, it is recommended to have a leachate treatment facility.

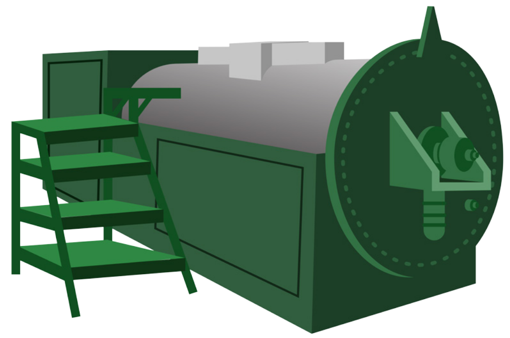
Variants

a. Aerated Static Pile Composting

Aerated static pile composting is a modified version of windrow composting. It is an aerobic composting method where the feedstock or organic discards in large quantities are laid as a long pile in an open area, much like in windrow composting. There are perforated tubes underneath each pile which is connected to an air compressor that aerates the discards pile. This method eliminates the need for turning the discards and accelerates the composting process.



b. Mechanized Composting



There are different types of composting machines available in the market. These machines convert the feedstock or organic materials into compost in 12 to 24 hours. Technically, these are just organic discard converters which grind the discards and maintain optimum temperature, moisture, and bacteria population for accelerated decomposition. These machines deliver a comparatively stabilized output which needs further curing and maturing for 15 to 20 days. These mechanized composting strategies are capital intensive and consume a lot of energy and inputs, but they are suitable for organizations and institutions with limited space.

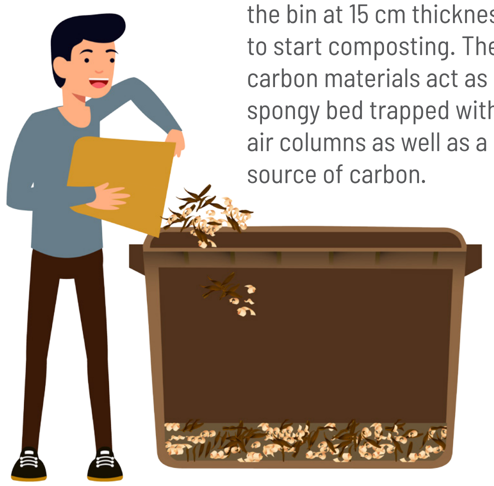
2.5.2 Bin Composting (Composting Cycle: 50–60 Days)

Rectangular box type bins or tanks built above ground are used to hold organic discards for composting. This composting technique is suitable for institutions, residential complexes, and cities that follow decentralized solid waste management systems.

Four sides of the tank or bin will have holes for aeration. Aerobic bins can be used for batch processing as well as continuous processing of organic discards. In a continuous process, a unit normally consists of two bins. The width and height of such bins are fixed to 1.5 meters to ensure air penetration to the bottom of the pile as well as to the center of the pile. There is no limit to the length of the bin, but a dimension of 1.5 m x 1.5 m x 1.5 m is the most efficient for trouble-free composting.

Steps

1. Place a layer of high-carbon materials like dry leaves, rice husk, or wood chips at the bottom of the bin at 15 cm thickness to start composting. The carbon materials act as a spongy bed trapped with air columns as well as a source of carbon.



2. Add organic discards about the same height as the carbon-rich materials.

3. Spray inoculum to activate the bacteria colony for composting.

4. Cover it with a layer of dry leaves or wood chips.

5. Repeat steps 2–4 until the bin is filled. This kind of layering eliminates the need for turning compost piles.

Tanks with holes on all sides used for composting often face issues of leachates oozing out of walls. In some places, bins are created without holes on the walls. Instead, they provide artificial aeration using an air compressor through the bottom of the compost tank.

Ready-made bins made of plastic or FRP (fiber-reinforced plastic) materials are available as ready-to-install and portable compost bins. It can be mounted on the rooftop of flats or in the garden.

Variants

a. Thumboormuzhi Aerobic Compost Bins

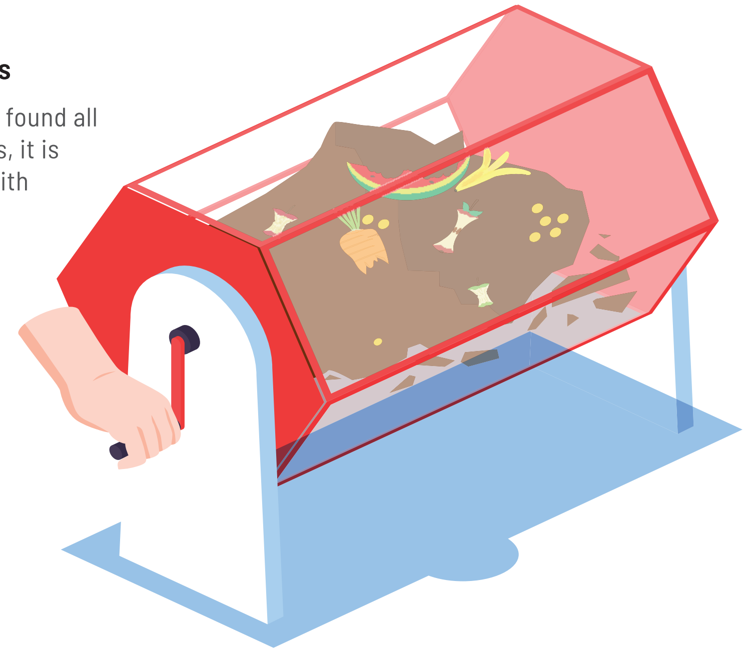
The Thumboormuzhi aerobic compost bin is a composting method perfected by Dr. Francis Xavier, Professor at Kerala Veterinary and Animal Science University in Kerala, India. This model was developed in the Thumboormuzhy campus of the university, hence the name.

In this method, cubicles of 4 ft x 4 ft x 4 ft (1.2 m x 1.2 m x 1.2 m) in size are used to hold materials for composting. The cubicles are designed with prefabricated ferro cement pillars and narrow slabs. There is a gap between the two slabs which is equal to the width of each slab to enable free flow of air from all sides of the cubicle. The material for composting is layered in the cubicle at 6 inches (15 cm) thick and is sandwiched between two layers of equal thickness of dry leaves or any carbon-rich material sprayed with inoculum extracted from cow dung or cow dung slurry (1 part of cow dung mixed with 5 times of water).

Two cubicles are needed for continuous composting of about 40 kg of materials on a daily basis. Proper layering with dry leaves ensures enough supply of carbon and allows absorption of extra moisture as this also acts as a sponge to lock air molecules within the composting materials. This method does not require the manual turning of materials, yet it gets composted without the release of any bad odor. This is a modular design which is flexible enough to meet any quantity of materials. Moreover, the design is suitable for cities that cannot afford the space for centralized facilities for composting. It may even be installed along the sidewalk of busy roads. The government of Kerala popularized it for decentralized solid waste management in local self-governments and cities.

b. Rotating Drum Composters

Rotating drum composters can be found all across Asia. As the name suggests, it is a drum made of plastic or metal with or without perforation. The drum is rotated horizontally to stir the organic materials and inoculum deposited into it for composting. Rotating the drum helps in mixing the contents and improves aeration. This speeds up the composting process and eliminates chances of foul smell. There are automated and manual rotary drums available in the market. Automated large drums are used for bulk discards composting.



2.5.3 Pit Composting

Pit composting is one of the most popular methods of composting in Asia since it is a common practice to the culture and lifestyles of communities in the rural area, such as depositing organic discards to a pit dug in the backyard or field. Once the pit is full, it is closed and a new pit will be opened. In farming communities, instead of harvesting the compost, they simply plant crops on the top of closed pits.

In villages, it is a common practice to collect animal excreta like cow dung as it is considered a valuable manure for their fields. They deposit the organic discards together with the animal excreta in the pit for composting. While the bacteria present in the soil help the composting process, the process will become faster when it is done with animal excreta as it provides additional microbes.

Some issues encountered when doing pit composting is when excess water during rains or high water tables trouble and prolong the composting process. Pit composts are also often visited by scavenging animals due to its exposed setup, which may later pose a threat to the people as well.

Around the world, pit compost has been modified to prevent these issues associated with it.

Variants

a. Tower Tire Composting

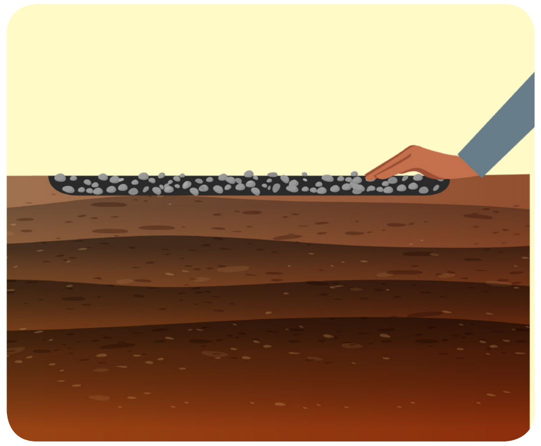
In the Philippines, especially in urban areas, onsite composting is done using discarded tires. In this method, stacks of two to three tires are used as a vessel for above-ground composting instead of a pit dug into the ground. The tires are durable, they can often withstand any climatic conditions, and they protect the organic materials from scavenging animals. Harvesting the compost from this approach is also easy, as one just has to lift the tires one by one to collect the finished product.

Steps

1. Find a suitable location which is not a waterlogged area.
2. Clear the land and dig a hole with 20 cm diameter and 10 centimeters deep.

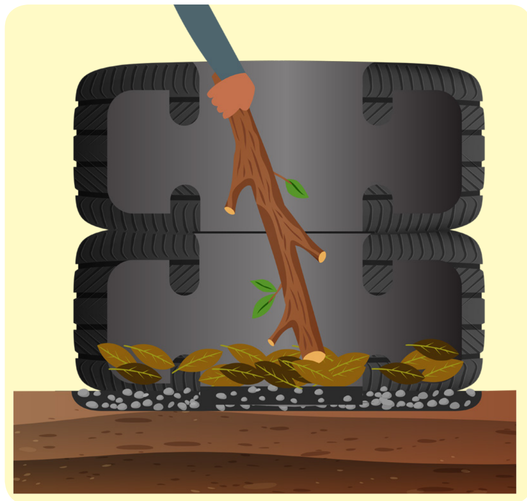
3. Fill the hole with gravel. This is for absorbing extra moisture and leachate from the composting.

