Turning Waste into Fuel

Methane Biodigester Basics

Ilan Adler

Top left: A gas storage unit, fully charged with ready-to-use biogas. Renewably generated methane has a number of uses, including cooking and heating.

Middle left: A technician inside the tubular biodigester tightens the gas output fittings. After the plumbing is finished, the digester will be filled with a mixture of water and manure.

Bottom left: Nutrient-rich liquid from the biodigester can be field-applied as a fertilizer.

Above: The author tests a biogas-fueled kitchen stove at Doña Tana's home in Michoacan, Mexico.

Doña Cayetana (Tana) holds a special status in the tranquil village of Eronga, in the highlands of the state of Michoacan, Mexico. She was the first one in town to have a homemade biodigester, which supplies biogas for most of her cooking and heating needs. The freedom from expensive LP gas or other less desirable sources of energy, such as firewood (commonly used in the area), has empowered Tana in many ways, providing not only a better quality of life, but also bringing journalists, students, and entrepreneurs from far points of the country to her modest house near the center of the village.

"Three pigs is all it takes," she says with a smile. But of course, it could be rabbits, cows, horses, or any other domesticated animal (including humans) that produces sufficient manure to feed a biodigester. For that is the main fuel involved—organic waste, which by being processed in this ingenious device is turned into fuel and nutrient-rich fertilizer.

What is Biogas?

If you want to know how a biodigester works, consider the human digestion system. Whenever we ingest any type of food, enzymes and bacteria in our stomachs and intestines start working on decomposing the long chemical chains of organic matter into simpler forms that our cells can feed on. The remains are excreted as much simpler, decomposed molecules. As a side product of this process, a usable gas, commonly known as biogas, can be captured.

Biogas is, and will always be, a fancy game of statistics. In any particular case, there is no way of predicting what exact percentage of the mixture each individual component of the gas will have, save by the most disciplined analysis.

Common Biogas Mixture

Component	Percent
Methane (CH_4)	50–70%
Carbon dioxide (CO_2)	30–40%
Hydrogen (H_2)	5–10%
Nitrogen (N_2)	1–2%
Water vapor (H_2O)	0.3%
Hydrogen sulfide (H_2S)	Trace amounts

Source: Instituto de Investigaciones Eléctricas (IIE), Mexico, 1980

The mix will vary depending on the type of manure and the climate the biodigester is in. The table above gives an idea of what to expect in most cases.

So what can we use all these gases for? It turns out that only one of them has any practical application, as far as our modern technology is concerned. Carbon dioxide (CO_2) we might just as well discard. It's a greenhouse gas and there's loads of it around, wherever creatures are breathing, organic matter is decomposing, or fossil fuels are being burned. Hydrogen sulfide is actually poisonous, and we have to filter it out, or at least try to ignore its nasty, pungent smell. There's not much use in the water vapor, unless you want a rather smelly steam bath. The main one left is CH_4, good old methane.

Fuel for the Fire

Methane is the flammable component in biogas—without it there would be no fire. This odorless, colorless gas can heat a stove, fuel a vehicle, or provide electricity to a community. Much of what we call "natural gas" is, in fact, methane.

One downside is that it is a very powerful greenhouse gas, 23 times stronger than CO_2, and that's saying a lot. One major advantage of a biodigester is that it generates methane that we can safely use, and also prevents it from escaping into the atmosphere as a greenhouse gas.

ADOPT A BIODIGESTER

Would you like to help a rural family build its own biodigester? The International Renewable Resources Institute (IRRI–Mexico), a registered nonprofit organization, is launching a campaign to link people or groups interested in supporting eco-friendly technology development in communities in Mexico that would benefit from these projects.

