

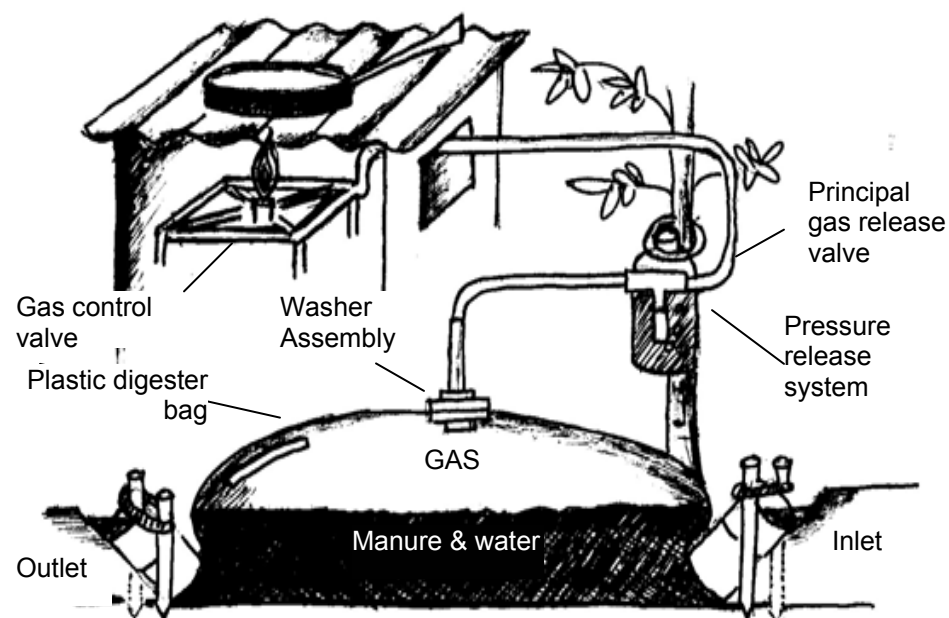
Gas Bio-digester Information and Construction Manual For Rural Families



Fundación Cosecha Sostenible Honduras
FUCOSOH
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Written and compiled by Laura Brown, November 2004. This report is based on information gathered by Bruce Maanum, Stuart Green, and the agricultural extensionists employed by FUCOSOH. FUCOSOH has provided technical and financial support for the construction of 25 bio-digesters in rural Honduras.

I. What is a bio-digester?

For many years rural families around the world have used bio-digesters to convert readily accessible animal or plant waste into gas fuel. Bio-digesters use a process of oxygen free decomposition in which bacteria in the animal or plant waste produce a mixture of methane, carbon dioxide, and other gasses that are stored inside. Bio-digesters are relatively simple to build and operate, and require little more than a steady supply of organic matter and water.

Bio-digesters provide benefits to families and communities by:

- *Reducing the amount of wood fuel used by the household*
- *Preserving forests that naturally clean the water and air and provide habitats for thousands of species of unique plants and animals*
- *Producing high-quality organic fertilizer as a by-product*
- *Improving household air quality by reducing reliance on smoky wood burning stoves*
- *Providing a method for treating raw waste and reducing the flow of raw waste into clean streams and rivers*

II. Considerations before building a bio-digester

Fuel needs

A family sized bio-digester will provide about 4 hours of fuel per day. Most families will still use some wood fuel for daily cooking or lighting needs.

Space

Bio-digesters require about 16 square meters of open space in a location below the ground level of the household.

Cost

At the time of publication the cost of parts (not including the plastic bag or stove) for a family sized bio-digester was about \$10 (in Honduras). At this time FUCOHSO is able to provide support for plastic and technical support for most bio-digesters. Ask your local extensionist for more information about the costs of a bio-digester for your family.

Maintenance

Bio-digesters must be refueled and checked for proper functioning daily and may require some annual maintenance. The cost of replacement of most parts

is minimal but polyethylene plastic tubes can be expensive. If maintained properly the plastic and parts of your bio-digester will last for up to 7 years.

Materials

Bio-digesters work best when fueled with pig manure, but cow manure, coffee millings (miel de café), human waste, conchas de banano, and any other clean, chemical and pesticide free, biodegradable material can also be used. Digesters require about 1-2 shovels of clean, chemical and contaminant free manure every day. If you have more than 10 pigs, you may want to consider constructing a larger digester system to allow manure and water from the pens to flow directly into your bio-digester. The water used to fuel the digester must also be at a moderate pH level and free of chemicals. Consult your extensionist if you are unsure about the water quality or materials you plan to use in the digester.

Time

It will take about 2 days to complete installation of your bio-digester. Plan one day to dig the trench and another to assemble the materials.

III. Instructions for installing a non-industrial family sized bio-digester

Materials



NOTE: We recommend that you read the entire instruction manual carefully before purchasing materials as some sizes and dimensions may vary based on the location of the digester and your family's needs. This list does not include materials necessary for the installation of your stove. See "Completing the gas line" in this section for more information on stove installation.

