TECHNOLOGIES DEMONSTRATED AT ECHO: HORIZONTAL BIOGAS DIGESTER

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INTRODUCTION

This demonstration is intended to illustrate the principles involved in biogas generation. We believe this is about as small a unit as can be made that would meet some basic cooking needs for a family (though we have not field tested it in a family setting). If I were making it for myself overseas I'd make it at least 4-6 barrels long. Biogas is simple in principle, but there are many things that you must consider before designing a biogas project for farmers in your community. Books (ask our librarian) describe many designs and sizes that are in use around the world. So be sure to do your homework before undertaking a biogas project. Some things should be adapted to your particular environment and climate. Pay attention to cost of construction and simplicity of operation, to why projects have or have not succeeded, to whether the design and size you choose will produce the quantity of gas to meet your needs, to differences in results from different kinds of manure, and to the things that can go wrong during operation and what to do about it.

As a general rule a cubic meter (m^3) of gas will cook three meals a day for a family of 4-6 and provide lighting. It would require two cows or 10 pigs. Our demonstration unit provides 2/3 that amount or a little less.

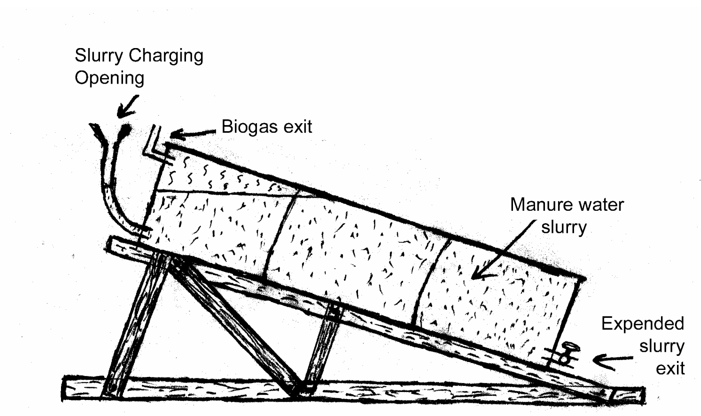
After you have done your own study, write me before starting construction. Be sure to include details of your purpose and the setting where it is to be built. I may be able to make some helpful suggestions.

DESCRIPTION

This biogas digester consists of a container to hold the slurry, a ‘scrubber’ to reduce the carbon dioxide (CO_2) and sulphur dioxide (SO_2) content in the biogas, and a storage container to hold the gas.

Figure 1. Inclined biogas digester.

Three 200-L drums are welded together to make the biogas digester. The lid and bottom of the middle drum are removed to accommodate slurry flow through the three drums. The bottom of the upper drum and the top of the lower drum has also been removed before welding.



A 2” (5.1 cm) valve is installed at the bottom of the inclined barrels in order to drain expended slurry. A 2” (5.1 cm) pipe curving upwards above the topmost point of the inclined barrels is installed for charging the manure slurry. A ½” (1.25 cm) pipe or hose is installed at the topmost point of the inclined drums to conduct the biogas to the gas scrubber.

Figure 2. The biogas scrubber.

Our biogas scrubber consists of a 20-gallon (80 liter) drum filled with about 15 gallons (60 liters) of water. Biogas from the digester is piped into a low connection on the drum. It bubbles up through the water to reduce the CO_2 and SO_2 content of the biogas. The gas is then piped off at a top connection to a storage container.

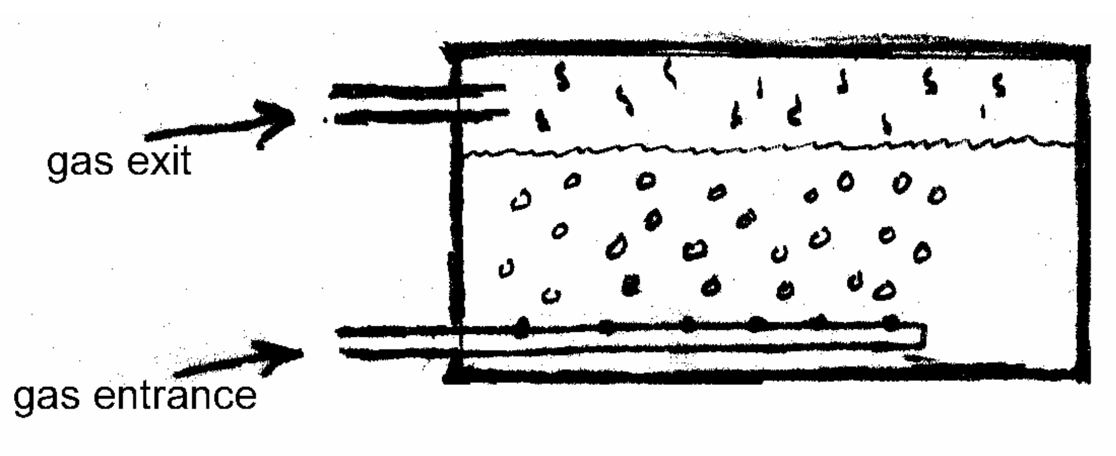


Figure 3. The storage container.