4. Ram the earth around the hole to seat the tire.



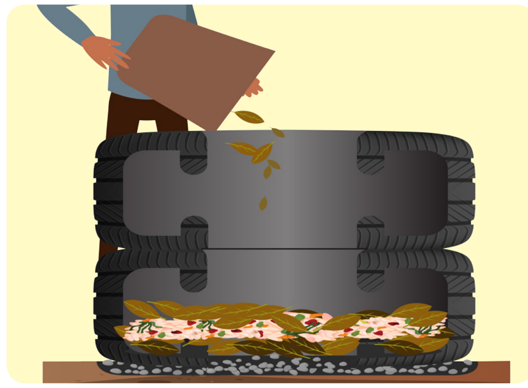
5. Place two tires one above the other by keeping the hole in the middle.

6. Line the bottom with dry leaves.



7. Pour the organic discards for composting.

8. Cover the discards with dry leaves.



9. Spray innoculum into the composting.

10. Keep doing steps 7-8 until the tower tire is full. You may add two additional tires on top if required.
11. Start a new unit when the tower is full. Harvest the compost from the first tower while feeding the second tower.

An innovation by the Consumers Association of Penang in Malaysia adds a pipe in the middle to increase aeration.

Recently, there were innovations in making compost receptacles using discarded tires. The tires are cut in a specific way to convert it into a proper shape of a compost vessel and then it is painted in colors to make it look like an aesthetically pleasing decoration for the space.

Precaution: Tires tend to leach chemicals into the soil and/or compost due to long exposure to sun and moisture. Hence, it is advised not to use the compost for cultivating edible plants to avoid contamination and prevent health issues from consuming potentially synthetic chemical-laden vegetables. Tires may be used as an intermediate or an ad hoc solution prior to establishing a permanent and proper composting system, but tires are not the right choice as a permanent solution.

b. Ring Composting

In the ring composting method, instead of a dug pit, two cylindrical rings with a minimum of 100 cm diameter and 50 cm height are placed side by side for composting. The ring may be made of cut metal or plastic barrels or ferro cement. The ring may be buried fully or partially on the ground. In some places, it is kept above ground. The ring gives protection from seeping water from the soil and it prevents exposure from scavenging animals. People may use a lid to prevent rainwater from entering the compost rings. In places where the water table is high, people add a non-permeable layer of plastic, clay, or cement in the bottom of the rings to prevent leakage. The compost is harvested periodically and the rings are emptied for continued use.

c. Biopore

Biopores are holes shaped like small hallways in the soil that are formed due to the various organic activities (flora and fauna) in them. The holes formed will fill with air, and will be a place for water to pass through the soil.

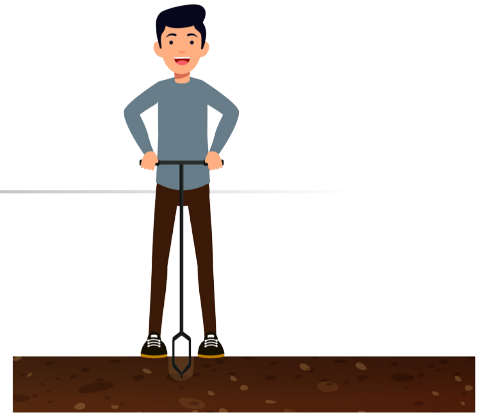
Biopores are habitats for soil fauna and plant roots that can also be inhabited by soil microorganisms. Biodiversity in soil requires nutrients (organic matter), water, and oxygen. This organic matter becomes a food source for various soil fauna to perform their activities including forming biopores.

Biopori diffusion holes, meanwhile, are man-made vertical cylindrical holes in soil and filled with organic matter (kitchen discards, garden discards, and other materials of natural origin). Yaksa Pelestari Bumi Berkelanjutan (YPBB), a GAIA member based in Bandung, Indonesia, is helping people practice this composting technique around the country.

When the hole is filled with organic matter, biopores are formed. Organic matter feeds food to the inhabitants of the soil, especially worms and other soil-boring insects, making them even more active in forming biopores. In trying to get the food, these soil inhabitants make small tunnels on the side of the vertical holes, giving room for air, water, and loosening the soil so that roots can penetrate the soil. After a while, you would also find roots in your biopores, where the nearest plant feeds on directly on the organic discards as they degrade.

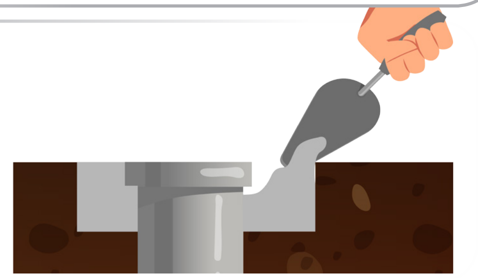
Soil rich in biopores are rich in organisms. As a result, the soil becomes fertile and healthy and has a better ability to digest various organic matter that we put into the biopore diffusion hole. Through time, the biopore diffusion hole becomes an even better means of processing organic discards.

Steps

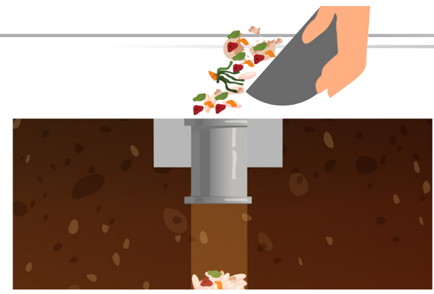


1. Select an area on the ground where the water table is very low and there is less foot traffic. Borders of gardens and parks are good options. Dig a hole 1 m deep, 10 cm in diameter using a ground drill[8] or crowbar. Ensure that the hole is perpendicular.

2. Insert the pipe into the hole, letting it stay close to the mouth. The pipe will secure the mouth of the hole.



3. Reinforce the pipe with cement. Give time for the cement to dry. If you produce large amounts of organic discards, you may make several biopore diffusion holes. The distance between each hole should be approximately 50 cm.



4. Feed the hole with kitchen discards, foliage, or other organic discards on a daily basis.

5. If you are putting in kitchen discards, cover it with soil or compost thick enough to prevent the setup from smelling. If you put garden discards or other organic discards that don't smell when they decay, there will be no need for it to be covered with soil.

6. Cover the hole to prevent scavenging insects from getting in by using a lid with holes big enough for sufficient aeration.
7. Do steps 4-6 every day until the pore gets filled. Once filled, leave it for six weeks for curing. Move on to the next biopore.
8. Harvest the compost after curing. Use a ground drill so that the biopore unit can be used again.

The biopores loosen the soil, fertilize it, and enable aeration aside from serving as carbon mooring. They also help water infiltration and retention, keeping the soil moist even in the dry season. They diffuse the nutrients to the subsurface soil, which helps with plant growth.

[8] If you do not have a biopore drill, a crow bar will do, or anything that can help in digging a vertical hole. If the hole is shallower than 1 meter, it is still okay.

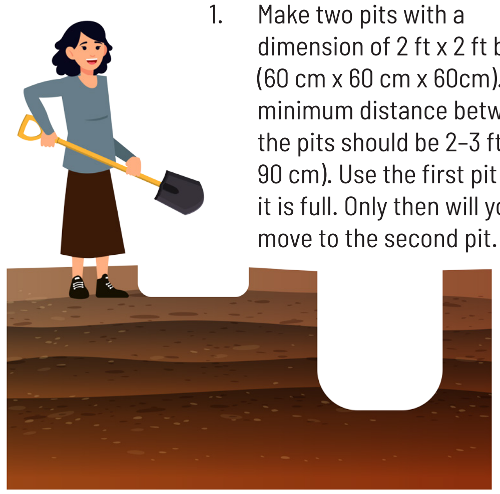
d. Pit Composting (Philippine Model)

This is a simple form of composting practiced in many Asian countries. This method has been further modified and optimized for better composting. GAIA member Mother Earth Foundation in the Philippines encourages people to follow this method as part of their Zero Waste campaign.

This is best for households with ample space in the backyard where the soil is exposed to air and sun.

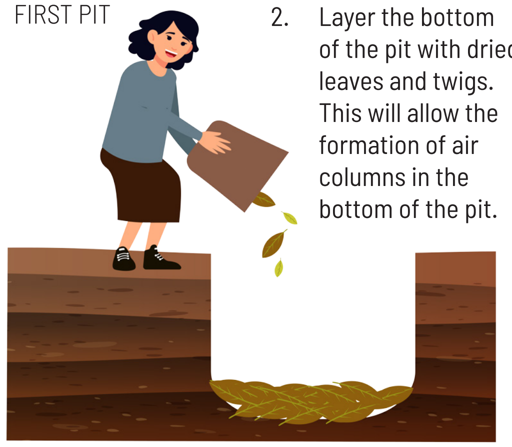
Steps

1. Make two pits with a dimension of 2 ft x 2 ft by 2 ft (60 cm x 60 cm x 60cm). The minimum distance between the pits should be 2–3 ft (60–90 cm). Use the first pit until it is full. Only then will you move to the second pit.



FIRST PIT

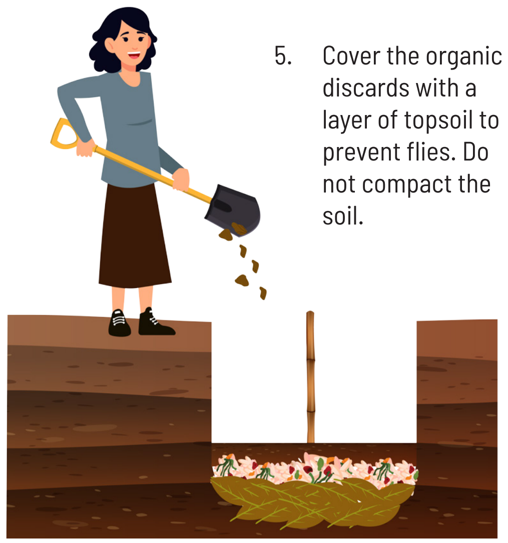
2. Layer the bottom of the pit with dried leaves and twigs. This will allow the formation of air columns in the bottom of the pit.



3. Erect a 2.5 ft (76 cm) long pipe or a hollow bamboo piece in the middle for additional air circulation.

4. Start layering the pit with organic discards from the household.

5. Cover the organic discards with a layer of topsoil to prevent flies. Do not compact the soil.



6. Continue steps 4–5 daily until the pit gets full.

Note: If it rains, cover the pit to protect it from excess seepage of water.

7. Once the pit is full, leave it for curing.

SECOND PIT

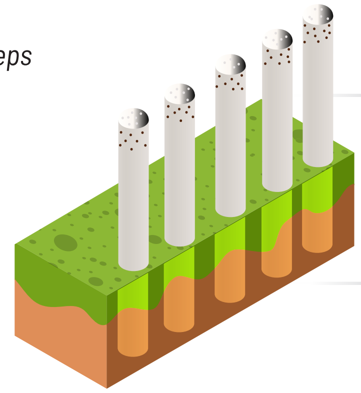
Move to the second pit. Do the same process as you did on the first pit. By the time the second pit gets full, which is about 3–4 weeks, the first pit would be ready for harvesting.

