ECHO Technical Note

METHANE DIGESTERS

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What's Inside:

INTRODUCTION

When organic material decomposes under anaerobic conditions, it produces biogas which is a mixture of methane (CH_4) and carbon dioxide (CO_2) with small quantities of hydrogen, nitrogen, carbon monoxide and other compounds. Biogas can be used as a fuel source for cooking, heating, producing light or even fueling a generator. A methane digester is a device used to produce and capture this biogas. There are many designs for methane digesters ranging from large and complex to small and simple. This document will cover 2 main types of digesters: batch digesters and flow-thru digesters; and 2 main types of gas collectors: tube collectors and floating collectors.

*METHANE AND BIOGAS**

As mentioned, biogas is a mixture of methane (CH_4), carbon dioxide (CO_2) and small quantities of hydrogen, nitrogen, carbon monoxide and other compounds. This mixture of gases is combustible if the methane content is greater than 50%. In anaerobic digestion of organic matter first the complex organic materials are broken down into simple organic acids, alcohols and CO_2; next the simple organic acids and CO_2 are either oxidized or reduced to methane.

Optimal conditions for this process to occur include:

- Oxygen: This is an anaerobic process so there should be no oxygen/air.
- Temperature: Optimum temperature is 15-35C (65-95F). With suitable temperatures micro-organisms are more active and biogas is produced at higher rate.
- Moisture: Water should comprise around 90% of the slurry weight. Too much water will reduce the rate of biogas production per unit of volume; too little water causes accumulation of acetic acids which inhibit fermentation and biogas production.
- Acidity: Micro-organisms require neutral or mildly alkaline conditions; optimum pH is between 7.0-8.5
- C:N Ratio: Carbon and Nitrogen are the main nutrients required by micro-organisms. The optimum C:N ratio is 25:1 - 30:1. Too much carbon quickly digests the nitrogen and the process slows; too little carbon is used up quickly, the process stops and the excess nitrogen escapes as ammonia.

Properties of Methane:

- Methane is odorless, colorless, and tasteless.
- The weight of methane is roughly half that of air (so it will tend to rise).
- The solubility of methane in water is very low (this allows it to be cleaned by passing through a simple water scrubber).
- The combustion of methane produces a blue flame and a great amount of heat.

One cubic meter of biogas:

- Produces 6-7 hours of 60 watt energy
- Can cook 3 meals
- Generates 1.25 kW electricity
- Can run 1hp motor for 2 hours

BATCH AND FLOW-THRU DIGESTERS

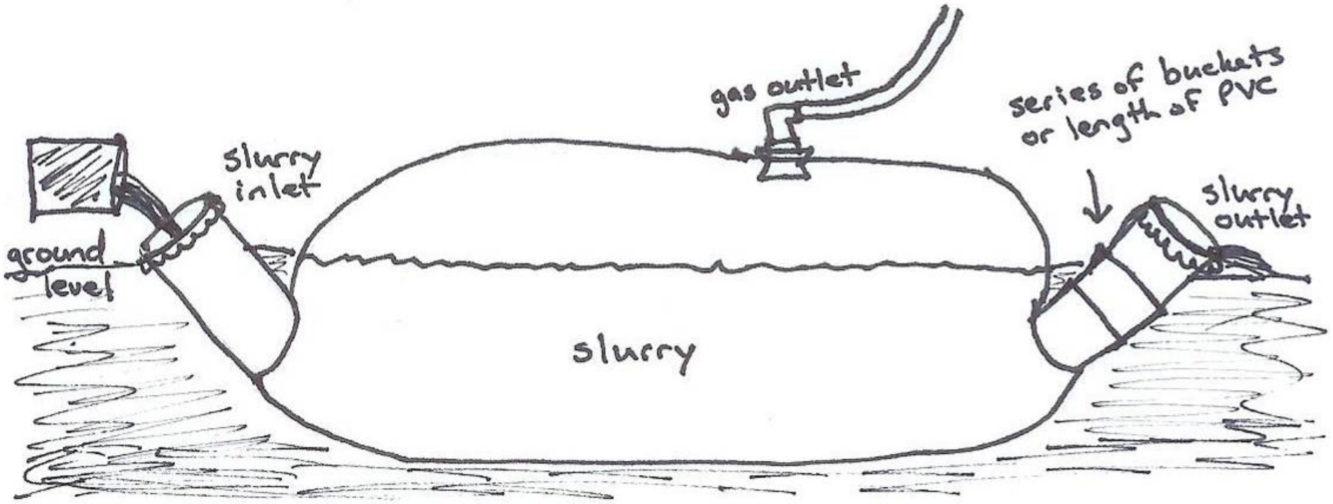
Methane Digesters can be divided into two main types: Batch Digesters and Flow-Thru Digesters. A Batch Digester is one which is filled with slurry, closed and used until it needs recharging. A Flow-Thru Digester is filled and slurry is added regularly to maintain the charge. Batch Digesters require large supplies of slurry and labor for the startup and then they must be emptied and refilled periodically (once every 2-3 months). Flow-Thru Digesters also require large supplies of slurry and labor for the startup and, once methane production starts, they require a daily addition of slurry. Both types produce biogas and a liquid fertilizer that can be applied directly to the garden.

