

AI 3010 WASTE AND BY PRODUCT UTILIZATION

UNIT III NOTES



waste treatment and disposal design using bio gas plant

The sludge cannot be dumped into water bodies. Therefore it is channeled into a chamber where the anaerobic bacteria decompose them further and produce biogas. In this way sewage treatment plants can be used to produce biogas as well. Hotel premises, army/big establishment canteens (private/ government), residential schools/colleges, housing colonies, religious places / temple trusts, hospitals, hotels, sewage treatment plants, villages, etc.

Bio Gas plant

A biogas plant is a facility that provides oxygen-free conditions where anaerobic digestion can occur. Simply put, it's an artificial system where you can turn waste into sustainable energy and fertilizers, with positive effects on the environment.

A biogas plant has three major components that make the biogas production process possible:

- a reception area
- a digester (or fermentation tank)
- a gas holder

The reception area is where the raw materials arrive and are prepared for anaerobic digestion. Each type of biomass has a different fermentation process, so the overall length of the biogas production process varies depending on the raw materials used, and it isn't uncommon to use pre-treatments in industrial biogas plants to accelerate fermentation and increase the production of biogas.

Some of the most popular biomass choices are crop residues, municipal and industrial sewage, agricultural material, livestock manures, seaweed, food-processing, and paper wastes, but the list of raw materials used is significantly longer.

The digester is an air-tight, waterproof container with a mean of entry for the biomass. Here, you introduce the raw materials to be transformed into energy. Then, agitators shift the biomass periodically to free the gases and prevent the formation of layers. The digester also includes a pipe that enables the digestate to be removed after the fermentation is over.

The gas holder is an airproof container, preferably made in steel, that collects the gas generated during fermentation. It's provided with a gas outlet that permits the biogas to come out of the system and produce energy and heat.

Depending on the quantity of waste you want to eliminate from the environment or the volume of biogas you need to produce, a plant might have more than one digester and gas holders.

Working

Step 1 – Pre-treatment and filling the digester

Multiple types of organic matter, called substrates, go into the digester. Some substrates can be liquid manure, renewable raw materials (such as corn or grass), or waste produced by the food industry. Some of them may need to be stored in cement containers and pre-treated before entering the air-tight tank. One plant can include several digesters, depending on its size.

Step 2 – The fermentation process

The substrates are heated to various temperatures inside the fermenter, and a series of microorganisms start breaking down the organic matter in the absence of light and oxygen. During the process, the organic matter is shifted to prevent layers from forming at the top and bottom of the tank.

Step 3 – Producing biogas

As a result of the fermentation, biogas with methane as the main ingredient is produced inside the fermenters. At this stage of the process, the gas includes, besides methane and carbon dioxide, water and hydrogen sulfide—which is one of the main reasons containers should be made in steel, known to withstand the effects of the gas for long periods.

Step 4 – Pulling out the residues

After fermentation, the residues called digestate are pulled out of the tank to be used as environment-friendly, high-quality fertilizer. This way, the biogas production process becomes a zero-waste system of eliminating garbage from landfills while providing a solution for better crops at the same time.

Step 5 – Eliminating impurities

The biogas goes through a cleanup process, in which water, hydrogen sulfide, and impurities are removed to produce biomethane that can further be used to generate energy and heat. The biogas is permanently monitored to ensure the quality of the final product.

Uses of bio gas plant

Biogas plants can have multiple purposes and fulfill a double role in the ecosystem and the economy. On the one hand, biogas plants can supply us with carbon-neutral energy and heating.

If the biogas plant compresses the biogas to obtain biomethane, this can substitute natural gas for industrial, commercial, and domestic uses. The fuel can be easily transported to supply gas filling stations.

Biogas is 100% renewable and carbon-neutral, as its combustion doesn't produce new carbon dioxide. Moreover, the production process prevents the release of methane into the atmosphere, with a positive impact on the environment.

The biogas can be combusted in domestic stoves for cooking after minor treatment. Otherwise, it can be used to generate heat, produce electricity, or, in heat and power (CHP) plants, produces both heat and electricity.

The energy produced by biogas plants can be directly fed into the power grid and serve one or more communities, depending on the size of the biogas plant. Furthermore, the heat generated throughout the process can be used to heat pools or buildings.