To test the maturity of the first pit, scoop a little portion from the top layer of the first pit and if it does not emit a foul smell, it is ready for harvesting. Empty the pit and get the compost dried in the shade. You now have compost for your garden crops.

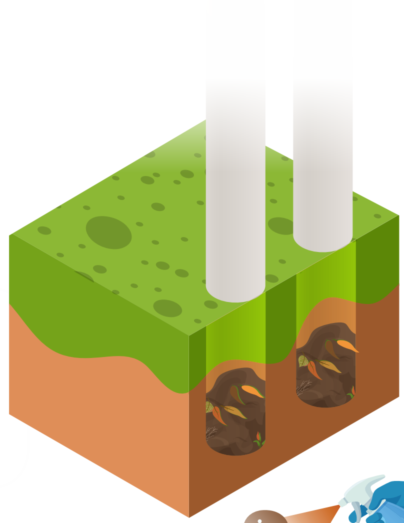
2.5.4 Pipe Composting (Composting Cycle: 50-60 Days)

Pipe composting is one of the simplest composting devices for households. Cement pipes, earthen pipes, or plastic pipes with a minimum of 20 cm diameter and 120 cm length are used for this. One end is buried on the ground or in a plant pot. The process is similar to that of an aerobic bin.

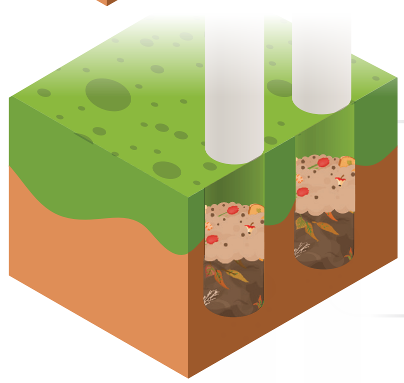
Steps



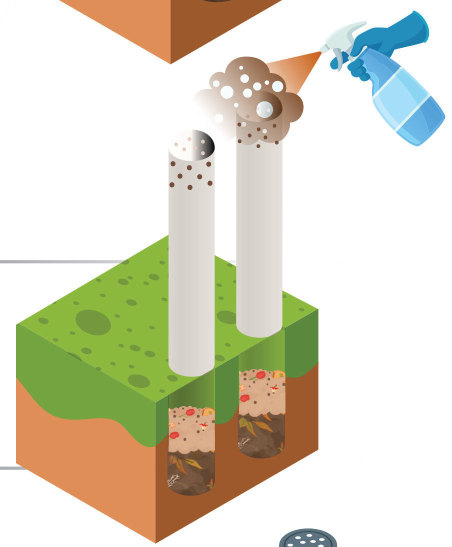
1. Bury the pipe on the ground or in a plant pot.



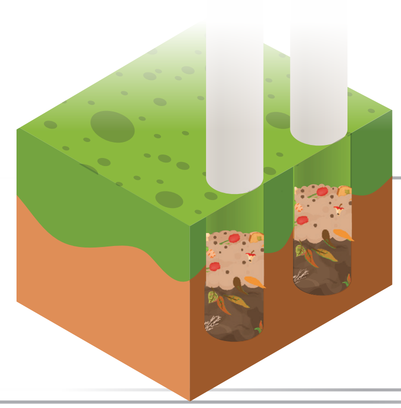
2. Layer the bottom with dry leaves.



3. Add a layer of organic discards.



4. Spray inoculum into the setup.



5. Put a layer of dry leaves.

6. Cover the pipe with a perforated lid to keep insects from getting into the setup. The holes on the lid will allow air into the setup for faster decomposition.
7. Repeat steps 2-6 until the pipe gets filled. Use the next pipe to continue.

The pipes can also be installed in a flower pot, bucket, or paint bucket filled with sand which makes it easy to move the pipe compost from one place to another. Installing the pipe in pots or bins allows pipe composting on the rooftop, perfect for high-rise apartment dwellers.

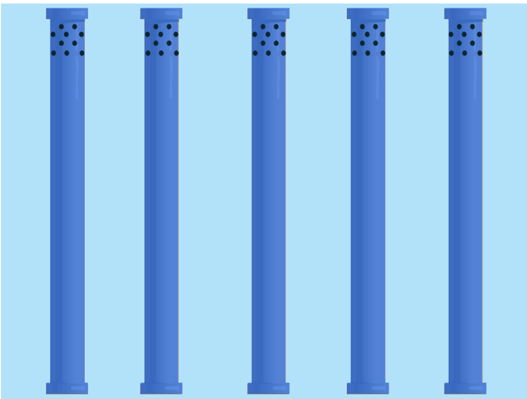
Variant

a. Comfort Composting (Malaysia Model)

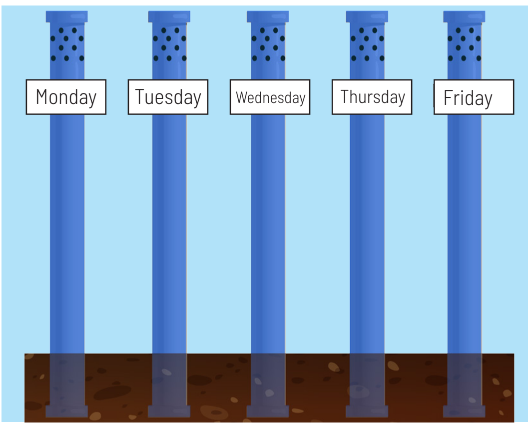
Comfort Composting is a composting method developed and popularized by the Consumers' Association of Penang (CAP), a GAIA member based in Penang, Malaysia. It is an extension of pit composting with an additional layer of protection. A PVC pipe 3–4 inches (76.2–101.6 mm) in diameter and 3 ft (91.4 cm) long is used in this process. Comfort composting is the recommended composting method for schools. Every day, the kitchen discards from the school canteen is fed to the pipe designated for the day. This gives ample time for the discards to get composted. This process will take longer due to less aeration inside the pipe.

Steps

1. On one end of each pipe, make several tiny holes, approximately 0.5 in (12 mm) in diameter, for aeration. This end will be the upper part of the pipe.

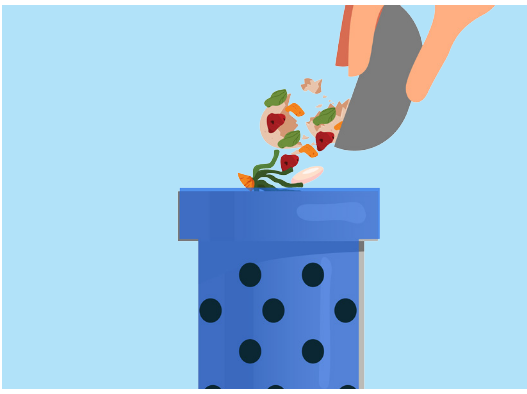


2. Erect the pipes on the ground by burying 3–4 inches (76.2–101.6 mm) of the bottom part of the pipe. Make sure that rainwater does not collect on the ground for your pipe composting. Assign and label pipes for each working day— Monday to Friday.



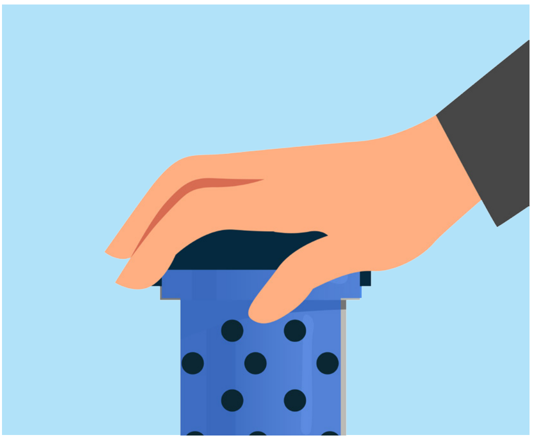
3. Pour the school's daily kitchen discards into the pipe. The kitchen discards produced on Monday should go to the pipe labeled Monday. Kitchen discards produced on Tuesday should go to the pipe labeled Tuesday. Follow the same process for the other days of the week.

Note: Make sure to drain the kitchen discards of moisture before putting them into the pipe.



4. Add a handful of soil—just enough to cover the discards to prevent foul smell.

5. Cover the pipes with anything that you can use to cover—cloth, used plastic sheet, etc.—to prevent insects from getting in and to prevent foul odor.



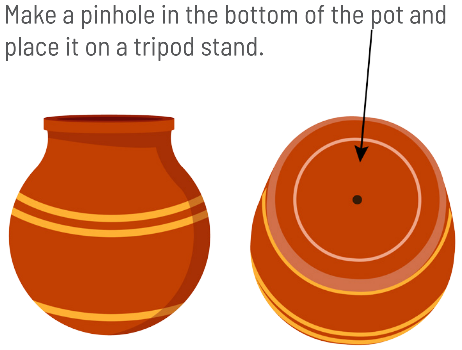
2.5.5 Pot Composting (Composting Cycle: 40-60 Days)

Earthen pots are known for porosity. This property makes it suitable for composting. The porous walls of the earthen pot allow air circulation in the pot.

Pot composting was promoted by Thanal, an environmental organization and GAIA member in India, during the solid waste management crisis in the city of Thiruvananthapuram, Kerala. Earthen pots are commonly available in India and South Asia.

Steps

1. Make a pinhole in the bottom of the pot and place it on a tripod stand.



2. Make a layer of dry leaves to form a spongy bed at the bottom of the pot.

3. Start feeding in organic discards at a maximum thickness of 3–4 cm. Spread the organic discards over the spongy bed of dry leaves or carbon matter at a thickness of 1–2 in (2.5–5 cm).

4. Spray inoculum into the compost.

5. Cover the organic discards with another layer of dry material.

6. Repeat steps 3–5 until the pot is filled.
7. Do the same for the second pot. By the time the second pot is full, the materials in the first pot can be harvested to reuse the pot for composting.

Note: Place a small bowl beneath the pots to collect the leachate/compost tea. It can be used as liquid manure provided it is diluted with 3–10 times of water.

Two pots with 15- to 20-liter capacity can manage about 1.5 kg of organic discards daily. It may take 20–30 days to get one pot full. By the time the second pot is full, the first pot must have covered 40–60 days, which is enough time to get materials composted. If necessary, use additional earthen pots to manage larger quantities of organic discards.

Variants

a. Flower Pot Composting (Philippines)

This is another version of pot composting, promoted in the Philippines by Mother Earth Foundation. In places where land is not suitable for pit composting due to water logging or presence of scavenging animals, or in high-rise apartments, flower pot composting is the next best option.