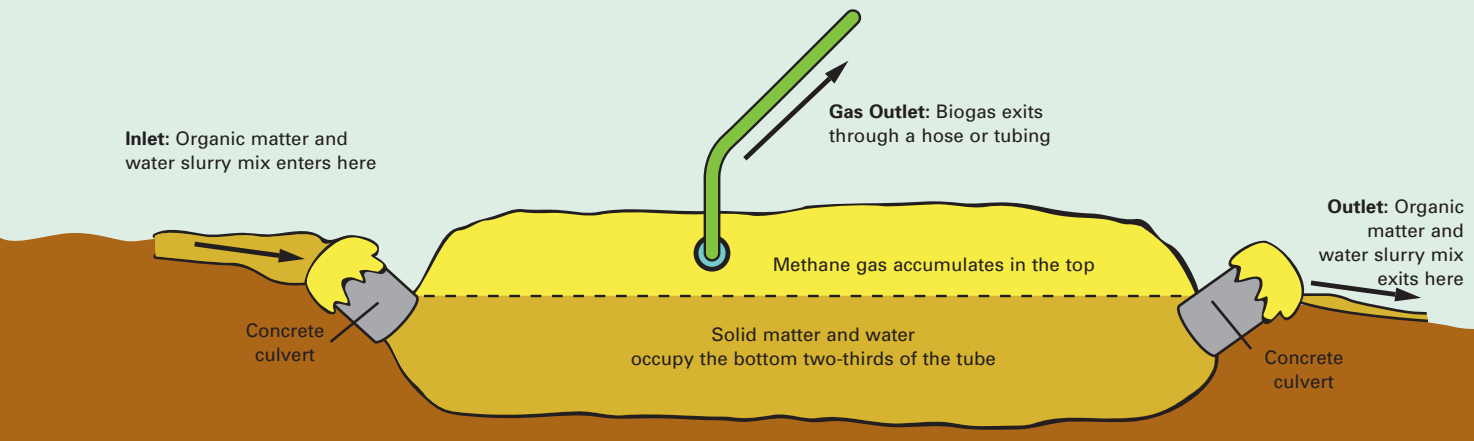
In the Adopt-A-Biodigester project, donations will be directly transferred to selected families in the form of basic tools and equipment to install a homemade biodigester. Sponsors will be able to know exactly how every dollar donated is used, the contact information of their adopted family, and may have the opportunity to participate as a volunteer in the installation! For more information, please contact info@irrimexico.org, or visit www.irrimexico.org.

Have you watched the bubbles that form in a swamp or in stagnant water? If the answer is yes, it's likely that you have seen methane as it is being formed underwater. Remember, all we need is enough organic matter, no oxygen, and anaerobic bacteria. All these can be found in a swamp, as the stagnant fluid loses all of its oxygen, especially in the bottom, and the decaying leaves and debris provide the nutrients. For the bacteria to thrive, we need adequate heat. In general terms, the warmer, the better (as long as it's not boiling hot). That's why biodigesters fare better in tropical climates.

Biodigesters

If we want to artificially recreate the methane production process in a controlled manner, we can make an airtight space into which we can put enough organic matter and guarantee the right conditions for bacteria to grow. Sounds

TUBULAR PLASTIC BIODIGESTER ANATOMY



CONSTRUCTING A TUBULAR BIODIGESTER

1. The plastic material is doubled up by pulling one end of the tube inside itself. This makes for a more durable, double-walled digester.

2. Farmer Juan Luis Salazar finishes digging the ditch for the biodigester, while workshop participants inspect the hole.
3. One of the concrete culverts is set into place at an angle.
4. The plastic tube is pulled through the concrete culverts at each end of the ditch, folded back, and tied with strips of inner tube.

easy, but how do you make an airtight space in which to add the wastes without having air enter the closed chamber and ruin the whole process? The key lies in the use of water.

Water acts as a perfect seal against air. Readily biodegradable organic matter can be fed into the device by passing it through water in an air-lock design to keep the digesting material enclosed.