Advantages

Most benefits of biogas plants are environment-related, as they produce renewable energy for domestic and industrial use. This energy can be stored or injected into the electricity grid to reduce dependence on fossil-fuel energy, which can help **reduce our carbon footprint**.

In other words, biogas plants can help to fight climate change. As domestic and industrial users rely less on the energy produced with fossil fuels, greenhouse gas emissions become lower. At the same time, by gathering organic matter and controlling the fermentation process, fewer methane emissions get into the atmosphere for improved air quality.

Communities reach these results while managing food waste and preventing garbage from ending up in landfills. Recycling organic waste means fewer odors, a minimum risk for spreading diseases, and protected water bodies, among other things.

Another advantage of biogas plants is eliminating the need for synthetic fertilizers, as they get replaced by digestate. It recirculates a series of nutrients, such as phosphorus, which is essential for healthy crops.

Besides the positive effects on the environment, biogas plants contribute to building a circular economy, in which more industries can become sustainable and self-sufficient by using their waste to obtain energy or heat. As the number of facilities grows, new jobs are generated across multiple verticals, with a significant impact on the quality of life in numerous communities worldwide.

Limitations

. The costs associated with building a biogas plant make investing in such facilities a challenge in many communities. Furthermore, the model as we know it today isn't feasible in large, urban communities that require high amounts of energy to thrive but can't provide the raw materials necessary for generating enough biogas.

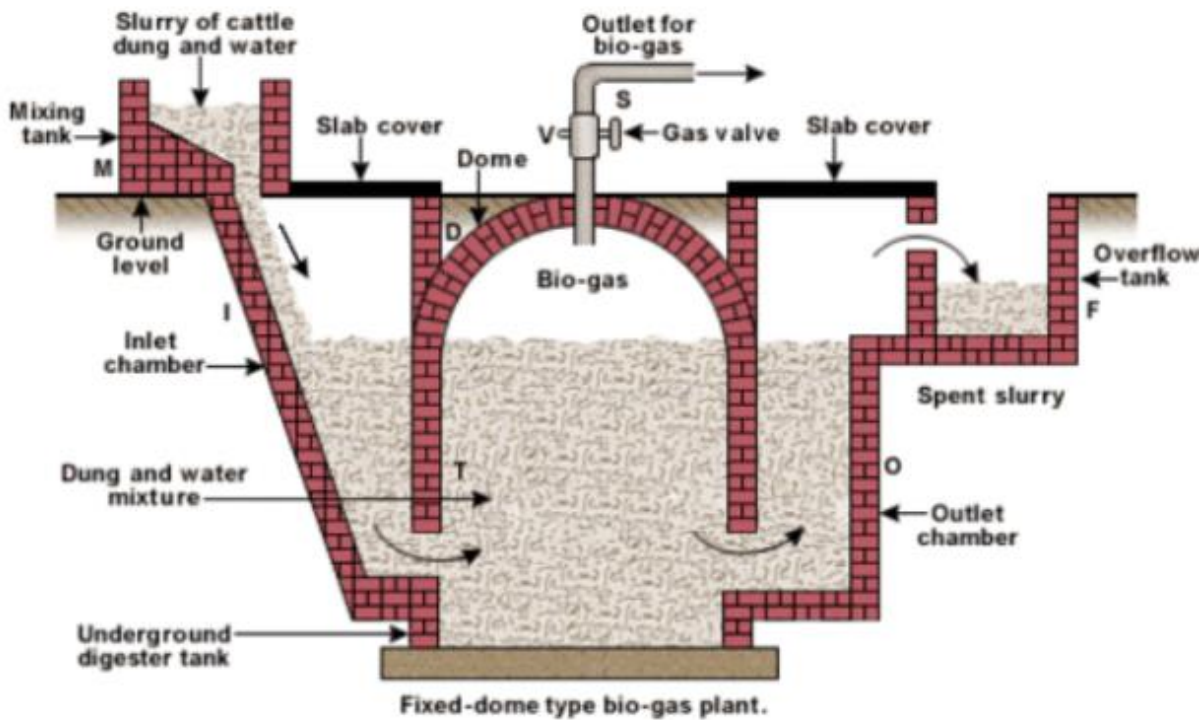
The technology used inside many biogas plants could use an upgrade, too, to be more efficient and cost-effective. This way, biogas plants could become easily scalable, and the biogas would turn into a low-cost renewable energy solution.