The process is almost like pot composting, where the flower pot will be lined with loose soil and/or dry leaves in the bottom and it is ready to receive organic discards. After layering it with organic discards, add a layer of loose soil to prevent flies and/or scavenging animals. Continue the process until the flower pot is filled to the brim. Move to the next pot. In this manner, within a month's time, a household may require about 7–10 flowerpots. By the end of the month, the first pot will be ready for harvesting and the pot can be reused. The number of pots can be increased or decreased based on the quantity of discards generated.

b. Kambha

Kambha is a Hindi word which means "earthen pot." It is designed and promoted by Daily Dump, an organization based in Bengaluru, India. Kambha are specially designed terracotta pots for composting at home. They are beautiful interior decorative products which are scientifically designed to make the process of composting faster and more efficient.
Kambha comes as three earthen pots stacked vertically. Kambha normally comes in three pieces, a bottom vessel, a middle piece, and a top piece. The middle and top pieces of the Kambha are composters and can be added as additional pieces if necessary. The bottom vessel provides an air column below the two composters to ensure good aeration which is needed for composting. It also acts as a collection vessel for extra leachate or compost material. The vessel does not have holes on the bottom. The composters—middle and top pieces have holes on the sides and bottom for aeration. (In some models the middle and top pieces are just like a cylinder with no bottom. In one end of the cylinder, there will be ropes woven across the rim to hold waste in it. This design ensures maximum aeration.)

Composters will be fixed on top of the bottom vessel one above the other. The bottom vessel and middle pieces are empty. The discards are fed on the top composter. Like in the pot composting, the composter piece is lined with paper or broad leaf and loose soil /or dry leaves, then it is ready to receive organic discards. After feeding organic discards, it must be covered with loose soil or dry leaves to prevent flies and/or scavenging animals. Since the bottom of the top part has holes, the leachate will fall into the middle piece and from there it goes to the bottom vessel. When the top part is full, it will be interchanged with the middle piece, thus bringing the middle piece to the top to receive new discards. Once it is full, the compost from the middle piece is harvested and it is placed on the top again for continuing composting.

This design helps the compost to get aerated from all directions including from the bottom. Once in a while the bottom piece has to be taken out to empty and clean the leachates and sediments of compost in it. Kambha are available in different sizes and designs. Kambha comes with ready-to-use inoculums or compost boosters.

The Kambha brought in a paradigm shift in attitude towards composting in urban India since it was introduced as a home decor product with a utility of composting.

c. Pelgreen Composting

One of the major challenges in composting in humid areas is maintaining the optimum moisture and aeration. Cocopeat (the spongy granules found in coconut husk) is a magic natural material available almost for free in places where coconuts are grown. It can absorb and hold water. It is also biodegradable. These properties make it perfect for the production of coco peat bricks. It is also a great potting mixture and a planting medium.

Pelican Foundation, an NGO and a GAIA member from India, developed a consortium of microbes to optimize composting and embedded them in treated coco peat. They called it composorb (brand name: Pelrich) and used it as layering material for composting in buckets.

Composorb absorbs extra moisture and leachate from the organic discards. The microbes in the composorb utilizes the air molecules trapped in the coco peat to digest the organic discards fed into the bucket. Two buckets of 50 liters and 10 kg of composorb is enough for a family of 5-8 people to get their organic discards converted into compost in a month.

The bucket has a bottom lid that collects the leachate through the valves fitted at the bottom of the bucket. The process of composting is purely based on microbial action with the help of composorb. A handful of dry leaves are spread into the bucket, then a thin layer of composorb is spread above this layer of dry leaves. The organic discards are then fed into the bucket. The organic discards will then be covered using composorb to prevent the breeding of flies and insects and facilitate the composting process. This process of sandwiching of food waste with composorb is repeated until the bucket is filled. This may take 15 to 20 days.

Once the first bucket is full, the second bucket is used for composting. The materials in the first bucket will be ready to be harvested after 25 days.

This model was adopted widely as a solution for municipal solid waste management in urban areas and helped the campaign for at-source composting. Composorb ensures smooth and fast composting without odor in a limited space. The resultant compost which is mixed with cocopeat is a good planting medium and this attracted more people to this model.

Composorb is also used in composting bulk quantities like 20 kg or more per day. Specially designed composting bins are used for this and the principle of function is similar as in the case of buckets.

This technology is now getting popular in South Asian countries where coconuts are available. Regular and adequate supply of inoculum is key in this process.

This model is comparatively expensive from the perspective of waste management. But it is super efficient when seen from the point of view of urban kitchen gardening.

d. Kitchen Bins

Kitchen bins or aerobic digesters are a modified version of Kambha but are made of plastic. It is an innovation facilitated by Thiruvananthapuram City in Kerala, India with the support of Green Village and Omega Eco-Tech products. The kitchen bin is a set of three perforated buckets stacked vertically. The composting inoculum is embedded in the treated coco peat—the spongy dust particles found among the fibers in coconut husk—that comes with it.

Steps

1. Place a layer of coco peat in the bottom of the top bin. Spread it evenly.

2. Pour the kitchen discards on top of the coco peat and spread it evenly.

3. Cover the kitchen discards with another layer of coco peat. Thus, the kitchen discards are sandwiched between two layers of coco peat. This helps to absorb extra moisture from the kitchen discards and provide aeration since the coco peat is a spongy material.

4. Continue steps 1–3 until the bucket is full.

Once the top bucket is full, it is interchanged with the middle bucket. Kitchen bin composting is preferred in urban areas since it emits almost no foul odor, gets perfectly composted in 25 days, and can be kept in the kitchen.

About 10 kg of coco peat is required for maintaining a kitchen bin for a month. This type of composting will only be feasible in places where coco peat is abundant, accessible, and cheap.

In kitchen bins, all three bins are used as composting since cocopeat provides enough aeration as well as acts as absorbent for leachate. So there is no need to keep a bottom vessel for aeration and collection of leachate.

TABLE 1. TROUBLESHOOTING COMPOSTING ISSUES

PROBLEM	REASONS	TIPS
Pest or rodents attack	Fresh food discards/meat discards in the compost	Cover the fresh food discards/meat discards fed with semi-composted materials. Use pest repellents like neem oil, lemongrass oil, or camphor oil around composting sites or on the outer side of the composting equipment. Sprinkling turmeric powder around the composting equipment will prevent pests including ants.
Foul smell	Compression	Turn the compost pile or poke holes to aerate it.
	Excess moisture	Add dry materials like dried leaves, rice husk, wood chips, etc to absorb extra moisture.
Ammonia smell	Too much nitrogen	Add more carbon-rich materials like dried leaves, wood chips, rice husk, saw dust, etc.
High temperature	Size too large	Spread the pile of organic discards to allow more aeration and cooling.
Low temperature	Size too small	Increase the quantity of discards to trap the heat within.
	Dry	Sprinkle water to improve and maintain moisture level at 50%.
	No aeration	Turn the compost regularly to improve aeration.

Black Soldier Fly (BSF)

Hermetia Illucens or black soldier flies (BSF) look like wasps and are native to the neotropical realm, but can now be found across the globe. These BSFs contribute to the composting technique by laying their eggs on crevices near decaying food materials. The larvae that come out of these eggs then feed on the decomposing food materials for 18–36 days. During this period, they eat a lot and then go into pre-pupal migration. Afterwards, they leave the decomposition/composting zone and look for cool dry places to pupate for 1–2 weeks. Once this stage is completed, they fly out of the enclosed area where they had just produced compost.

BSFs are harmless since they do not sting or bite, and they have not been found to be carriers of any diseases that have affected human beings. Having the larvae in large numbers help to speed up the composting process. The larvae at prepupal stage are a good source of protein to be used as animal feed especially for poultry. For this reason, BSFs are farmed in many places on a large scale using food discards to feed them. The larvae also eat the eggs and larvae of houseflies found in discards.

BSFs often stay outside our homes and buildings and lay eggs wherever they find decaying matter. They occur naturally in many of the composting sites. BSFs are friends of composting though the sight of larvae is a bit disgusting to many.

The larvae are photophobic, meaning they hate light. In the pre-pupal stage, they crawl out when it is dark. They may enter houses in search of a cool dry place, which becomes unpleasant for residents of these homes. BSF breeding in home-composting devices can be prevented. The first step is to keep all food discards and kitchen discards in a tightly closed container in the kitchen, instead of in open bins. This prevents BSFs from laying eggs on food discards.

When feeding food discards to the composting unit, layer it with dry leaves. Spraying citronella oil, eucalyptus oil, or neem oil around the composting unit will help keep BSFs away. Providing light to the surroundings of the composting device using a light bulb at night will also prevent the pre-pupal migration of larvae.

In some places, people culture BSF for making compost faster and as a feed for their poultry and/or fishery since the BSF larvae are a good source of nutrients. In such a process, they add additional devices to harvest the larvae from composting devices for further use.

PHOTO BY TUBAGUS ARI SATRIA BAKTI

2.5.6 Vermi-composting (Composting Cycle: 40–60 Days)

Earthworms help the digestion of organic materials in the composting process. Earthworms consume semi-composted or fermented organic materials and convert them into vermi-cast, a nutrient-rich fertilizer and soil supplement. The infrastructure required for vermicomposting is the same as that of simple aerobic composting with modifications to prevent scavenging by rats, rodents, and ants. The composting vessel will have partitions within to form separate chambers but will have holes for worms to move from one chamber to another.

Organic discards are fed in the first chamber where worms are ready. The worms start feeding on the discards and once it is done, it will move to the next chamber where fresh discards are available for their consumption. During the process, worms will multiply which speeds up the composting process each day.

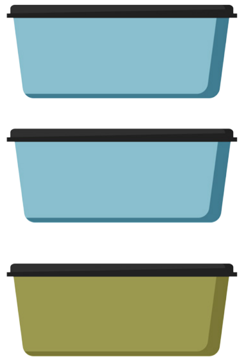
Once the vermicompost has matured, remove it from the chamber and make a heap in a place with shadow. Matured vermicompost will look like dark brown granules. The leftover worms will go to the bottom of the pile which will make it easy to separate the compost. In industrial composting facilities, they use rotary sieves for separating the compost and live worms.

For large plants with a capacity to process above 10 kg to several tonnes of material, rectangular tanks made of brick and cement are used. In such tanks, the width (1.5 m) and depth (0.6 m) is fixed, and the length is determined based on the total quantity of discards to be processed. These days, especially designed, compact, and vertically stacked bins are available. In such bins, the feeding begins in the bottom tray where worms are waiting. Then discards are fed in the topmost trays and worms move from bottom to the top to feed on fresh discards. By the time the worms move to the topmost tray of the compost bin, the tray in the bottom will be ready with matured compost which can be removed to be used as manure. The empty tray may then be used to stack on the top to continue the process. These simple ready-made vermicompost units come with additional storage space with a tap to collect and remove vermi wash—a decoction from the vermicompost. The vermi-casts are good manure.

