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ORGANIC MATERIAL

Waste Technology Management Options

December 2020

This publication provides details on some of the most appropriate waste management technologies identified for Organic Materials - with consideration to the inherent constraints of the Pacific island region.

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Introduction

This publication provides details on some of the most appropriate waste management technologies identified for Organic Materials - with consideration to the inherent constraints of the Pacific island region. Of all waste items received at Pacific Island landfills, organic material is one that is easily avoided. Stopping organic waste going to landfill, we immediately reduce increased greenhouse gas emissions and start supporting a circular economy (if we actively compost the organic material that is!)

Organic material recycling can convert a "waste" material into valuable products with low to moderate levels of capital investment (some under <US$100,000) and low operating costs. Additionally, organic recycling operations can be scaled and modified to suit your local context.

Organic material recycling can achieve the following social and environmental benefits:

Saves Landfill space – 60% of material removed from landfill will almost double the life of the Pacific's rapidly-filling landfills

Beneficial for soil – Compost is considered "black gold" because of its many benefits to soil. Adding compost to sandy soils typical in the region, improves the nutrients content and water holding capacity. In clay or volcanic soils, the addition of compost can provide nutrients and make soil easier to work. Use of locally made compost can also replace the need for imported chemical fertilizers

Valuable resource – Mulch, compost, and soil enhancers are valuable resources and can be sold for profit.

Cleaner streets – By removing organic material from household waste, rubbish bags will be cleaner, have less odour, and be less attractive to dogs and insects.

Reduces leachate – organic material, when intermingled with other waste and disposed in a landfill or dump (an "anaerobic" environment), can release toxic leachate which can pollute surrounding water and soil and can represent a health risk.

Reduces climate change - When organic waste is dumped in landfill, it undergoes anaerobic decomposition (because of the lack of oxygen) and generates methane. This methane is 25 times more potent as greenhouse gas than carbon dioxide.

Ultimately, the determination of whether a technology is applicable to your situation will be project based. This publication is designed to provide initial information and guidance to assist your decision-making.

What is Organic Material?

Organic material is material that is biodegradable. Organic waste materials typically include:

Food waste - fruits, vegetables, peelings, bread, certain meat, and dairy

Garden/tree litter - coconut husks and fronds, grass clippings and twigs and branches, leaves

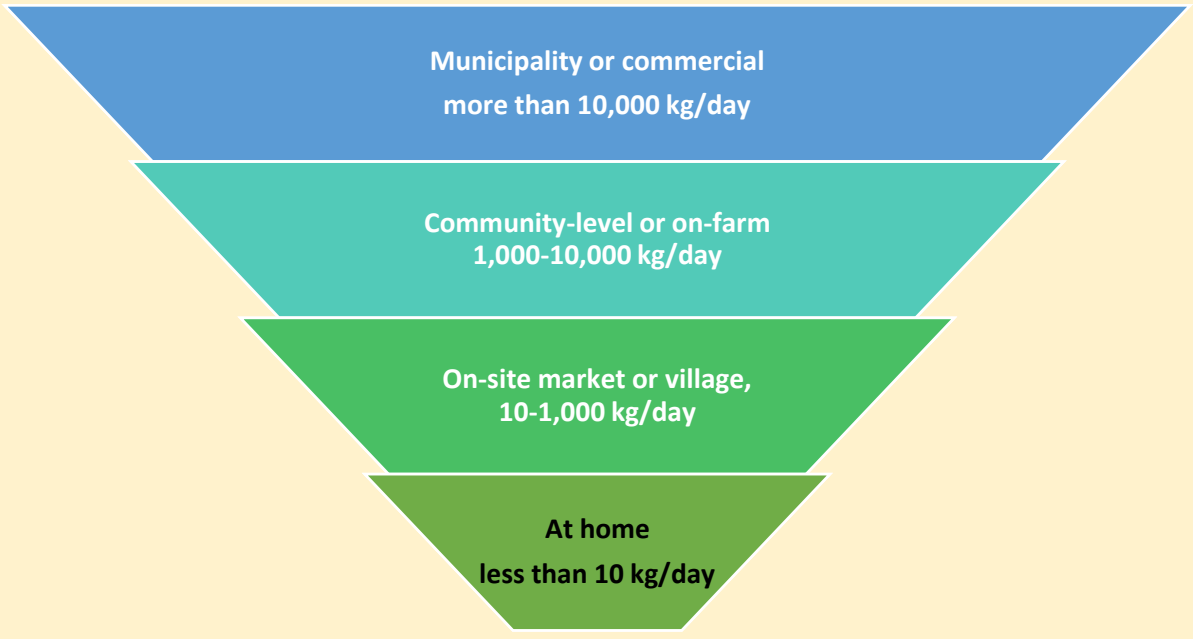
Paper/cardboard (non-glossy) - newspaper, paper bags, boxes, egg cartons, toilet rolls

