microRenewables HANDBOOK

BIODIGESTERS

CREST

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Introduction to Biodigestion

Biodigestion is a natural process of decomposing organic matter in an anaerobic (no oxygen) condition. For this process to happen, organic matter is fed and sealed in a closed container called a biodigester. Anaerobic decomposition (AD) can be found in ecosystems like swamps and peatlands. AD is different from usual composting practices where organic materials decompose in an aerobic manner.

Biodigestion has two main byproducts:

a) **biogas** that can be used in cooking or to create energy, and
b) **digestate** that is an effective fertilizer for plants and is a valuable soil conditioner.

Since 50-60% of the waste produced in the Philippines is biodegradable or organic, biodigestion offers a reliable and efficient way of managing municipal and agricultural waste. The system does not produce harmful chemicals or byproducts such as dioxins, which are produced through incineration or open burning of waste.

Biodigester system in Barangay Dampalit, Malabon City

Feedstock

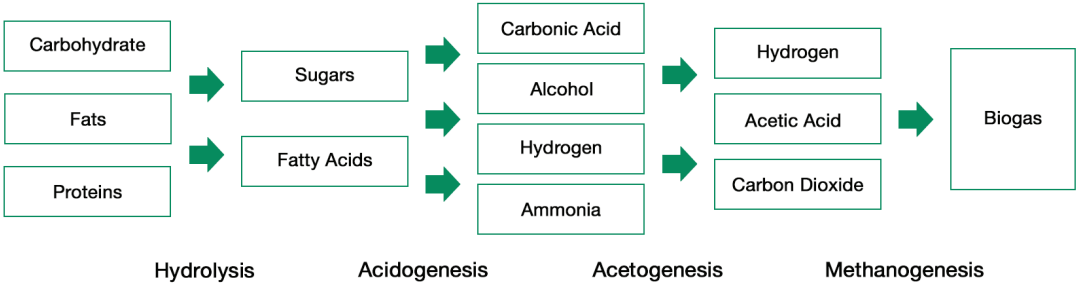
It is important to feed the digester with the right feedstock, volume and consistency to ensure that biodigestion happens properly. Treat the digester as your stomach: it will have an undesirable reaction if you overfeed or underfeed. If you don't feed your digester properly, the microorganisms inside that are responsible for anaerobic decomposition will get weak and die.

Almost all kinds of organic waste can be fed into a digester. But caution must be taken with regards to a few materials to make sure that they don't harm your digester and the digestion process.

Do Feed with:	Do Not Feed with:
• Food waste; • Used cooking oil and grease (only from food); • Animal manure (from cows, dogs, cats, etc – make sure the manure is free from contaminants like sand); • Rotten fruits and vegetables, peelings and inedible parts of fruits and vegetables; • Rotten eggs; • Meat and fish products (without the bones); • Dairy products such as milk, butter, yogurt, etc.	• Non-biodegradable items such as plastic cutleries or wrappers (even plastic materials labelled "*biodegradable*"); • Water with soap, bleach or detergent; • Chemicals solutions; • Chicken waste (high in antibiotics); • Bones and seashells like clams and oysters. Shredded shrimp shells are acceptable but only in a limited basis (1-2x a month); and • Calamansi, lemon and other citrus, and acid-rich food and mixtures.

Process of Anaerobic Decomposition

There are different kinds of microorganisms that interact with each other to decompose biodegradables inside the digester. First, oxygen-loving bacteria will actively decompose the organics. When the oxygen has been successfully depleted, anaerobic bacteria will come in to turn decomposed matter into simple substances like organic acids. Methane bacteria will then act to decompose the organic matter further, and in the process create biogas. The remaining solids and liquids through these multiple processes, called digestate, will be released through the effluent pipe.