Another concern around biogas production regards intentionally planted maize. Biogas production is a sustainable process as long as the raw materials used solve waste management problems. If biogas plants replace waste with energy crops, these plantations can quickly become unsustainable and even harmful to the environment.

Structure of biogas plant

Biogas basically is a gaseous mixture of gases produced by fermentation of different organic matter which involve household waste, domestic waste, animal waste, etc. This gas mainly consists of methane which is a result of metabolism of microorganisms feeding on the organic waste. So, we develop different and effective structures for biogas production.

Now, Biogas plants are somewhat, like dome structures. These are made up of bricks and cement. This is a sample diagram of a Biogas plant.



This plant consists of different chambers or rooms:

- > Mixing tank – This tank is present above the ground where all waste is collected and everything collected is mixed to be processed further.
- > Inlet chamber- This basically consists of two parts inlet pipe and storage place where inlet pipe will collect all the waste from mixing chamber.
- > Digester- This tank is present underground so that proper anaerobic conditions can be provided to microbes to grow and to produce desired output. In this tank an outlet pipe is also connected which takes out gas which is produced inside.
- > Outlet chamber – this tank is required to collect all dead biomass or remaining fragments of input waste. It took out all the waste from the digester.

> Overflow tank – Outlet chamber opens in a small overflow tank where all processed or waste material can be stored.

Installing bio gas plant in community

.Some of the other advantages of a community plant are listed below:

1. Sanitation: with proper management of animal and other agriculture/organic wastes/ village will be clean leading to better health and hygiene in rural areas. 2. Energy security: conversion of organic waste into methane and its use as fuel will lead to energy security because the fossil fuel is not going to last forever. 3. Pollution control: normally aerobic decay of organic waste leads to emission of green house gases like carbon dioxide or carbon monoxide. The process of methanation reduces green house gas emission and helps in arresting depletion of the ozone layer. This is likely to earn carbon credits. 4. Employment generation: Such plants can be easily set up and operated at village level and can be managed by women self help groups or local entrepreneurs with lower per capita investment. Since the product has a captive market the plant is bound to be economically viable and generate employment opportunity for a large number of people

Design

Flawless design is the key to smooth and efficient operation of the plant. A small design error can lead to high loss of efficiency or even complete failure of the plant. This plant being a large-scale community biogas plant further emphasizes the need for accurate design. Considerably large design errors can be tolerated in the case of small, individual plants but not in the case of a community plant which is many-fold in size, operational cost, revenue etc as compared to the former.

Design of the plant:

The design of the plant is based upon many factors. Some of the major factors imposing specific design constraints have been discussed below.

1. Location of the plant: The site of the plant had to be chosen in the close vicinity of the main settlement of the village. This constraint is imposed as the plant cannot be far off from the

beneficiary owing to the daily transport of dung to the plant and piped pressurized gas supply to the beneficiary.

2. Sizing: The size of the plant was primarily decided by the number of beneficiaries that signed up for the project. For example if 121 beneficiaries = 121×30 kg cow dung per day = 3630 kg per day Plant has to be designed with a capacity of 4500 kg per day.

Case study of a biogas plant

A biogas plant consists of three components – a digester, a gas storage container, and a burner,”.

Kitchen waste is stored in a large bucket



Before feeding the kitchen waste, it is important to process it and convert it into a semi-solid pulp, so that there are no solid bits of waste which may get stuck in the biogas plant, hindering the biogas production. The processed kitchen waste is then fed into the digester, which is essentially a large tank-like structure. This is where the biogas is eventually produced. When one feeds wet waste into the digester, bacteria break the waste down over time to produce biogas, releasing a slurry as a by-product that can be used as organic fertiliser for plants. This process is called anaerobic digestion.

The tank touching the ground is the digester of biogas plant. kitchen waste is fed into into a bowl-like structure that is on the left to the tank.

Just above the digester, there is a floating drum



As biogas is produced inside the lower tank, it rises up to fill the gas storage container above, propelling it upwards.

Then as the biogas is gradually consumed, the floating drum is pushed down. When the drum is halfway down, Suresh feeds the next batch of waste into the digester.

The storage connects to the burner, where one does the cooking, via gas pipes. Pipes connect the floating drum to a burner in kitchen. The pipes run along the walls of backyard, go through the kitchen window and are attached to the burner.