Manure - from herbivores (plant eating animals such as cows and horses)

Understanding Scale

Organic material recycling can be scaled to suit any context, from a backyard composting system for use by one household and made from local products (see **Appendix A** for examples), through to a large, commercial scale composting operation receiving organic material from thousands of households, markets, and business.

Generally, organic material recycling can fit in the following scales:



Composting Fundamentals

The scale, input product, capital investment, operating costs, and technology may differ for each operation, but there are many similarities in their operations.

All operations will need:

- Correct balance of organic materials (carbon and nitrogen)
- Appropriate particle sizes
- Sufficient moisture and oxygen
- Correct temperature and temperature/time relationship

The PWP team can assist you with more detail on these composting fundamentals and help you understand the system best for your context.

Technology Options

There are a wide variety of technology options for organic material recycling, depending on the scale of operation and desired outputs.

This publication includes technology options for "centralised" or community-level organic management that provides for the management of material from many households, markets, and businesses, at a commercial scale operation being run by government or the private sector.

The technologies included in this publication are:

Mulch (particles >40mm) -used for an array of applications such as water retention, weed control, boosting carbon, and landscaping.

Composting (aerobic digestion) - produce pasteurised and composted soil conditioners and mulches

Anaerobic digestion - produce biogas, energy and digestate

Vermicomposting (using worms) **-** produce a superior soil conditioner

Rapid digestion (using combinations of heat, agitation, and enzymes) - produce an organic fertiliser

Biomass Plant - heating and electric power generation

Dehydration - produce an organic fertiliser, animal feed or just to reduce transportation costs

Organic Material Collection

Collection of organic materials is ideally managed at the source (households, markets and other businesses), in combination with an education program so individuals understand what organic product should be placed out for collection. Centralised organic recycling may also start with drop-off system (i.e., requesting individuals or markets and other business to drop materials to the facility).

The collection of organics requires minimal infrastructure other than a standard collection truck/trailer. These can range from low technology collection "cages" on a trailer to high technology trucks with a split compartment – allowing collection of organics and other solid waste at the same time.

Collection vehicles should be selected only after consideration of:

(i) **the type of organic material to be collected** - e.g., organic material from a grower's market may have a high moisture content, requiring the collection vehicle to ensure this liquid is captured and not spilt during the collection process.
(ii) **The typical size of the material to be collected** – e.g., trees and branches may be too large (length, diameter) or too heavy for collection, or may need to be collected and go through pre-processing (size reduction) prior to being able to being processed.

Mulching or shredding organic material is the most basic form of organic material recycling. Mulch is commonly made from woody organic wastes – trees, branches, fronds, and leaves.

The mulching process is often the first stage of any organic processing (e.g., to get the correct particle sizes for effective composting), but mulch can be a beneficial product in its own right:

- **Coarse mulch** – particle size of 30-40mm, used for water conservation projects, weed control and erosion management. May also deliver soil conditioning and enhanced biota benefits in gardens. Other applications include use as playground soft fall.
- **Fine mulch** – particle size of 16-20mm, used for landscaping and improve water retention, and boost soil carbon and health if turned in during cultivation. Some fine mulch may be used as soil conditioner to introduce organic matter, humus and boost soil biology.

Producing mulch requires minimal technology, usually just a chainsaw and wood-chipper or shredder of appropriate size for the input products received.

Advantages and Disadvantages of Mulch

Advantages

- Effective way to remove organic matter from landfill with minimum specialized equipment and operators
- Relatively low capital expenditure, and minimal land requirement
- Equipment is already common in the Pacific with maintenance programmes in place
- Mulch is useful for water conservation projects, weed control, erosion management, and can boost soil carbon and health

Disadvantages

- Is not able to process food and other putrescible wastes
- Mulch does not provide the enhanced benefits for soil and crop cultivation that compost does

Centralised Composting

There are three main technology operations that exists for centralised composting operations:

Open Windrow Composting

Aerated Static Pile Composting

In-vessel Composting

Each method requires minor plant and technology such as chainsaws and chipper/mulching machines. This equipment is important to reduce the size of organic materials, so they are at an appropriate size for effective composting.