Stages of Anaerobic Decomposition. Source: GAIA

The effectivity of the biodigester relies on the microorganisms at every aspect of anaerobic decomposition. It is important to maintain right conditions inside the digester to produce biogas and keep a balanced relationship between the microorganisms living inside. In addition to the right amount and frequency of feeding, an ideal pH level of 7.5 – 8.5 must be maintained, as well as an ideal temperature of around 37 degrees Celsius.[1]

BIOGAS COMPOSITION		
COMPOUND	**SYMBOL**	**%**
Methane	CH_4	50-75
Carbon Dioxide	CO_2	25-50
Nitrogen	N_2	0-10
Hydrogen Sulfide	H_sS	0-3
Hydrogen	H_2	0-1

1 Stoner, Carol Huppin, Producing Your Own Power, 1974.

Biogas

One of the useful by-products of anaerobic digestion is biogas. Biogas is composed of different compounds, 70% of which is methane and 29% is carbon dioxide, with insignificant traces or oxygen and hydrogen sulfide which gives the gas a distinct odor (rotten egg smell).

The fuel value of the biogas is directly proportional to the amount of methane it contains. Other gases present in the biogas are either non-combustible or of very low amounts.

The amount and fuel value of biogas is also dependent on the nature of the feedstock or organic material. For example, animal manure produce higher amounts of methane compared to plant-based organic waste. This is the main reason why biodigestion is popularly used as an efficient waste management option in the livestock sector.

Biogas can be used directly for cooking, compressed and stored in a tank (like liquefied petroleum gas or LPG), or connected to a biogas generator to provide electricity. A 1 cubic meter (1000 liter) capacity biodigester fed daily and running efficiently can produce enough biogas to cook food for more than 30 minutes every day.

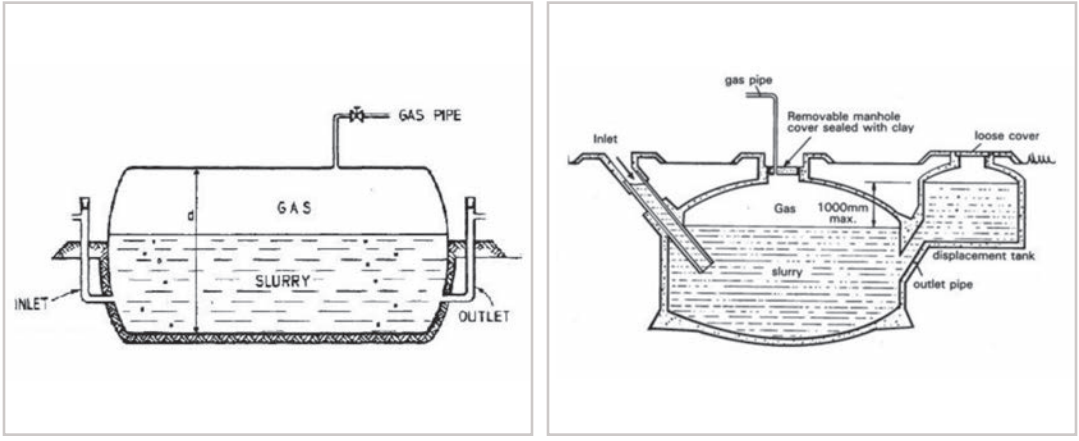
Digestate

For any amount of organics fed into a digester, an equivalent amount of digestate is produced and pushed out as effluent. Digestate is a mixture of liquid slurry and solids that have passed through anaerobic decomposition. The slurry is safe, non-toxic and can be harvested directly from the effluent tank using a dipper or pail.

Since digestate contains mainly nitrogen, it is an excellent plant fertilizer particularly for nitrogen-loving plants, and can be used to replace agro-chemical fertilizers. It is also an excellent soil conditioner, and can increase the soil's water retention capacity and improve its structure.

It is best to dilute the digestate before applying it to the soil or plants. Plants that were watered by diluted digestate have been observed to yield productive results.

The Digester



▲ Tubular biodigester (left) and vertical chamber biodigester (right).

The amount of feedstock is dependent on the size of the digester. It is important to get the size of your digester right: an oversized digester requires higher capital costs and more feedstock, while an undersized digester could result in overflow and incomplete digestion.