BIOGAS COLLECTORS

Gas collectors are also main components of methane digesters. A gas collector should provide a means of capturing and storing the biogas as well as providing the pressure required to force the gas through a cookstove. Collectors can be made out of a variety of materials such as a large inner tube, a floating drum, a specialized bladder, tubular plastic sheeting, etc.

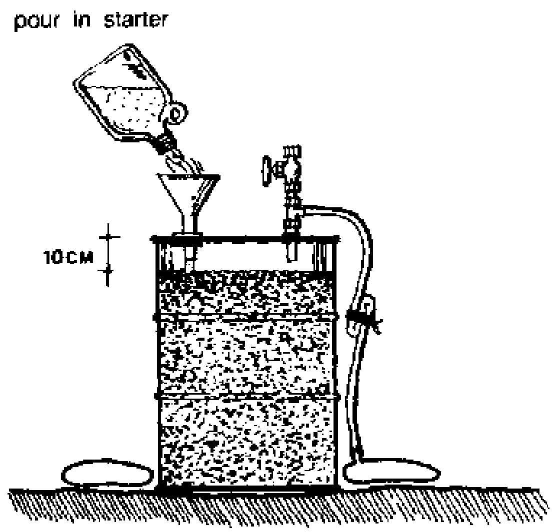
One of the simplest gas collectors is a large inner tube that has an air valve with a removable valve stem. It can be connected to the digester gas line using the air valve. The inner tube works well to both store the biogas and also to pressurize it and force it through a cookstove. Several inner tubes can be attached to one digester to create more storage capacity. [Several pictures and diagrams in this document show the inner tube gas collector.]

In most methane digesters the gas collector is a separate unit. However, in some digester models the processes of producing and capturing the biogas are combined in one large unit such as the tubular flow-thru digester/collector shown here. The sheeting can be cut to any length and is normally doubled. Both ends are placed through a section of large diameter PVC pipe or a series of plastic buckets (with the bottoms cut out) to form the slurry inlet and outlet. The tube is partially buried and the slurry inlet and outlet are positioned so that the openings into the tube are always below the slurry level. A biogas outlet hole is cut in the top and connected to the gas line. [Tubular plastic sheeting can also be used for individual components of a collector or a digester.]



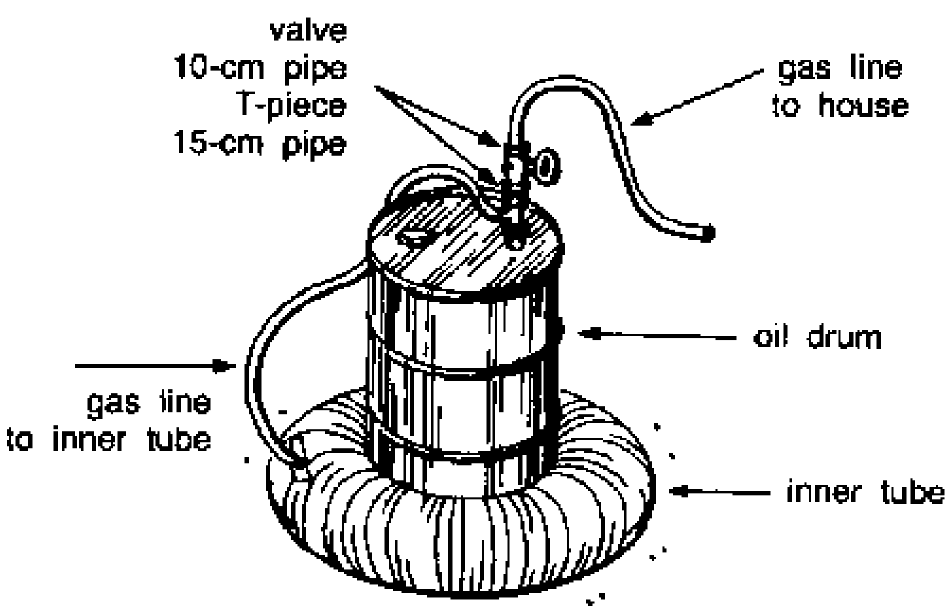
*BATCH DIGESTER***

A basic batch digester can be made from any size container. They are commonly made from a 200 liter (55 gal) metal drum that has a large threaded hole and a small threaded hole in the top. The drum should be in good shape and able to seal with no leaks. The large hole can be used for filling the drum with slurry and then it is capped. The small hole can be used for the gas outlet.