The storage container may be a bladder type (as shown, or a series of tractor inner tubes) or a flotation container (see ECHO's Concept Papers "The Floating Drum Biogas Digester." Also see figure 4 below). A bladder type should use rubberized fabric or vinyl sheeting of approximately .45 ml thickness.

Figure 4. Flotation type storage tank. (Also see ECHO's Concept Papers "Technologies Demonstrated at ECHO: Floating Drum Biogas Digester.")

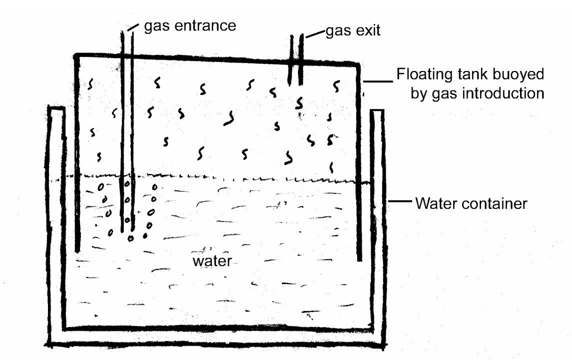


Figure 5. Gas from the storage container can be used in salvaged gas stove burners or any similar locally fabricated device. Gas may also be used in any common pressure lamp after its fuel orifice has been modified.

SOME DETAILS ABOUT THE DIGESTER

This is an inclined plane continuous flow digester. Organic material that is entered into the upper end of the digester exits the lower end. When fed 2% of its volume per day, the process takes about 50 days for a volume to pass through. During this process, about 50% of the carbon in the material is converted into methane and carbon dioxide. This digester will convert about 1400 pounds of cow manure into about 1400 cubic feet of gas in 50 days, or about 750 liters per day, when the temperature ranges between 65 to 90°F.

A carbon to nitrogen ratio of between 20/1 and 40/1 should be maintained. Carbon greater than 40/1 quickly digests all of the nitrogen and the process slows or stops. Nitrogen greater than 20/1 consumes the carbons and the excess escapes as ammonia.

Cow manure has an average C/N ratio of 25/1. When diluted 2 pounds with 1 quart of water, it becomes slurry with about 20% solids. This is an ideal mix with which to charge the digester. When fed about 5 gallons of slurry per day, this digester can be expected to produce about 27 cubic feet of gas per day. A family of 4 to 6 would need about 35 cubic feet of gas in order to cook three meals. The digester described in this technical note has been sized for demonstration in order to explain the technique.

Two cows or ten pigs should furnish enough manure to maintain operation of this digester. The most efficient use of the biogas is for cooking. Cooking efficiency is about 33% compared to about 3% efficiency for lighting. The effluent is an anaerobically digested compost. It is odorless. It should be mixed 2/1 or 3/1 with water and used as a fertilizer. It dries readily and can be pulverized and stored for later use as a dry fertilizer.

Any organic material can be anaerobically digested. Cow manure is an ideal substrate because of its average C/N ratio. Manure from monogastrics tends to have greater undegraded fiber content, which digests at a much slower rate and digests much less completely. Leaves and other crop substrates may digest tolerably well, but my experience is that a greater quantity of CO_2 is produced in proportion to methane.

I never use pretreatment when initially starting a digester nor when subsequently charging it. However, when starting a new digester, digestion may be greatly speeded if you make about five gallons of slurry and let it begin fermenting aerobically before adding it to your newly charged digester.

If, after your digester has been producing for a while, it slows production, valve off some effluent and reenter it at the charging entrance. This will tend to buffer the slurry inside the digester and production should soon resume. If proper C/N ratios are maintained with proper slurry viscosities, this continuous flow digester should operate indefinitely providing that it is regularly charged.

I use a scrubber (see Figure 2 in the Technical Note); however, the affinity that CO^2 has for water increases that caloric value of the biogas for ordinary uses without the need for lime neutralization. A natural gas burner orifice works well for cooking, but you should experiment with different orifices and air mixtures. This Technical Note focuses on bladder gas storage. Other storage possibilities are the fixed dome type or the flotation tank type. I prefer the flotation tank. Any writings on biogas digesters and storage of the gas will dwell on the different merits of the respective systems.

Good Luck!