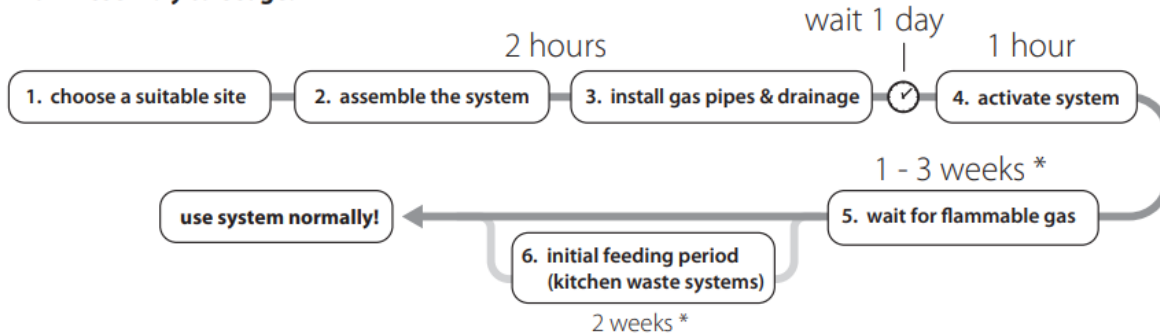
As the biogas is produced in the digester, slurry is also let out and collected in a separate bucket, as shown in the picture below. It can be diluted this with water and adds it as a fertiliser to the plants.



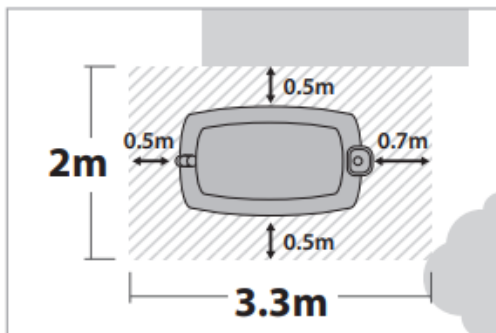
kitchen leftovers, cooked food, uncooked food, spoiled food, vegetable peels in the digester. The only catch is that the waste must be in liquid or semi-solid form. Therefore, it is better to either soak the waste or grind it in a mixie before feeding it into the digester. This is because the solid bits of waste may get stuck in the plant, hindering the biogas production.

Steps for a Individual bio gas plant

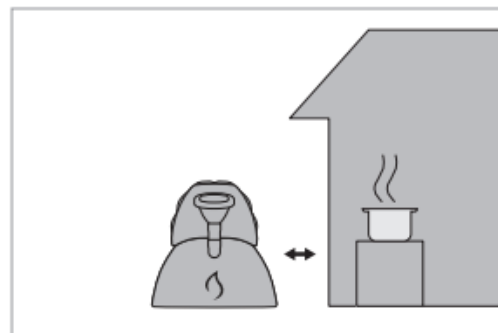
From Assembly to Usage:



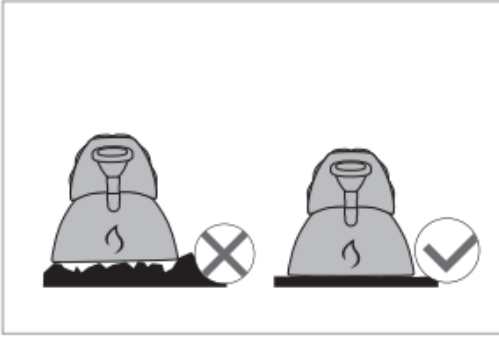
Important points



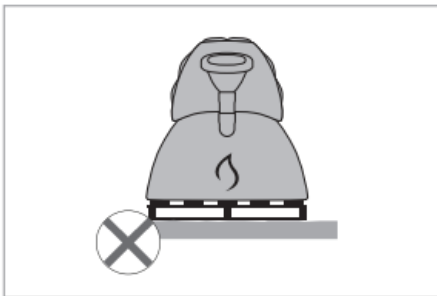
prepare at least 2 x 3.3m space for the system
(0.5m side, 0.7m front clearance for maintenance & daily usage)



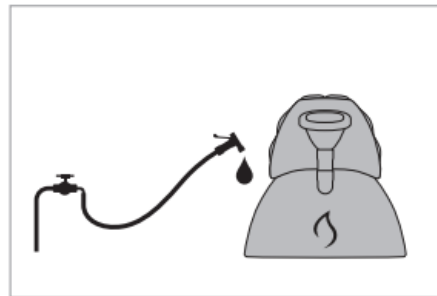
system should be installed close to kitchen/cooking area



prepare a firm, flat surface clear of obstructions - do not place on soft or unstable ground
e.g. flat dry ground, tile, concrete



do not place system on shipping pallets or other weak raised surfaces



place system within reach of a water supply.