To prepare the drum, clean it well with soapy water (especially if it contained a petroleum product); then rinse it and allow it to dry. Next, connect a shut-off valve and a gas line to the small threaded hole. The other end of the gas line will be connected to a gas collector and a cookstove. Once the drum, gas lines, gas collector and cookstove are prepared, the drum is filled almost to the top with slurry and then sealed. When the unit begins producing biogas, the gas should be released for about the first week before trying to ignite the stove to assure that there is no air left in the system. This is critical because oxygen mixed with methane can be dangerous if ignited.

Once sealed, a batch system can produce biogas for several months. Most micro-organism activity takes place near the surface of the slurry so periodically agitating the slurry by tilting the drum will enhance the effectiveness of the digester. Once the unit is no longer producing gas it can be emptied and refilled with fresh slurry. The old slurry can be used as a fertilizer and a small amount can be added to the fresh slurry to help it start faster. After refilling, remember to purge the system until there is no longer any danger of having oxygen in the gas mixture.



BATCH DIGESTER WITH FLOATING DRUM COLLECTOR

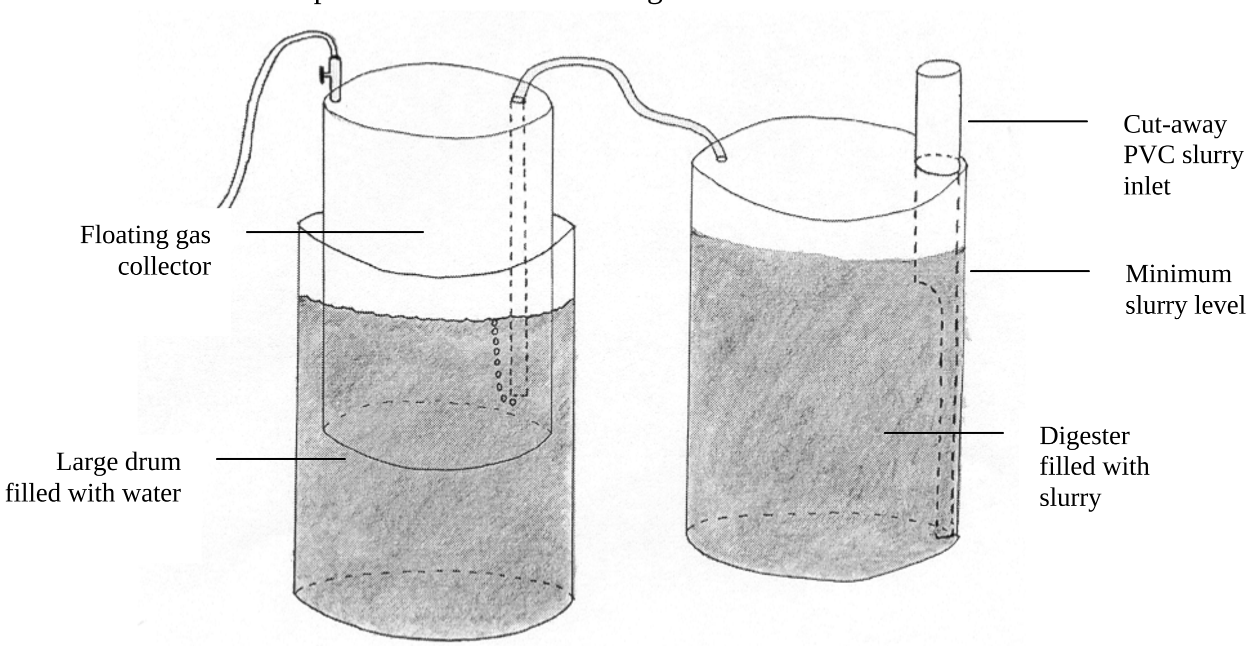
The following materials are needed to build a batch digester with a floating drum collector:

- 2 drums 190 liters (50 gal), one with a tight fitting lid
- 1 smaller drum that will fit snugly inside the larger drum
- 1.22m (4ft) piece of PVC pipe 12.7cm (5in) diameter
- 2 pieces of tubing 20.3cm (8in) long, 2.5cm (1in) diameter
- 1 valve that fits tubing to adjust flow of biogas

To build this digester, cut a hole in the lid of one of the larger drums, near the outer edge. The hole should be the same diameter as the PVC pipe. Now cut away a 60cm (2ft) section of half the PVC pipe as shown in the illustration below. Slide the pipe into the hole and all the way down until it rests on the bottom of the drum. Seal the area between the pipe and the lid with waterproof epoxy sealant or any other tight sealing method.