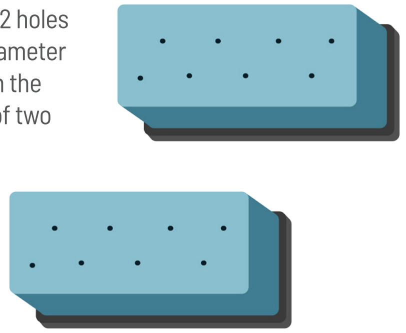
Those who cannot afford to buy vermicompost bins for their home can simply release worms into their pit compost, pipe compost, pot compost, or any other composting device to make it into a vermicompost unit. However, precautions should be taken to prevent ants and scavenging animals from getting into compost units as well as exotic species of worms escaping the compost unit.

Steps

1. Get three plastic crates (used for transporting goods) either 40 cm x 30cm x 12 cm or 60 cm x 40 cm x 12 cm that are not perforated.



2. Make 6–12 holes with a diameter of 1 cm in the bottom of two crates.



3. Keep the crate without holes (first crate) at the bottom as it will be used for collecting the leachate called vermi-wash. Place the second crate on top of the first crate. Initially, you will only be working with the two crates.

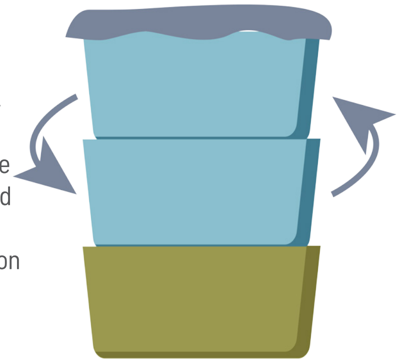
4. Deposit semi-composted organic discards in the second crate.

5. Release about 50–100 worms into the semi composted organic discards in the second crate. Keep the crate covered with a cloth or a perforated lid to prevent scavenging animals from getting inside the composting unit while also ensuring aeration.

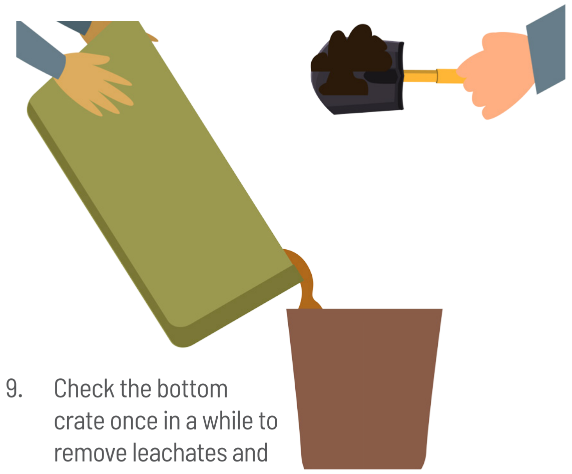
6. After a week, start adding kitchen discards on a daily basis.

7. Once the second crate is full, place the third crate on top of the second crate and start feeding it with kitchen discards. The worms will start moving upwards to feed on the fresh discards.

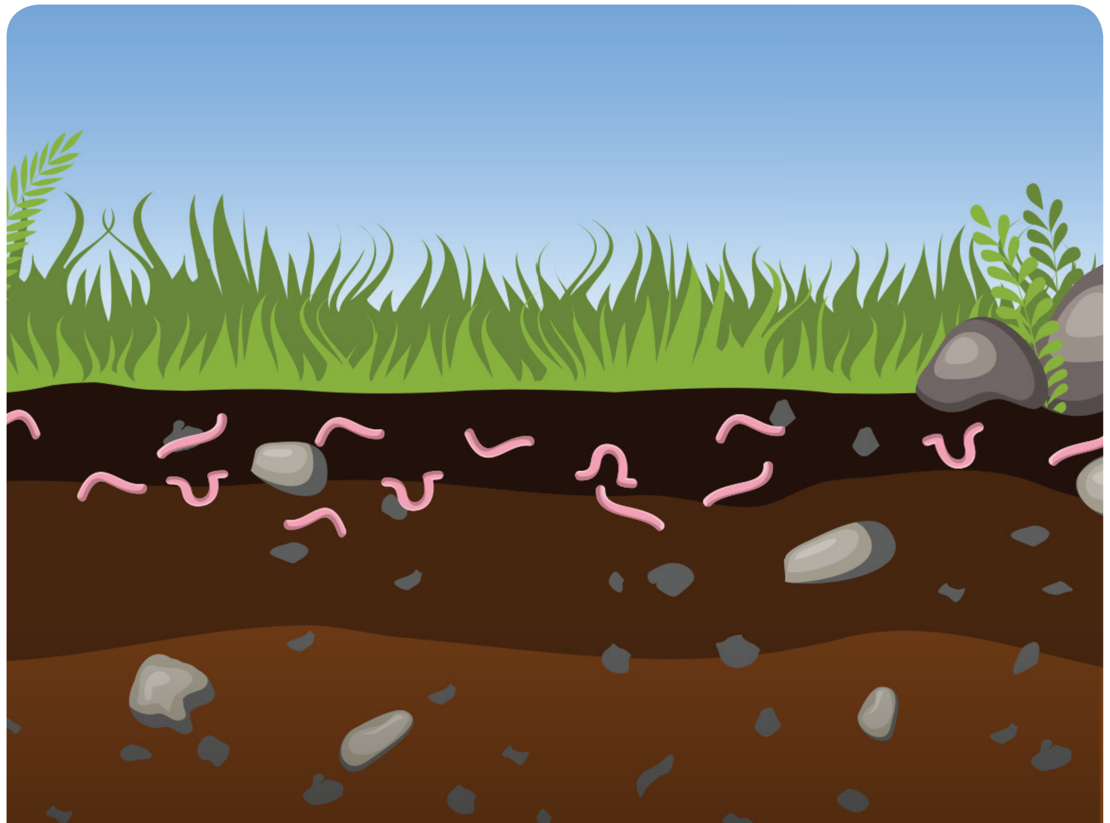
8. By the time the third crate is full, the second crate can be emptied and reused by stacking it on the top.



9. Check the bottom crate once in a while to remove leachates and vermi-casts, if any.



Note: Ensure that no excess salt, oil, vinegar, pickles go in the vermicomposting material since it will affect the worms. Do not use any anti-microbial solutions, cleaning agents, lotions, or deodorants in the vermicomposting since it will kill the worms and the bacterial colony. Avoid feeding meat discards in household-level vermicomposting since it may emit a foul smell for a couple of days. Meat discards may only be suitable for industrial-level vermicomposting.



How to Harvest Worms

Worms need to be harvested for vermicomposting. Local or exotic species of worms can be used for composting, and these can be bought from commercial vermicomposting units or shops that sell agricultural inputs. To harvest earthworms locally, identify any piece of land near your house where there are more earthworm activities. This area can be identified by the vermicast mounts on the surface. Get 500 grams of jaggery and 500 grams of fresh cow dung and mix it with water to make a 5 liter solution and sprinkle it on a 1 m x 1 m soil surface. Cover the area with thick cloth or jute fabric and keep it moist for at least a week. After one week, remove the covering and on the surface and subsurface, there will be a colony of earthworms ready to be harvested.

One kg of earthworms (about 4,000 worms) consume 500 grams of organic material on a daily basis. Once introduced and maintained well, the worms multiply within the compost facility and will maintain a stable population.

Eisenia Fetida, Eudrilus Eugeniae, lumbricus rubellus are commonly used earthworm species for vermicomposting or vermi-culture. Vermi-wash, a liquid formed from the vermi-cast (the excreta of earthworms), is used as liquid fertilizer.

2.5.7 Fortified Composting

The newly contructed composting unit where moistened green and brown organic materials are kept for 10 days. PHOTO BY CARMO NORONHA

Bethany Society, a nonprofit organization based in Shillong, the capital city of Meghalaya in the Indian Himalayan region, propagates a unique composting process as part of their natural farming campaign.

The composting begins in a tower made of split bamboo that is 4 ft (1.2 m) long, 4 ft (1.2 m) wide and 5 ft (1.5 m) high cubicle. Green and brown organic material is mixed and moistened with water and a concoction of microorganisms—lactic acid—made locally. Then it is left in the cubicle for 10 days for aerobic composting. After 10 days, the materials are taken out and mixed again and left in the cubicle for 10 more days for aerobic composting. After that, it is taken out and put in a hedge row with cover for 2 weeks for maturing.

Wood ash, forest soil and powdered eggshells are added to it to make it a proper compost. This is odorless composting and provides good quality compost. The tower takes about 80 cubic ft (2.26 cubic m^3) of material at a time, which amounts to about 3 tonnes of material. After composting, the material will get converted into about 1-1.5 tonnes of compost.

The composted materials as the tower is being dismantled. PHOTO BY CARMO NORONHA

CHAPTER 3

ANAEROBIC ORGANIC WASTE MANAGEMENT

Anaerobic composting, which manages waste in the absence of oxygen, is perfect for the management of leftover cooked food and meat discards. By-products of this natural process include fuel for cooking and slurry which may be used as natural soil fertilizer.

PHOTO BY THOMAS VARGHESE

Organic discards can also be managed in the absence of air or oxygen. There are two processes that fall under the anaerobic (without air) method: bokashi and anaerobic digestion (biodigester or biogas). The anaerobic method is mostly a fermentation process which functions in highly acidic conditions. The process releases carbon dioxide and methane, which are greenhouse gases.

3.1 BOKASHI COMPOSTING

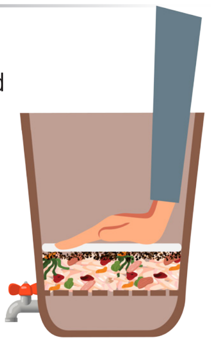
Bokashi composting is a very popular two-step anaerobic composting technique developed in the 1980s by Dr. Teuro Higa, a professor from Okinawa, Japan. Bokashi composting uses a bucket with a tap attached to the bottom and a tight lid placed on top. Kitchen discards, including meat discards, are fed in the bucket and are compressed with a lid inside. An inoculum made from fermented bran is added to the discards. Discards are fed daily until the bucket is filled to the brim. Once the bucket is full, it is kept for 3-4 weeks. This is called pickling. During this process, the leachate—also called compost tea—is drawn through the tap at the bottom. This leachate is used as a soil supplement. After pickling, the material in the bucket is removed and buried in the soil for the next level of composting which takes another 3-4 weeks.