The digester can be placed below ground or above ground depending on its design.

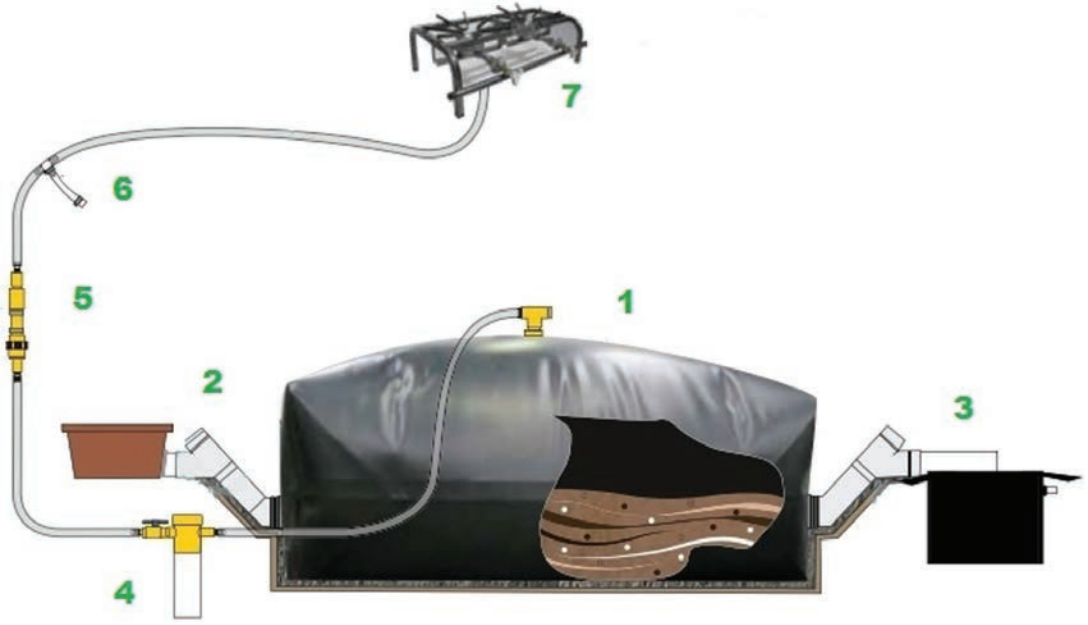
Vertical chamber digesters are usually made from multiple containers where slurry is fed. These are usually made from cement or ferrocement. The top of the chamber may be fixed or floating, and can be made of steel or fiberglass. Smaller and more simple vertical chamber digesters can be made using container drums or IBC tanks. In a vertical chamber, the digestate is forced up and out of the effluent pipe when the chamber is full. In some instances, the digestate may be forced out even if the decomposition process is incomplete. To solve this problem, additional chambers may be added.

Displacement digester are cylinders or tubes that are placed horizontally on the ground. These are typically made from flexible plastics like tubular polyethylene, PVC or HDPE geo-membranes. These digesters can be set up as quickly as one day. In a displacement digester, the slurry is fed into the feeding pipe. The slurry passes and is pushed slowly into the chamber, where it will fully pass through complete anaerobic decomposition before coming out of the effluent pipe as digestate.

Basic Components

A typical anaerobic biodigester system contains the following:

1. Digester/Reactor: Chamber where anaerobic decomposition and formation of biogas takes place.
2. Feeding Tank: Where organic matter is mixed with water to make a slurry and fed into the digester.
3. Digestate Tank: Where the digestate comes out of the digester.
4. Pressure Safety Valve: Where excess biogas comes out.
5. Sulphide Filter: Filters Sulphur dioxide, a dangerous gas.
6. Water trap: Traps condensed water formed inside the biogas hose.
7. Stove: Cooking stove that uses the produced biogas.