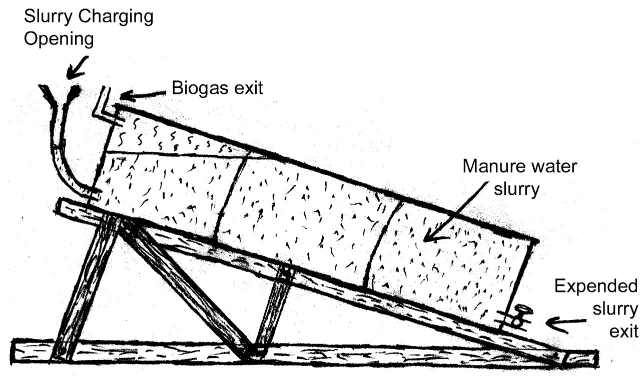
Now cut a smaller hole (sized to fit the tubing) near the opposite edge of the same lid and another hole (sized to fit the tubing) in the bottom of the smaller drum, near the edge. Attach one of the pieces of plastic tubing with waterproof epoxy to the larger drum and run the tubing into the smaller drum; slide it into the smaller drum so that it runs the depth of the drum. Be certain to seal all connections with epoxy or with an equivalent sealing method.

Cut a second hole in the bottom of the smaller drum sized to fit the valve for the tubing. Attach the valve to the hole. Remove the top of the second large drum and fill with water. Invert the small drum, open the valve and push it down into the large drum with water, forcing the air out the tubing and then close the valve. The digester is now ready to be filled with manure slurry (the slurry should always remain above the level of the cut-away PVC). As gas is produced it will bubble up through the water and fill the small drum making it float. Rocks or rubber straps can be used on the floating drum to pressurize the gas and force it into a cookstove. This floating drum collector can be adapted to work with other digester models.



FLOW-THRU DIGESTERS

A flow-thru digester can also be made from any size container. Three 200 liter (55 gal) metal drums welded end to end make a good size. The drums should be clean and in good condition. A drum with 2 threaded holes in the lid works well for the top drum. The bottom is cut from the top drum; the top and bottom are cut from the middle drum; and the top is cut from the base drum. The drums are then welded together end to end.



The three drums can be placed on a stand that holds them at a slight angle (most micro-organism activity takes place near the surface of the slurry so the angle should be very low). A 5cm (2in) slurry inlet is installed in the lid of the top drum, it should curve upward with the opening above the top of the barrel unit. A fitting for the gas exit is also installed in the lid of the top drum, at the highest point. A 5cm (2in) slurry outlet with a valve is installed in the bottom of the base drum, at the lowest point. Once the barrel unit, gas lines, gas collector and cookstove are prepared and connected, the unit can be filled with slurry.

When the unit begins producing biogas, the gas should be released for about the first week before trying to ignite the stove to assure that there is no air left in the system. Once the system is purged of oxygen and ready to use, new slurry can be added and expended slurry released on a regular basis. To maintain production, 20lt (5gal) of slurry should be processed through the unit each week. To maximize production, 20lt (5gal) of slurry can be processed daily. This amount can be adjusted according to local conditions of weather, slurry, usage, etc. Never release too much slurry so that air enters the unit (if air does enter, the unit must be purged again). Occasionally some of the expended slurry can be added back in to boost micro-organism levels.

Once this unit is established, it provides a continual supply of biogas and slurry fertilizer. It is estimated that this 3-drum unit could produce about 27 cubic feet of biogas per day and that 2 cows or 10 pigs could supply sufficient manure.

SLURRY MIXTURES

Any organic material can be anaerobically digested including manure from any type of animal. Chicken, cow and pig manures are commonly used for biogas because they have a good natural C:N ratio. Collect the manure in a container and crush it so that there are no large chunks (especially when using dry manure). Add water and mix together until it forms a thin slurry of a consistency that can be poured into the digester (about 50% water, 50% manure). Depending on ambient temperatures and slurry mixtures, you may need to wait seven to ten days for gas production to begin.

HINTS AND TIPS

Cooking is one of the most efficient uses of biogas. Cooking efficiency is about 33% compared to about 3% for lighting. Biogas effluent is anaerobically digested compost. It can be mixed 2/1 or 3/1 with water and used as a fertilizer. It also dries readily and can be pulverized and stored for later use as a dry fertilizer.

For batch type digesters, a second unit can be started about 4 weeks after the first unit to provide a continuous supply of biogas. For all methane digesters be sure that the level of slurry is always maintained at a level higher than the inlet and that the unit is always sealed so that air does not enter.

REFERENCES AND RESOURCES

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**FAO Better Farming Series Booklet #31 & #32:
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http://www.undp.kz/library_of_publications/start.html?redir=center_view&id=153

Practical Action (ITDG):
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http://www.jrwhipple.com/sr/nf_methane.html

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Methane: Planning a Digester by Petter-John Meynell, published by Shocken Books, 1978.

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