Open Windrow Composting

Open windrow composting or aerated (turned) windrow composting involves piling the correct balance of organic materials (carbon and nitrogen) in long rows called "windrows". These windrows require periodic aerating by either manually or mechanically turning. Aeration is essential to improve oxygen content, mix in or remove moisture, and redistribute cooler and hotter portions of the pile.

Technology options and capital investment for open windrow composting can range from:

- low-tech – use of manual labour to turn the piles
- medium-tech – use of existing equipment such as front loader to turn the piles
- high-tech – use of specialist equipment such as a windrow turner

The equipment used for turning determines the size, shape and spacing of the windrows. Bucket loaders with a long reach can build high windrows. Turning machines produce low, wide windrows. Most of the cost associated with establishing an open windrow composting facility can be the construction of hardstand and surface water drainage to capture leachate. The composting process in a manually turned windrow system is typically between 10-14 weeks.

Open systems are the lowest cost option and, when managed correctly, produce a high-quality product. Due to low technology requirements and scalability, they are **highly suited to the Pacific island context.**

Assessment of the Windrow System

Advantages

- Open windrow systems offer the lowest cost option and, when managed correctly, produce a high-quality product
- No specialised equipment is necessary for a windrow system, with the most significant capital expenditure likely to be a frontend loader with a large (3 or 4 cubic yard) bucket
- This equipment is already common in the Pacific with maintenance programmes in place
- A windrow composting program is flexible and scalable to account for variety of input volumes
- Many communities have experience with windrow composting systems, so operational knowledge exists
- There is potential for sludges and saw dust to be composted through the windrow system

Disadvantages

- Windrow systems require more land area, and hard surface area, than in-vessel systems
- The process can take slightly longer than other methods of composting
- construction of hardstand and surface water drainage to capture leachate may be expensive
- Weather affects windrow composting systems. During storms or a rainy wet season, piles may become saturated with water, causing leachate run-off and anaerobic conditions, and additional labour costs may be needed to spread the windrow out to dry and then rebuild it. During the dry spells, decomposition may slow requiring the addition of water.
- Food and other putrescible wastes require careful management in this system

Aerated Static Pile Composting

Aerated static pile composting takes windrow composting a step further, placing the organic material windrows on top of a “blower” and pierced aeration pipe which supplies air to the composting materials, eliminating the need for turning. The blower provides direct control of the composting process and allows for larger windrows and faster composting.

Selection, layering and initial mixing of materials in the windrow is important for aerated static pile composting, to avoiding poor air distribution and uneven composting. The base layer needs to be wood chips or other very porous material.

The air flow rates are based on the dry weight and type of the primary raw material. Air flow rates and blowers can be run continuously or intermittently, via a time clock or a temperature sensor. The air can be supplied via a suction system with the air drawn through the pile; or a pressure system with the blower pushing the air into the pile.

As with open windrow composting, most of the cost associated with establishing an aerated static pile facility can be the construction of hardstand and surface water drainage to capture leachate, plus similar initial plant (frontend loader with a bucket). Technology also includes a blower connected to a timer or to a temperature sensor (usually diesel powered), and PVC pipe with perforations or holes.

When the pile has been formed properly and where the air supply is sufficient and the distribution uniform, the active composting period is completed in about 3-5 weeks.

Aerated static pile composting is a relatively cost-effective composting method, requiring higher initial capital but less labour and operational requirements. Aerated static pile composting can produce a quality product in a short timeframe. This method is **suited to the Pacific island context.**



Assessment of the Aerated Static Pile system

Advantages

- Aerated static pile composting program is flexible and scalable to account for a variety of input volumes
- There is potential for sludges and saw dust to be composted through the aerated static pile composting
- Aerated static pile requires relatively low-medium level technology – similar initial plant as windrow system (frontend loader with a bucket), plus a blower connected to a timer or to a temperature sensor (usually diesel powered), and PVC pipe with perforations or holes
- Faster composting with less labour requirements once piles are established

Disadvantages

- Equipment and methods required for aerated static pile composting is not common in the Pacific so communities may not have experience with the composting process
- Potentially complex maintenance for the blower and temperature sensors
- Aerated static pile composting may produce odour, so location of facilities should consider neighbours
- Aerated static pile systems require more land area, and hard surface area, than in-vessel systems
- Construction of hardstand and surface water drainage to capture leachate may be expensive
- Weather affects aerated static pile composting systems. During storms or a rainy wet season, piles may become saturated with water, causing leachate run-off and anaerobic conditions. During the dry spells, decomposition may slow requiring the addition of water.