▲ Biodigester system components. Photo from: https://sistema.bio/

Build Your Own Home Biodigester

You can build your own digester by using materials commonly found in hardware stores. You will need the following:

200L used air-tight barrel drum with removal lid

5 ft ½" gas hose

½" brass gas nozzle

stove

PVC tee with 2" diameter

PVC elbow with 2" diameter

PVC cap with 2" diameter

PVC pipe with 3" diameter and 2.5 ft PVC pipe with 2" diameter

1/2 plastic pipe nipple

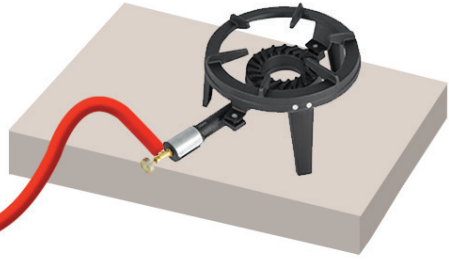
½" plastic pipe coupling

½" PVC ball valve

50kgs cow dung (dried)

Steps:

1. Drill the following holes for your 3", 2" and 1/2" PVC pipes in the lid of your drum.
2. Insert the 3" PV pipe into the hole leaving the 1-foot length exposed.
3. Insert the 2" PV pipe into the hole leaving ½-foot length exposed.
4. Combine the ½" coupling and nipple and insert it into the hole.
5. Carefully seal the PVC pipes with epoxy. It is best to apply epoxy in multiple layers to prevent any potential gas/air leaks. Allow epoxy to dry between applications.
6. Ensure that the epoxy resin is completely dry.
7. Put the cow dung inside the barrel drum. Put 100 liters of water and mix thoroughly to break the cow dung. The consistency must be that of a slurry, and it might take a few days to achieve this consistency.
8. Place the air-tight lid to seal the drum.
9. Connect the ½" plastic nipple to the ½" PVC ball valve and then the brass nozzle.
10. Connect the brass nozzle to one end of the gas hose and the stove on the other end.
11. Wait for at least two weeks then test for fire. Once the digester produces flame, it is already ready to receive fresh organic waste or feedstock.



Preparing the Biodigester for Use

- Remember to locate the digester in a safe place. Make sure the area is not prone to flooding and storm surges.
- Put the digester, stove and other components in an area inaccessible by children and animals. It is ideal to put a fence around the entire area, or at the least, around the digester and its components.
- Ensure there is enough water source and feedstock in the area every day. Rain water or AC water can also be used.
- Before using the digester, ensure that there is a healthy amount of inoculants inside the digester. Cow manure mixed with water is an ideal source of inoculant. Feed this mixture into the digester, wait for at least two weeks for it to mature and for the pH level to stabilize inside the tank before feeding the digester for the first time. The pH level has stabilized when your digester is able to produce a flame.
- You can use low-cost accessories for your biodigester. You can use ordinary steel/iron wool for filtering sulphide.

Feeding the Biodigester

- Once the digester is ready, you can feed your digester by mixing organics with water to make a slurry. The ideal ratio of waste to water is 1:2.
- It is important to feed the digester properly. Improper feeding can kill the microorganisms inside the digester.
- Make sure that only organic or biodegradable matter is used as feedstock. Remove contaminants such as plastic materials, rocks, sharp objects and others.
- Never put water mixed with soap, detergents or chemicals inside the digester.
- To hasten decomposition, shred organic matter manually or by using a shredder.

Maintenance

- Mix or agitate the digester once or twice a month.
- Regularly monitor the pressure safety valve, and replace the water when necessary.
- If there is a noticeable smell, replace the steel wool inside the sulphide remover. Steel wool can be easily and readily found in any hardware store.

Benefits of Anaerobic Digestion

Clean energy.

Biogas is a viable alternative to LPG and to other, more unsafe fuel for cooking such as coals or wood products. It can also safely produce electricity. Through anaerobic digestion, the unsustainable and destructive process of continuously extracting fossil fuels, forest products and other raw materials for cooking or to produce electricity can be dramatically lessened.

Higher agricultural yield.

Digestate is an excellent natural fertilizer that has been proven to raise yields by as much as 30%. Liquid digestate can be fed directly to plants or to soils, and is an excellent natural product that can maintain and bring back the health of soils.