A biodigester can be any container that will hold soluble organic matter without letting air in, and that provides enough space for biogas to accumulate. The container or chamber can be made from a variety of materials—ferro-cement, concrete, plastic, even metal—as long as it doesn't have any leaks. The size of the chamber is determined by the amount of gas required, which also determines the amount of manure needed.

I prefer tubular plastic biodigesters. These use the same plastic used for greenhouses; it is locally manufactured in Mexico and many parts of Central America and has a relatively low cost. This type of digester retains heat much better than concrete or ferro-cement digesters. The material must be UV treated, and ideally covered by some sort of roof to shield against excess sunshine and rain, as well as against physical damage. It is also necessary to dig a trench so that the tubular plastic will stay in place and be protected from the wind. Using PVC tubing and connecting valves, it is relatively simple to plumb the gas line to the house.

Using a Biodigester

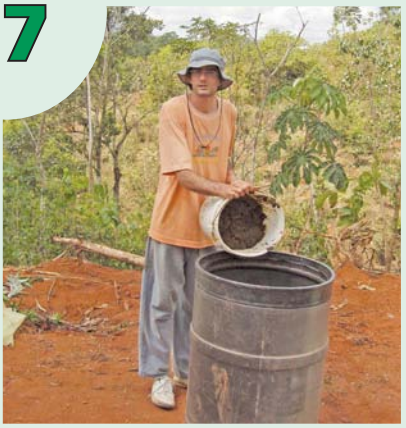
The digester is initially filled with water until it overflows. This creates an air lock, with water in the lower two-thirds of the tube and air in the top third. Then a daily "charge" of manure-water slurry is added. The bacteria start decomposing the organic matter once it's in the chamber. The time they take to complete the process is called the retention time of the biodigester. As the matter flows through the container, biogas begins to accumulate in the upper part of the digester. This gas can be transported to the kitchen by a hose or tube fitted with a valve, or it can be stored in a separate plastic tube.

For the first few weeks, the only gases obtained will be a mixture of air and CO_2, from what was remaining in the

This biodigester was constructed at an SEI workshop in Mastatal, Costa Rica.

5. The biogas output tubing is attached before the tube is fully inflated.

6. The fully inflated tube. The tube is filled with water until it overflows, creating an air lock.



7. The author mixes manure with water to make a slurry.

8. The slurry is poured into the digester.

container at start-up time. Depending on the temperature and the type of manure used, it may take between 15 and 45 days to produce usable gas (production occurs quickly in warm, tropical climates).

Ideally, the biodigester should be charged daily with a mixture of water and organic matter in a fixed ratio. The new daily load will push water out through the exit tube. This water is partially treated, making it ideal for use in irrigation or, with more advanced purification and filtering, potable water. Several successful projects in Mexico have used biodigester effluent for aquaculture or horticulture, given the high amounts of dissolved nutrients that it contains. Plants irrigated with this effluent tend to grow better and stronger, without requiring additional chemical fertilizer.

Sustainable Development Tool

In the absence of a good treatment system, animal manures tend to accumulate in stagnant creeks or ravines, polluting groundwater and attracting disease-carrying insects.

A biodigester is a tool for sustainable development, providing biogas to cook, heat, or generate electricity, and is also an efficient means to reclaim a waste product, which would otherwise create greenhouse gases and health hazards. Methane biodigesters are low-budget, appropriate technology. They can be used widely in the developing world and elsewhere, turning waste into usable fuel and fertilizer.

Access

Ilan Adler, Director, International Renewable Resources Institute–Mexico, Alliant Intl. University–Mexico City, Alvaro Obregon 110, Colonia Roma, Mexico DF 06700 • ilan@irrimexico.org • www.irrimexico.org

Solar Energy International, PO Box 715, Carbondale, CO 81623 • 970-963-8855 • Fax: 970-963-8866 • sei@solarenergy.org • www.solarenergy.org

Rancho Mastatal, Apdo 185-6000, Puriscal, San José, Costa Rica • info@ranchomastatal.com • www.ranchomastatal.com