In-vessel Composting

In vessel (enclosed) composting generally describes a group of methods that confine the composting materials within a building, container, or vessel. The choice of an in-vessel system will depend upon the raw material feedstocks, the volume of material to be composted, the capital available, and the site characteristics. The general types of in-vessel systems are passively aerated bins, mechanically aerated containers, agitated-aerated containers, rotating drums, and agitated beds.

These containerised systems have high-technology requirements, all needing:

- a container supplied with air flow and leachate drainage
- mixing and loading machine to thoroughly mix the raw materials and load them into the container
- biofilter, which can be filled with finished compost or wood chips, to control odours
- process monitoring
- an unloading system
- site for curing the compost

In vessel composting allows good control of the environmental conditions such as temperature, moisture, and airflow. The material is mechanically turned or mixed to make sure the material is aerated. The size of the vessel can vary in size and capacity. In vessel composting is generally suited for large scale operations, minimum viable scale is generally 10,000 tonnes/year, costing US$3-4 million.

In vessel composting method produces compost in just a few weeks. However, it can take a few more weeks or months until compost is ready to use because the microbial activity needs to balance, and the pile needs to cool.

In vessel composting requires significant capital and specialist operation and maintenance. Due to high technology requirements, they are **not suited to the Pacific island context**.

Advantages and Disadvantages of In Vessel Composting

Advantages

- In vessel compost units take up little space, and therefore the amount of land that must be hard surfaced is minimised.
- The compost process is enclosed. Any odours that might arise from the decomposition would be contained. Since the system is impervious to weather, dust during dry times or leachate run-off during rainy periods would not be an issue.
- The compost produced by an enclosed rotating drum may be land-applied without a lengthy curing period.
- Required reduced operational requirements (time involved to load and turn drum is less time needed to build and periodically turn windrows)
- In vessel composting is preferred in countries such as Australia because they add an extra layer of odour control compared to open windrow composting systems.

Disadvantages

- Even though the process is self-contained, and may have built-in monitoring of odour, exhaust gases and leachate, these require maintenance, or it is possible to result in unexpected air or odour discharges.
- If biological imbalances do occur, they are more difficult to correct in an enclosed container.
- The capital cost of a system is high compared to windrow solution and is not as scalable. Minimum viable scale is generally 10,000 tonnes/year costing US$3-4 million
- A vessel has a limited life span. Given the corrosive nature of the composting process, particularly if food waste were to be added, it may be worn out in seven to ten years.

Anaerobic Digestion

Anaerobic digestion is an anaerobic treatment technology that produces:

(a) a digested slurry (digestate) that can be used as a fertilizer

(b) biogas that can be used for energy

Anaerobic digestion uses bacteria to break down organic materials – often animal manure and human sludge – without oxygen. As the bacteria "work," they generate biogas. Biogas is a mix of methane, carbon dioxide and other trace gases which can be converted to heat, electricity, or light.

Anaerobic digestion systems come in a variety of sizes, from:

- home and market scale simple systems which can produce small scale biogas for energy or cooking costing from as little as US$750
- "small" commercial operation - minimum viable scale is generally 20,000 tonnes/year costing US$7.5million
- Large commercial scale (used in Europe) – processing up to 60,000 tonnes/year costing US$18 million

Home systems

Small scale commercial

Large scale commercial

Anaerobic digestion for biogas production is a technology well known globally in the municipal waste and wastewater treatment plants. It is commercially ready to use and has multiple benefits such as production of energy, waste management, reduction of carbon footprint, etc.

Small scale biogas reactors can be directly connected to private or public toilets with an additional access point for organic materials. At the household level, reactors can be made from plastic containers or bricks. Sizes can vary from 1,000 L for a single family up to 100,000 L for institutional or public toilet applications.

Small scale units may be an effective low technology option for managing organic material, with the added benefit of producing gas for cooking. Due to low technology requirements, they are **suited to the Pacific island context**.