Concept of vermicomposting

Vermicomposting is the scientific method of making compost, by using earthworms. They are commonly found living in soil, feeding on biomass and excreting it in a digested form.

Vermiculture means “worm-farming”. Earthworms feed on the organic waste materials and give out excreta in the form of “vermicasts” that are rich in nitrates and minerals such as phosphorus, magnesium, calcium and potassium. These are used as fertilizers and enhance soil quality.

Vermicomposting comprises two methods:

- **Bed Method:** This is an easy method in which beds of organic matter are prepared.

- **Pit Method:** In this method, the organic matter is collected in cemented pits. However, this method is not prominent as it involves problems of poor aeration and waterlogging.

his process is mainly required to add nutrients to the soil. Compost is a natural fertilizer that allows an easy flow of water to the growing plants. The earthworms are mainly used in this process as they eat the organic matter and produce castings through their digestive systems.

The nutrients profile of vermicomposts are:

- 1.6 per cent of Nitrogen.
- 0.7 per cent of Phosphorus.
- 0.8 per cent of Potassium.
- 0.5 per cent of Calcium.
- 0.2 per cent of Magnesium.
- 175 ppm of Iron.
- 96.5 ppm of Manganese.
- 24.5 ppm of Zinc.

Also Read: Garbage in garbage out

Materials Required

- Water.
- Cow dung.
- Thatch Roof.
- Soil or Sand.
- Gunny bags.
- Earthworms.
- Weed biomass
- A large bin (plastic or cemented tank).
- Dry straw and leaves collected from paddy fields.
- Biodegradable wastes collected from fields and kitchen.

Procedure

1. To prepare compost, either a plastic or a concrete tank can be used. The size of the tank depends upon the availability of raw materials.
2. Collect the biomass and place it under the sun for about 8-12 days. Now chop it to the required size using the cutter.
3. Prepare a cow dung slurry and sprinkle it on the heap for quick decomposition.
4. Add a layer (2 – 3 inch) of soil or sand at the bottom of the tank.
5. Now prepare fine bedding by adding partially decomposed cow dung, dried leaves and other biodegradable wastes collected from fields and kitchen. Distribute them evenly on the sand layer.
6. Continue adding both the chopped bio-waste and partially decomposed cow dung layer-wise into the tank up to a depth of 0.5-1.0 ft.
7. After adding all the bio-wastes, release the earthworm species over the mixture and cover the compost mixture with dry straw or gunny bags.
8. Sprinkle water on a regular basis to maintain the moisture content of the compost.
9. Cover the tank with a thatch roof to prevent the entry of ants, lizards, mouse, snakes, etc. and protect the compost from rainwater and direct sunshine.
10. Have a frequent check to avoid the compost from overheating. Maintain proper moisture and temperature.

Advantages Of Vermicomposting

The major benefits of vermicomposting are:

1. Develops roots of the plants.
2. Improves the physical structure of the soil.
3. Vermicomposting increases the fertility and water-resistance of the soil.
4. Helps in germination, plant growth, and crop yield.
5. Nurtures soil with plant growth hormones such as auxins, gibberellic acid, etc

Disadvantages of Vermicomposting

Following are the important disadvantages of vermicomposting:

1. It is a time-consuming process and takes as long as six months to convert the organic matter into usable forms.
2. It releases a very foul odour.
3. Vermicomposting is high maintenance. The feed has to be added periodically and care should be taken that the worms are not flooded with too much to eat.
4. The bin should not be too dry or too wet. The moisture levels need to be monitored periodically.
5. They nurture the growth of pests and pathogens such as fruit flies, centipede and flies.

Vermicomposting turns the kitchen waste and other green waste into dark, nutrient-rich soil. Due to the presence of microorganisms, it maintains healthy soil.

Vermicomposting is an eco-friendly process that recycles organic waste into compost and produces valuable nutrients.