Steps

1. Deposit organic discards in the bucket.

2. Sprinkle bokashi bran on the organic discards.

3. Compress the discards with a lid to squeeze it and keep closed.
4. Repeat steps 1-3 until the bucket is full.



5. Regularly drain the leachate collected in the bottom through the tap.
6. Leave the bucket for 3-4 weeks for pickling. It should smell acidic like a pickle.

7. Make a pit in the garden.

8. Dump the fermented organic discards into the pit.

9. Cover the discards with soil. In another 3-4 weeks it will get composted completely.

3.2 ANAEROBIC BIODIGESTION OR BIOGAS

Anaerobic digestion is a renewable energy source because the process produces methane and carbon dioxide-rich biogas suitable for energy production. Moreover, the nutrient-rich slurry (semi solid) left after digestion can be used as fertilizer.

The anaerobic digestion happens through these four stages of biological processes:

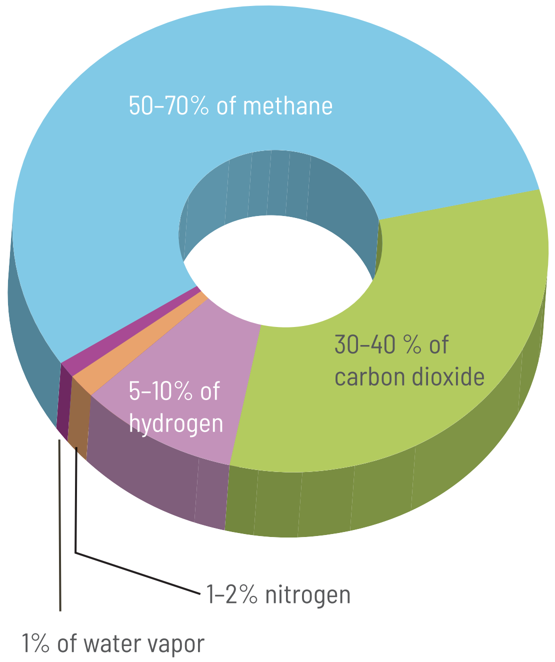
a. **Hydrolysis.** Large organic compounds like carbohydrates, fats, and proteins that make up organic materials are broken down into smaller molecules with the help of enzymes released by bacteria that are present. This process converts the complex materials into simpler sugars, fatty acids, and amino acids that can now be easily digested by microorganisms.
b. **Acidogenesis.** This is a fermentation process which converts the products of hydrolysis further into organic acids by acid-forming bacteria. Alcohol, hydrogen, carbon dioxide, ammonia, and most of the hydrogen sulfide are also produced. Acid fermentation is the same process that takes place in making yogurt. Additionally, products of acidogenesis, especially hydrogen sulfide, ammonia, and volatile organic acids are responsible for the strong and foul smell of anaerobic digesters.
c. **Acetogenesis.** This is the process where organic acids and alcohols get converted into acetic acid, hydrogen, and carbon dioxide by acetogenic bacteria.
d. **Methanogenesis.** Microorganisms generally classified as methanogens convert the products of the previous reactions into methane, carbon dioxide, and water.

The mixture of gas produced in the process will have 50-70% of methane, 30-40 % of carbon dioxide, 5-10% of hydrogen, 1-2% nitrogen, 0-1% of hydrogen sulfide, and less than 1% of water vapor. *See Figure 2 below.*

Anaerobic digestion processes happen naturally in the environment. It happens in swamps, ponds, lakes, paddies, and wetlands. Decomposition of organic material underwater causes the formation of methane in these natural conditions.

Recreating a similar airtight facility to decompose organic material will help to harvest methane as a fuel. Anaerobic bio-digesters for biogas plants are used for managing organic discards as well as to harvest fuel for heating or cooking. The technology is simple and it is used worldwide for both rural and urban settings.

Figure 2. Composition of Gas Produced in a Biogas Plant



3.1 COMPONENTS OF BIOGAS PLANTS

There are different variants of biogas plants across the world. Basically, a biogas plant will have the following components:

a. **Digester.** This is the main part of a biogas plant where the digestion happens. It is a water-sealed compartment made of plastic, fiber-reinforced plastic (FRP), metal, or cement. The size of the digester depends upon the daily intake of discards. The digester should have space to hold equal volumes of organic discards and water for 40 days. If the daily intake of discards is 1 kg, which is roughly 2 liters in volume, adding an equal volume of water makes it 4 liters daily. To hold discards for 40 days, the digester should have a capacity around 160 liters (4 liters x 40 days).

b. **Inlet.** This is a tube which lets the organic discards into the digester.

c. **Outlet.** This is a tube which lets the digested slurry flow out of the digester. The slurry is nutrient-rich and can be added to soil to improve its fertility. It has to be diluted with minimum 10 times of water before applying it to soil or plants.

d. **Gas Vent.** This is a tube through which the gas is harvested for storage and utilization.

e. **Gas Storage.** Gas primarily gets collected within the digester and is transferred to a storage, which can be a balloon, a bag, or any container made for this purpose.

If the digester capacity is 160 liters, about 50 liters of space has to be provided for daily gas collection. The collected gas can be compressed and stored in tire tubes, balloons, bags, floating domes, or metal tanks.

The biogas needs to be regularly cleaned to maintain the efficiency of the gas. Water vapor can be removed using a water filter or silica gel filter. Hydrogen sulfide is scrubbed using steel wool-filled filters or calcium or sodium hydroxide scrubbers. At the household-level where small-scale biogas plants are used, it is not feasible to have filters. Filters are generally used in biogas plants which feed on organic discards above 500 kg daily.

3.2 TYPES OF BIOGAS PLANT

There are small-scale, medium-scale, and large-scale types of biogas plants. Small-scale biogas plants are mostly used in households where the daily discards intake is below 10 kg. Medium-scale biogas plants are used in institutions and commercial establishments, small markets, animal or poultry farms where the daily intake of discards is between 10 kg to 1,000 kg. Large-scale plants are anything capable of processing discards amounting to over 1 tonne per day.

Based on the nature of biogas plants, there are portable and permanent biogas plants. The small-scale biogas plants designed for domestic purposes are often made of plastic and/or FRP. They are portable and ready-made. One has to buy a unit from the market and install it like installing a water tank. On the other hand, permanent biogas plants are constructed on-site and cannot be moved. All the large-scale biogas plants are designed as permanent. Some small-scale biogas plants are also designed as permanent.

Based on their gas-harvesting mechanism, biogas plants are classified as fixed dome, floating dome, bag based, and hi-tech biogas plants.

- ***Fixed-dome biogas plants*** store the gas within the digester and pressurize it using the pressure of the gas and the displacing weight of the slurry from the outlet.
- ***Floating-dome biogas plants*** store the gas in a container above the digester which floats up when it gets filled with gas and comes down when the gas is utilized. The container moves up and down several times in a day based on the gas generation and utilization. Additional weight will be added onto the tank to pressurize the gas while it is being used during cooking.
- ***High-tech biogas plants*** are large-scale biogas plants that are different in design from that of small- or medium-scale biogas plants. Small- and medium-scale biogas plants use one digester and all stages of digestion are happening in one place. In high-tech plants, the discards are kept in different digesters at different stages, as in hydrolysis, acidogenesis, acetogenesis, and methanogenesis *(Please see 3.1)*. This improves the efficiency of digestion and provides better control over the process. The gas is harvested, cleaned, and compressed to be used for heating, cooking, or for generating electricity.

3.3 BIOGAS PLANTS IN WASTE MANAGEMENT

Biogas is good for managing organic discards, but it prefers nitrogen-rich organic discards like food discards to carbon-rich materials like dry leaves, garden trimmings, wood chips, etc. Biogas is best for managing fish, meat, and poultry discards, cooked food discards, and vegetable and fruit discards. Biogas technology is also applied to process and harvest biogas from sewage sludge, sewage treatment plants, and agriculture residuals from farms and agro-based industries.

Biogas plants require daily operation and maintenance and must be managed all throughout the year. Hence, it cannot be used for seasonal purposes. It is best for households, institutions, commercial establishments or other facilities that generate more nitrogen-rich organic discards and have a demand for heating fuel.

3.4 GOOD PRACTICES IN BIOGAS PLANT MAINTENANCE AND OPERATION

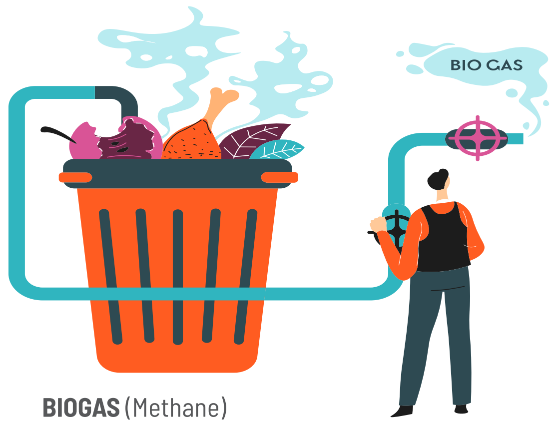
- **Segregation at source.** Segregation of waste at source is very important for any biogas plant. Only organic discards can be fed to the biogas plants. To be more specific, only nitrogen-rich materials like cooked food, vegetables, fruits, meat, fish, poultry discards, animal excreta can be managed in a biogas plant. It is better to avoid feeding dry leaves, garden trimmings, twigs, wood chips, shells, and bones into a biogas plant because carbon-rich materials yield no or low levels of methane which slows down the bio-methanation process in the plant.
- **Pre-treatment.** Pre-treatment of the feeding materials makes the biogas plant efficient. Mincing, slicing, shredding, or grinding the organic discards is the first step. Keeping them in mild warm water for a day for fermentation before feeding is also helpful. The quantity of daily feed should be kept stabilized to allow quantity. Excess feeding or under feeding will create problems for the biogas plant.
- **Post-treatment.** The slurry coming out of the plant needs to be collected and treated. Either use it for fertigation (diluting the slurry with water and using it for irrigating crops) or recycle the water and get the sludge in dry and solid form. The gas has to be managed well to maintain the pressure within the plant. The gas cannot be released to the atmosphere since it is a greenhouse gas. If at all there is an emergency, the gas should be flared up while releasing.

3.5 BIOGAS AND ENERGY

The energy content of methane from biogas is lower than that of LPG (Liquified Petroleum Gas or cooking gas). The energy content in LPG is about 93.2 MJ (MegaJoules) per cubic meter. It may vary from place to place since the ratio of propane and butane in LPG varies in different countries. Meanwhile, methane has only 38.7 MJ per cubic meter. The density of methane (0.65 kg) is lower than that of LPG (2.1 kg). This makes it highly expensive to compress and bottle methane from biogas for domestic or commercial use.