Commercial systems require more input volume than is typically received in the Pacific with high capital costs and are **not suited to the Pacific island context.**

Advantages and Disadvantages of Anaerobic Digestion

Advantages

- Produces a biogas from which a renewable energy can be recovered.
- Small land area required (most of the structure can be built underground)
- Small scale units may be able to be built and repaired with locally available materials
- Small scale units enable households to convert organic material into gas for cooking
- No electrical energy required
- Combined treatment of animal, human and solid organic waste
- Proven technology that is well known in the municipal waste and wastewater treatment plants.
- Sustainability - Anaerobic digestion has the potential to provide multiple benefits (energy savings, waste management cost savings, reduction of environmental impact, etc.).

Disadvantages

- Digestate may need to be treated prior to disposal or reuse to agriculture.
- Sensitivity to contamination - hard objects can damage up front shredding equipment such as labels in food waste from restaurants and contaminants such as pesticides in green waste can kill the micro-organisms on which the process relies.
- The capital cost of a commercial systems is high and not able to be scaled. Minimum viable scale is generally 20,000 tonnes/year costing US7.5million

Vermicomposting

Vermicomposting is a type of composting in which certain species of earthworms are used to enhance the process of organic waste conversion. Earthworms feed on the organic waste materials the resultant granular material, known as vermicompost, can be applied directly to land and soil as a soil additive.

Vermiculture produces a higher-quality product than compost. Vermiculture can be operated at home, market, and municipal scales. However, the process is slower and more sensitive to environmental conditions (temperature), contaminants, and/or excessive amounts of one material.

The average time it takes to complete the Vermicomposting process is 3-6 months. Due to environmental sensitivity and time, Vermicomposting is **not considered suitable at a community scale in the Pacific**.



Advantages and Disadvantages of Vermicomposting

Advantages

- Vermiculture produces a higher-quality product than compost
- Small land area required, with low technology (earthworms play the main part) and minimal energy input
- Can be scaled to operate at home, market, or municipal scales

Disadvantages

- Vermicomposting is slower and more sensitive to environmental conditions (temperature), contaminants, and/or excessive amounts of one material
- High Maintenance compared to traditional compost processes. Requires constant monitoring and addition of food and moisture

Rapid Digestion Composting

Rapid digestion composting is a high-technology automated in-vessel option designed to produce compost in less than 24 hours, some in just 2-3 hrs. Rapid digestion composters uses heat and enzymes to expedite the composting process.

The technology generally uses three components:

- Composting chamber - with internal rotating arms for mechanical agitation, and an oil jacket for heating
- Microorganisms - naturally occurring microbes to assist with the composting
- Pasteurisation - temperature of the tank is raised to high temperatures to eliminate harmful bacteria

Rapid digestion composting is a fast process designed to produce virtually no odour. Rapid digestion composting is generally suited for large scale operations as uses significant energy and involve high capital costs. Due to high technology requirements, they are **not suited to the Pacific island context.**



Advantages and Disadvantages of Rapid Digestion Composting

Advantages

- Rapid digestion composting can produce compost in less than 24 hours, required reduced operational requirements
- Rapid digestion composting units take up little space.
- The compost process is enclosed. Any odours that might arise from the decomposition would be contained. Since the system is impervious to weather, dust during dry times or leachate run-off during rainy periods would not be an issue.

Disadvantages

- Requires high capital costs and uses significant energy
- Potentially intensive maintenance program
- Medium to high skill level required to operate machinery and electronics.
- Suited to highly populated countries/community centres

Dehydration

Dehydration is an organics management option to convert material into an easily manageable material.

Dehydrators heat up a chamber to 80°C which induces evaporation and produces a solid material that is very dry and lightweight, biologically inert, and virtually odorless.

The material maintains a high nutrient value which makes it a great ingredient for use in soil additives, animal feed, and can be an effective and time saving feedstock for traditional compost or vermiculture due to it being processed under high temperatures which kill pathogens and weed seeds.

The dehydration process uses significant energy but actually produces distilled water (that is evaporated from the food waste) which can be used for irrigation, cleaning, or can be safely disposed to land.

Dehydration is generally suited for specialist operations where reduction in volume of waste is an important component. It is not generally suitable to manage garden/tree litter, especially high fibrous material such as coconut husks and fronds. As such, Dehydration is **not suited to the Pacific island context**.