Green technology.

The technology of anaerobic digestion is safe and does not emit harmful chemicals and pollutants, unlike incinerators and other waste-to-energy facilities. AD is a proven technology that can solve waste problems particularly in cities and urban areas.

Easy to use.

The biodigester technology is extremely simple. Operators do not need advanced or technical degrees or certificates to operate and maintain a biodigester.

Healthy families.

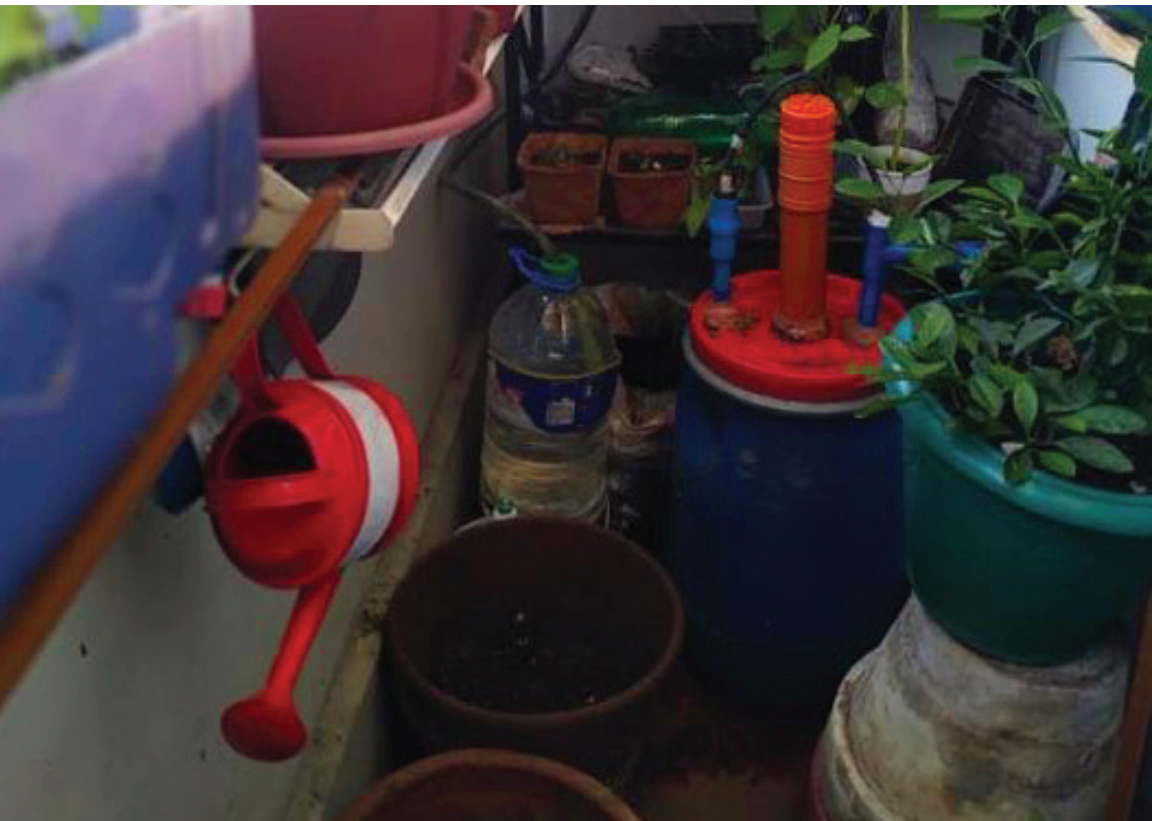
Indoor pollution caused by cooking indoors using wood or coals is a leading cause of health problems for families, particularly for children and the elderly. Cooking using biogas does not produce emissions that are harmful to health and the environment.

Clean communities.

The AD technology is an excellent solution to waste problems in cities and municipalities. Because it can process wastes that are voluminous and are typically the most difficult to manage such as biodegradable waste, food waste, used oils, meat products and the like, utilizing biodigester technologies in communities is an excellent way of ensuring that communities stay safe from disease and pests.