Figure 3. Comparison of Energy Content of Liquified Petroleum Gas and Biogas (Methane)

LPG (Liquified Petroleum Gas or coaoking gas)
Energy content 93.2 MJ (MegaJoules) per cubic meter



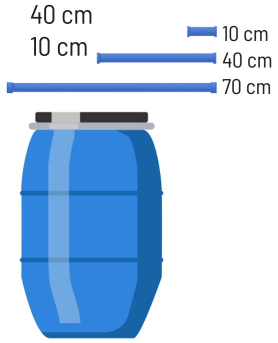
BIOGAS (Methane)
Energy content 38.7 MJ (MegaJoules) per cubic meter

3.6 DO-IT-YOURSELF BIOGAS PLANT

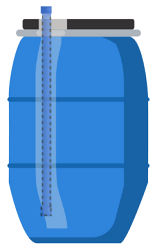
Materials Required
1 Plastic barrel, 80 liter
1 Plastic pipe, 1.20 m long, 4 in diameter
1 Reducer connector, 6 in to 4 in (152.4 mm to 101.6 mm) diameter
1 Elbow connector of 4 inches (101.6mm) diameter
1 Ball valve, ¾ inches (19.05 mm)
Gas stove, 1

Steps

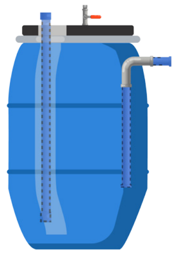
1. Cut the plastic pipe into the following sizes (assuming the height of the barrel is 80 cm and the diameter is 36 cm).
   a. 70 cm
   b. 40 cm
   c. 10 cm



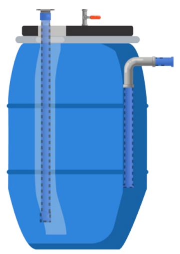
2. To make the inlet for feeding discards:
   a. Make a 4-inch (101.6 mm) hole on the lid.
   b. Insert 60 cm of the 70 cm pipe, leaving 10 cm above the top.
   c. Fix it with adhesive or using a tank connector for better stability.



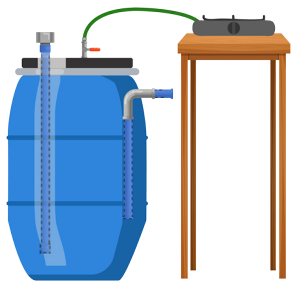
3. To make the gas vent for taking out the gas to a stove:
   a. Make a ¾ inch (19.05 mm) hole in the center of the lid.
   b. Fix the ¾ inch (19.05 mm) ball valve onto the lid using a tank connector.
   c. Seal the joint using a sealant or adhesive.



4. To make the outlet take out digested materials from the digester:
   a. Make a 4-inch (101.6mm) hole on the side of the barrel 20 cm below from the top.
   b. Make an elbow connection with pipes with (b) 40 cm and (c) 10 cm length.
   c. Insert the shorter side (c) through the hole from inside of the barrel, keeping the longer part (b) vertically downwards inside the barrel and seal the joints with adhesive to prevent leakage.



5. To make the funnel-shaped inlet
   a. Close the barrel with the lid and fix the 6-inch (152.4 mm) to 4-inch (101.6 mm) reducer on the 4-inch (101.6 mm) inlet pipe fixed *(Refer to step 2)* onto the lid. This provides enough space and acts as a funnel to feed discards through the inlet pipe.
   b. Seal the joint using adhesive or sealant to prevent leakage.

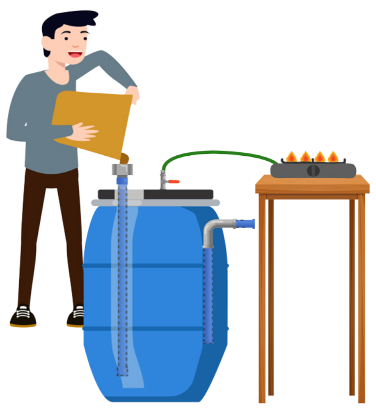


6. Close the ball valve on the lid and connect a flexible hose to it.

7. Add 40 liters of water to 20 kg of fresh cow dung and fill the barrel through the inlet pipe. Stop feeding it when the slurry starts coming out through the outlet pipe. Leave the plant for 3-4 days.

8. On the fourth day, open the ball valve and release the pressure and close it. Repeat this once in three days for 12 days.

9. On the 12th day, try lighting the gas at the end of the flexible hose while opening the ball valve. If it is burning, close the ball valve and connect the hose to a stove. Your biogas plant is ready to take in 5-7 liters of food discards from the kitchen on a daily basis.



What Happens to Organic Discards in Landfills?

When mixed waste is dumped in landfills, the included organic discards undergoes anaerobic digestion even long after it is permanently covered. The gases emitted by landfills are collectively called Landfill Gas or LFG. As we learned, LFG as a product of anaerobic digestion is mostly composed of methane and carbon dioxide. Methane is 84 times more potent than carbon dioxide as a greenhouse gas. This is why LFG emission is a serious climate hazard.

As opposed to intentional anaerobic digestion at source at a 40-day cycle, LFGs are slowly formed and released for periods of up to 50 years or more. This means that any management plan, even in harvesting this huge amount of methane for energy using power plants, will require big public investment spanning at least two generations. In addition, the resulting slurry from the digestion in landfills is impossible to collect. It is also contaminated with toxins from residual waste, effectively eliminating its potential use in agriculture.

Organic waste management through at-source segregation fulfills the sustainable nature of organic materials. This prevents this useful resource from becoming wasteful and hazardous, which is what happens when it is mixed with non-organic waste. ***—Julie Zarene De Guzman***

CHAPTER 4

STORIES FROM THE GROUND

COMPOSTING IN A MATERIALS RECOVERY FACILITY

SHERMA BENOSA

Every morning, Lucila Sandoy, or simply Tita Luz, Senior Community Organizer at Mother Earth Foundation, spends her time tending the garden in their staff house in *Barangay*[9] Tinajeros, in Malabon City, Philippines. If she is not adding compost to the plants, she's watering them or planting new ones.

After her morning routine in their staff house, she would visit the materials recovery facilities (MRFs) in the city that are accessible to her. One of the MRFs she often visits is the one in barangay Dampalit, which she helped build and is now being maintained by the waste workers she oversees.

The Dampalit MRF is a 250 sqm facility made of mixed materials: concrete and bamboo fences. It manages waste from 2,258 households as well as from a public and community market. It also accepts some organic waste from their neighboring *barangay*, Hulong Duhat. It has an eco-shed where segregated dry waste is temporarily stored either prior to the collection of the city (in the case of residuals and hazardous waste) or prior to their sale (in the case of recyclables). It also has a biodigester and various above-ground composting units to manage the organic waste. These include windrow composting, tire composting, box composting, and eight-chamber composting.

A total of 500 kg of organic waste is managed in the MRF weekly, 280 kg of which are fed to the biodigester while the remaining 220 kg are composted. Other food discards from households are used as animal feeds for a nearby piggery and are no longer brought to the MRF.

"The MRF is at the heart of waste management. Without an MRF, the community solid waste management program would fail. Where else would you bring the biodegradables?" Tita Luz said.

According to Tita Luz, they use the compost to provide nutrients to the soil to make it good for planting. With the soil improved, they are able to plant a mix of herbs and ornamentals in the MRF. This makes the MRF look like a garden slash composting demo site.

Since its establishment, the MRF has been visited by local and international guests who were interested to learn about efficient waste management programs in the Philippines or were participants of the Zero Waste Academy, a workshop on developing Zero Waste programs co-organized by Mother Earth Foundation and GAIA. It has even stirred the curiosity of the locals who happen by the MRF, and Tita Luz along with the waste workers managing the site are happy to explain what it is to anyone who would ask.

"People generally don't know what an MRF is and so they harbor misconceptions about it. They think MRFs are dirty and smelly. The image of an MRF that they have in mind is that of a mini dump site. So having an MRF in the *barangay* is important. When people see it, we get to explain what it is, and they begin to see its importance. They see for themselves that if managed properly, an MRF can become like a garden where you can relax. We teach people that they can compost at home and that they can use the compost as natural soil fertilizer," she said.

She added that many households now compost their waste. "When we go around the *barangay*, the people whom we taught about composting would recognize us and happily show us their composting setups and their gardens. It feels good to know that people are learning from us, and that they practice the things we're teaching them," she said.

[9] A barangay is the smallest administrative unit in the Philippines.

COMPOST FOR SALE

SHERMA BENOSA

The Foundation University in Dumaguete City, Philippines, home to nearly 3,000 students, is an early adopter of Zero Waste principles. As early as 2009, the university started composting their organic discards. Every month, they compost around 38 cubic meters of organic discards.

The university uses various composting methods such as BMG (biomechanical goat) composting, natural composting, biowaste process (black soldier flies or BSF) and vermicomposting. Vermicomposting, unfortunately, was halted since the start of the COVID-19 pandemic as some employees had to take a vacation leave.

According to Russelle Jamili of the university's Safety and Environment Office, the university produces approximately 450 kg of compost per month via the BMG composting, 4 cubic meters every two months via the natural composting technique, and 400 liters of compost in two months via the biowaste process.

Russelle shared that the university had just started the BSF process in 2020 but it was discontinued because of the COVID-19 pandemic. Nevertheless, they are planning to use this composting technique for their agriculture students once the situation improves.

"We see numerous benefits of composting our organic waste. First, we are able to minimize organic discards in the university. Second, we save on fertilizers as we use the compost in our farms. Third, we get to produce organic eggs and organic vegetables and fruits from the organic fertilizers we are using. Fourth, we get to maintain the cleanliness and greenness of the university. Finally, we get to earn extra from the farms we maintain using our own compost," Russelle said.

Russelle added that because they use the composts in maintaining the school farms and all the greens in the campus, they only sell compost when they have extra. They had just started selling their compost at the start of 2021 so they have yet to gain regular clients. Thus far, most of their buyers are university employees.

Since February 2021, they have sold a total of 234 kg worth of compost, which are sold by the sack. The sacks come in two sizes: 25 kg and 30 kg. They also sell by the kilo to those who only require small quantities. At Php 10 per kg, they have made Php 2,340 (USD 50) from selling their compost.

Russelle shared that she herself has bought compost from the university for their home garden. "I bought 30 kg of fertilized soil and I would say it is really good quality soil. When we added this soil to our okra and eggplants, we observed growth and flowering spurt in the plants with compost, which we did not observe in the plants without compost," she said.

Russelle added that the university hopes to be successful with the biowaste process and to finally reinstitute vermicomposting. "We have more plans regarding organic waste composting. We hope they will all materialize," she said.