Advantages and Disadvantages of Dehydration

Advantages

- Dehydrated material not a compost but stable with minimum odour unless re-wet
- It is a clean and easy to use on-site technology popular in Korea and Japan
- Does not require water during processing
- Maintains a high nutrient value which makes it a valuable ingredient for use in soil amendments and animal feed

Disadvantages

- Relatively expensive compared to capacity and uses significant energy
- Dehydrated material not a compost but can be an effective and time saving feedstock for traditional compost or vermiculture due to it being processed under high temperatures which kill pathogens and weed seeds
- Not generally suitable to manage garden/tree litter, especially high fibrous material such as coconut husks and fronds
- Potentially intensive maintenance program
- Medium to high skill level required to operate machinery and electronics.
- Suited to highly populated countries/community centres

Biomass Plant Technology

Biomass plant technology refers to facilities that burn biomass (materials, including wood, agricultural residues, and animal and human waste) for energy production. Biomass is considered a renewable energy source used for heating and electric power generation.

Biomass technology can be scaled for different purposes.

- Small systems are commonly used for household heating (through wood pellets) and are available off-the-shelf from numerous manufacturers.
- Larger community scale systems typically require significant customisation before power can be integrated into the existing electrical grid.

Compared to most other renewable energy options currently available (solar and wind), biomass has the advantage of dispatchability, meaning it is controllable and available when needed, like fossil fuel heating and electric generation systems.

The disadvantage of biomass is that the fuel needs to be purchased, procured, delivered and stored, and ash removed and moving parts maintained. Biomass combustion also produces emissions, which must be monitored and controlled to comply with regulations. Biomass plants are also expensive to build and operate.

The economic viability of biomass is dependent on government mandates and/or subsidies, due to high costs of infrastructure and ingredients for ongoing operations relative to other sources of energy, this technology is unlikely to be **suitable for many Pacific island countries**.

Advantages and Disadvantages of Biomass Plant technology

Advantages

- Biomass power generation is a renewable energy for heating and electric power generation
- Biomass power generation technology is much cheaper than fossil fuel power generation
- Biomass energy production can use a large variety of materials, including bi-product waste from the forestry/wood processing industry, residues from agricultural, and animal and human waste

Disadvantages

- Technology requires higher operator skills and training requirements.
- Air emissions can be controlled but at a cost.
- Ash if produced by the technology may not have a recyclable outlet and may have to be disposed of in a landfill.
- Since wood is one of the most used sources of biomass energy, vast amounts of wood and other waste products have to be burned to produce the desired amount of power
- While biomass power generation can be carbon neutral, the use of animal and human waste in the process increases the amount of methane gas generation
- Biomass plants require a lot of space

Appendix A – Backyard Composting

Backyard composting is an effective composting method requiring the least amount of technology or capital expenditure. Instead of governments or the private sector collecting and processing organics at a central facility, households can instead turn their organic material into their own nutrient-rich soil enhancer – in the luxury of their own backyard!

This option requires minimal space, technology, expenditure and expertise.

The main element households will need is a compost bin. Compost bins can be made using a variety of items readily-available in the Pacific – many of which are "waste materials" themselves – such as old pellets, chicken wire, bricks, blocks, tyres, seed drums, tree branches/trunks, washing machine drums.

While this composting method is at a far smaller scale than other methods discussed, the fundamentals of composting remains the same.

Compost you require three main ingredients:

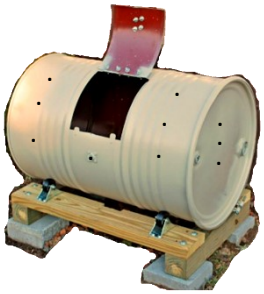
- Correct balance of organic materials (carbon and nitrogen)
- Appropriate particle sizes
- Sufficient moisture and oxygen
- Correct temperature and temperature/time relationship

The composting process in a backyard composting system is typically between 3 – 6 months.

Backyard composting is the lowest cost option, requiring minimal investment and coordination by government yet producing an effective result. They are **highly suited to the Pacific island context**.







Advantages and Disadvantages of Backyard Composting

Advantages

- Households able to transform kitchen and garden waste into a nutrient rich food for their garden.
- Requires minimal technology or capital expenditure
- Requires no central collection service
- Simple technology with low level skills required
- High quality of compost since waste is efficiently separated and risks for contamination are minimised

Disadvantages

- If compost not managed correctly, may cause minimal odour or be attractive to animals
- Reduces opportunity for local small-scale enterprises

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