Climate-friendly.

AD is a carbon-neutral technology. Every kilo of biodegradable waste that is fed into a digester is the same amount of waste diverted from a landfill or dumpsite. Biodegradable waste in landfills create methane, a powerful greenhouse gas that drives climate change. Every kilo of organic waste fed into a digester prevents an equivalent of 1.9 kilos of carbon dioxide from being created in landfills (carbon dioxide equivalent or CO_2e).



NOW OPEN!

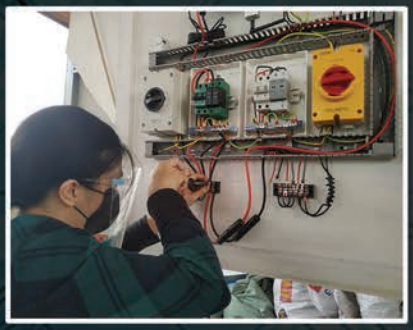
CREST

microRenewables Learning Center

Do you want to expand your knowledge and skills on RE systems?

Visit our center and learn about different renewable energy and small-scale climate systems. The facility provides a venue for professionals, advocates and enthusiasts to learn practical applications for various microrenewable such as solar photovoltaic (PV) rooftop and wind technology.

The facility also has a regenerative urban garden system that combines an organic garden with rainwater harvesting, soil management, and composting.

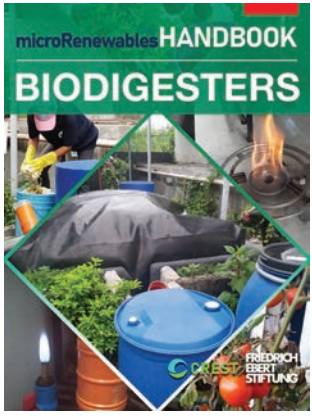
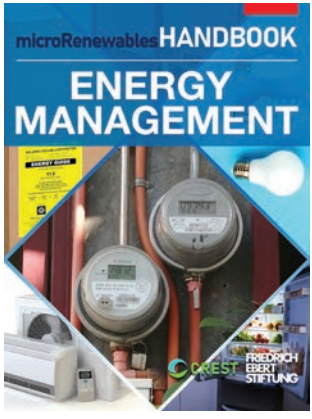
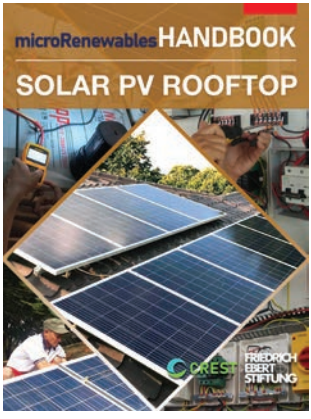


The CREST's microRenewables Learning Center is located in **69 Bansalangin Street, Project 7, Quezon City**.
To know the training schedules and/or arrange visits, please contact **crestphilippines@gmail.com**

Go microRenewables!

Renewable energy is one of the fastest growing global industries. In the Philippines, solar PV rooftop has already achieved grid parity, and it is now the cheapest electricity source. Electricity produced from other renewable energy sources are also already cost-competitive with those produced from conventional fossil-fuel power facilities such as coal and oil.

Current and future innovations on renewable energy are already shifting to decentralized, small-scale systems. CREST sees the renewable energy industry today in a similar stage as the computer industry, when microcomputers were starting to be used by techies and increasingly by businesses. When these products reached a certain market volume, the economy of scale began to take effect, resulting in a virtuous cycle of steady price reductions and continuing market growth.

CREST releases this handbook to encourage all to adopt sustainable energy and climate systems in your own homes and business establishments. These learning products will be useful to interested local government officials, teachers and students, technical professionals, energy advocates, and even to individuals that have no deep technical background.

The adoption of sustainable practices in homes and workplace will result to healthier and safe environment for families, co-workers and fellow members of our community.