COMPOSTING IN A HIGH-RISE APARTMENT

ANNE LARRACAS

Every morning upon waking, the first thing that greets our family is the sight of plants swaying gently in the wind on our tiny balcony. Our balcony sits right outside our tiny house's only window, so the plants are impossible to miss wherever you are in the house. At least 70% of our plants are edible, and they're fed by compost we make ourselves.

Composting and maintaining a small garden are unremarkable activities in themselves. The only challenge to our composting and gardening activities is the fact that it's done on the 19th floor balcony of a condominium unit. The balcony is very small, about 3 sqm, and it's difficult to move around, but there is enough room to put just the right number of compost pots to manage all of our organic waste.

Everything from our kitchen is managed according to the waste hierarchy recommended by regulatory and advocacy organizations such as Zero Waste Europe, EU or the US EPA. We diligently practice food waste reduction measures to lessen leftovers.

Leftover food not fit for human consumption is placed in a container and put in the freezer. When the container is full, we feed it to stray cats and dogs in the neighborhood, or give it to relatives and friends with pets. Inedible kitchen waste goes into the compost pots on the balcony. What cannot be composted such as meat or fish products and used oil is fed into a small do-it-yourself biodigester occupying about a square foot on the balcony. In this manner, 100% of our organic waste is managed from home, and we're able to divert roughly 25 kilos of organic waste from landfills and dumpsites every month.

For our three-member household, five pots made of clay (35 cm in diameter) is enough to handle all of our composting needs, and these pots are rotated regularly. Every day, kitchen waste is put in one pot and it is mixed with old compost, old leaves, shredded tissues, cardboard paper, etc. When the pot is full, it's left to decompose for about three weeks and allowed to mature for another couple of weeks before it is fed to our plants. Every month, we make roughly a kilo of compost out of our kitchen and food waste.

The limited space is definitely a challenge, and there is literally no more room for an additional pot. But food waste reduction is a priority in our household, and this helps in making sure that our compost pots don't get filled up fast.

Since I started composting in 2004, I've learned how to minimize composting challenges. Still, we get the occasional fruit or house flies which are managed by vigorous swatting and an extra layer of soil over the compost pot currently being filled. We put a plate under all of our pots to make sure that no errant soil or compost tea bleeds out into the balcony floor, and I vigorously scrub the balcony floor once or twice a month to prevent clogging the drainage.

We are committed composters and we purposefully looked for a house with some outdoor space to make sure that we will be able to continue composting. For people living in a condo building or apartment with some outdoor space, composting can and should be part of everyday activities. It's especially great for children—it's interactive, scientific, and a valuable activity that when started at an early age, can become a lifelong commitment to responsible waste management.

FUN AND EASY COMPOSTING FOR CHILDREN

CONSUMERS ASSOCIATION OF PENANG AND SHERMA BENOSA

Every school day since 2017*, a group of students composting organic discards in the composting area of SJK Tamil Nibong Tebal, a primary school in Penang, Malaysia, has been a regular sight.

This practice started after they attended a lecture on organic waste management by Consumers' Association of Penang, a member of GAIA based in Malaysia, that is promoting sustainable lifestyle, mindful consumption, and Zero Waste living.

Through the guidance of their teacher, Vatsala Jayaraman, the students learned to reduce their food waste, sort their waste, and compost the organic discards. They have learned that by composting their discards, they can ensure that their biodegradables are returned to the earth as nutrients—a great lesson in science. They are also able to showcase their creativity by making art in their composting pipes.

The school has five composting pipes labelled from Monday to Friday. Organic waste collected from the school canteen and garden for a particular day is disposed of in the pipe allocated for that day. The organic discards collected on Monday go into the pipe labeled Monday, the discard collected on Tuesday go into the pipe labeled Tuesday, and so on. Following this process, it takes another seven days before they dispose of waste into the same pipe again, which gives ample time for the composting process to take place.

To make things efficient, a group of students is assigned to oversee the composting, and each member has a specific task, such as collecting dry leaves, collecting kitchen waste, and so on. A group leader ensures that everyone does their tasks. If the one in charge is absent, someone else covers for them to make sure that composting is not disrupted.

By taking part in this project, the students say they are also learning about responsibility.

"One should not feel averse to the waste because after all it is produced by us, and hence it is our responsibility to ensure that the waste ends in a manner that does not harm the environment. I am happy to have overcome such aversion and carry on with this project," said G. Divyanraaj, one of the students who have been part of the project since it started.

"We should not waste food in the first place. The rightful place of the food is our stomach and not the waste bin. I weigh the food waste daily and realize how much food is wasted. I take this opportunity to tell my friends not to waste food," added V. Ringgeshwaran.

In their visits to schools, CAP has found that some of the reasons the students do not finish their food include the following: food being not tasty, the students being full or not liking vegetables, and/or having put too much food on their plate.

CAP underscores that schools are an easy channel to instill values, thus targeting schools to create a society that avoids food waste will bring about the desired result, albeit in a long-term. The organization firmly believes that when students are educated at a young age about the value of food, the impact that food waste has on the environment, as well the relationship between food and climate change, they will grow as adults that do not waste food.

Students at SJK Tamil Nibong Tebal managing their pipe composts. Photo by Theeban Gunasekaran of Consumers' Association of Penang.

Ms. Shyamla, one of the first residents to sign up for the Zero Waste smiles as she stirs segregated biodegradable waste.
PHOTO COURTESY OF CITIZEN CONSUMER AND CIVIC ACTION GROUP.

ZERO WASTE IN A LOW-INCOME COMMUNITY

VAMSI SANKAR KAPILAVAI

The Greenways community in Chennai, India, which is a mix of largely residential, and some commercial and institutional entities, is home to 5,000 residents organized along nine streets. Due to inadequate and irregular municipal service for door-to-door waste collection in the area, most residents used to dump their unsegregated household waste in an open area along the riverbank. Although they valued this area as a source of water since this is where the community water tank is placed, they felt that open dumping was the only way they could manage their waste. Or at least put it out of sight.

As a collaborator in the Zero Waste Cities collaborative project (ZWC) coordinated by GAIA Asia Pacific, Citizen consumer and civic Action Group (CAG) had an opportunity to develop local alternate models of waste management that focuses on decentralization in the Greenways community.

To start with, CAG requested Greater Chennai Corporation (GCC) to clear the waste that had accumulated in the open space. They conducted a baseline survey which included mapping and brand audit of the waste generated in the community. The survey results gave an idea about route planning for waste collection and the quantum of different types of waste. In all these steps, the community was involved, and this gave them an understanding of the problem. After the baseline survey, CAG conducted several street plays and street-level meetings to sensitize the people about improper waste disposal.

CAG likewise conducted dialogues with different residents like working women, homemakers, and shop owners. From their findings, CAG developed an incentive model that rewarded residents with points for segregating, composting, and refusing plastic bags.

CAG also set up composting and material recovery facilities in the community. They also distributed around 160 earthen pots with bamboo lids for home composting.

CAG launched the pilot in one of the streets with 44 households, out of which, 40 signed up for the scheme. Within three weeks of the pilot launch, CAG saw 100% compliance, and there was a demand from other residents to extend the scheme to their streets and other commercial entities. The commercial entities had been given tokens with which they rewarded customers who brought their own bag or box and refused a plastic bag from the shop. The scheme was implemented in another four streets by CAG where it received overwhelming response and compliance.

The organic waste segregated by the community is composted using a well ring composting method. CAG has set up three well ring structures to suit the community capacity. The composting facilities were managed by CAG and the enrolled residents have given their segregated organic waste and they haven't complained at any point of time regarding the composting structure or smell. The harvested compost is used by the community for their plants and the remaining compost was distributed to the residents who needed it from other areas.

Community-based approaches for resource management have frequently failed to fulfil their promise and have generated unexpected conflicts. This is partly because their settings are more socially, institutionally, and ecologically differentiated and dynamic than is often assumed. The need of the hour for policy makers and development practitioners, as we see from this example and many such similar experiences, is to design and develop robust processes that can respond to the socially diverse interests and dynamics existing among resource users.

This suggests that community-based waste management efforts should seek to be adaptive rather than built as templates or pre-planned. Another important observation is that providing only shared or community facilities in the absence of appropriate mechanisms like constant hand-holding and regular services are bound to fail in low-income communities who constantly struggle for access to adequate water, sanitation, and land rights.

STRATEGY AND POLICY FOR ORGANICS MANAGEMENT

- **Source Segregation.** This step is the key in effective solid waste management. The segregation of all types of waste, but especially of organic waste, in households, institutions, commercial establishments, community halls, markets, and every other bulk waste generator where organic discards are produced must be promoted to ensure that the organic discards that are collected remain fresh and uncontaminated. This will increase the chances of effective recovery for a more efficient composting process.

- **Sector-specific Approach.** Homogenizing organic discards is possible only when there is a sector-specific segregated collection and/or management. For example, the organic discards from restaurants in the city possess common features that make it easy for adopting a technology or process to manage it. Meat discards from poultry shops, meat shops, and fish stalls possess some common features and characteristics. Organic discards generated in households are very small at household-level but it forms about 40-50% of total municipal solid waste. It is better to have a different collection and management plan for different sectors.

- **Waste Reduction.** Programs recognizing that we cannot afford wasting food and agriculture crops have to be launched to minimize the production of organic discards in different sectors. Organic waste management at source could potentially bring community appreciation of a circular resource economy that builds on conscientious product design, consumption, and waste generation.

- **Biological Process.** The organic discards should be managed through biological processes only.

- **Prioritizing Recovery Options.** Organic discards need to be prioritized based on its utility in the locality. The first priority should be given to recover the discards as feed for animals. The second priority should be given to programs that channel the organics to farms for composting. If these possibilities are not available, then it only needs to be managed using any of the biological processes.

- **Source-level and Decentralized Management.** The priority should be given to source-level management of organic discards, at household level, institutional level, or community level. Decentralized systems for organic discards management should be established at different levels —cluster level, community level, and a common facility. Overflow of organic discards due to spikes in discard generation can be managed with the network of cluster, community and common facilities.

- **Integration with Food Production.** Organic waste management programs should be integrated with programs that ensure food security and food safety. It is important to encourage the use of compost or digested materials from organic discards as feed to local food production. Compost is a natural and safe soil supplement that helps to retain or enhance soil fertility.

- **Integration with Climate Resilience.** Organic waste management should be prioritized as a climate-resilient activity since it helps to increase soil carbon and reduces use of chemical fertilizers which leads to GHG emission. Diversion of organic discards from landfills eliminates the problem of long-term release of methane into the atmosphere and consequently, the costly and intergenerational management of this GHG.

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