- 2 clear plastic tubes (Use # 6 or # 8 thick clear polyethylene plastic. This type of plastic is common and is usually available as a tube (a flat sheet with the two long sides sealed to each other). A tube 4

feet in diameter and 25 feet in length will supply a family with 4 hours of gas per day.

- 2: 5-gallon pails with the bottoms cut out
- 2–3: used rubber tire inner tubes cut into 3-4 foot long, 2" ties
- 1: 1/2" male adaptor threaded to compression joint PVC
- 1, 1/2" female adaptor threaded to compression joint PVC
- 2: large aluminum washers to fit male threaded PVC adaptor. (These can be fashioned from used metal if necessary.)
- 2: rubber washers, (1-2 cm larger than aluminum washers)
- 1: 1/2" PVC "T"
- 1: piece of steel wool or fine mesh steel window screening
- 1: 1/2" PVC pipe (about 3-4 feet, this will vary depending on the location of your digester)
- 1: 1/2" flexible tubing (length will depend on distance to water source and to gas use site)
- 1: 1 or 2 liter soda bottle.
- 4: 3' sturdy wooden stakes
- 1: small tube of PVC cement
- 1: piece of rope 5-10 feet longer than the digester

- 2: pieces of rope 8-10 feet each

You will also need a hacksaw, scissors, a machete or large knife, a hand or foot pump (if available) and shovels for digging the trench. A wrench will be helpful for tightening the washer assembly.

Choosing and preparing the site for your bio-digester

In order to protect your bio-digester from animal and weather damage it must be located in a smooth flat-bottomed and flat walled trench. Locate a site that is free of large trees, stones, and free of any chemical contaminants (pesticides, fertilizers, herbicides etc.). The site should be no more than 60 feet (20 meters) from the house. Because gas rises, the site



Above: Bio-digester trench

must also be below the ground level of your house. Begin preparing the bio-digester site by clearing it of all brush, roots, and trees.

Dig the trench to the following dimensions:

Width: diameter of the plastic tube

Length: about 2-4 feet shorter than the length of the plastic

Depth: diameter of the plastic tube

In mountainous areas it may be necessary to dig a terrace and create walls with rocks and mud. Make the bottom of the trench as level as possible. Run your hands over the entire surface of the trench. Clear all roots or rocks as they may puncture the bio-digester bag.

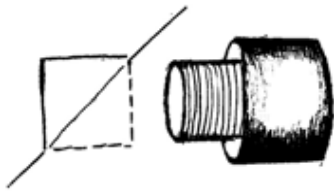
Preparing Materials

1. Find an open flat area (a sports field works well) and lay out the plastic tubes end to end. Remove your shoes and carefully crawl through one of the bio-digester bags holding the end of the other. Be very careful not to puncture the bags. Once the bag is threaded completely through, remove any folds or wrinkles.



Above: Threading bio-digester bags. Be careful not to tear the bags.

2. Now is a good time to cut the hole for the washer assembly. Holding both corners and both bags, fold the plastic in half lengthwise about 6 feet from one end. Cut a hole as shown below that will allow the 1/2" PVC adaptor to fit through both bags on one sealed side of the plastic.



If you will need to transport the bags to a different location, fold and secure them so the elements or the heat of a motor will not damage them.

Assembling the Gas Outlet

- Place one washer and one gasket on the male adaptor (as shown below) and thread through the inner side of the plastic bags. Push the male adaptor through the hole. Assemble the remaining washer and gasket on the outside of the bags. Apply PVC cement to the male adaptor and secure the female adaptor firmly. Tighten with a wrench if available.



Above: Installing the washer assembly in the digester bag.



- Attach the long solid PVC pipe to the washer assembly with cement. **NOTE:** Unless otherwise indicated, all PVC attachments in the bio-digester should be cleaned sandpaper or a knife to ensure a proper cement seal.

Installing Inlet and Outlet Buckets

- Lay your bio-digester carefully in the trench being sure that the gas outlet is centered. Cut out the bottoms of the 5-gallon buckets and sand or file the edges to remove any sharp areas that may damage the plastic. Slide one side of the tied digester bag through the bottom of one of the 5-Gallon buckets. Leave about 1 ½ -2 feet of plastic coming out the top of the pail. Carefully fold the ends of the bag over 2-3 times and tie off each end with straps of rubber.
- Push the bucket into the trench so it sits at about a 45-degree angle. At this time it may be necessary to dig ramps at the entrance or exit of the digester to accommodate the angle of the buckets. You may also consider digging a terrace that will allow for easy accessibility to the entrance bucket. Repeat on the other end of the bag.
- To secure the buckets pound stakes on each side of the inlet between the pails and the bag. Stakes should be placed a distance slightly smaller than the diameter of the bucket so the bucket will fit very snugly between them. Be very careful not to puncture the bag.

Positioning and Filling the Digester

- Before filling your digester you must ensure that it sits snugly in the trench without fold or wrinkles. Any folds or wrinkles that remain when the bag is filled with water may chafe and form holes. This may be accomplished in several ways:

- If a diesel motor is available the digester may be filled with exhaust. Attach one side of a flexible hose



Above: Bio-digester bag is hanging between two trees while filling with water.

(do not glue) to the PVC pipe extending from the washer assembly and the other to the exhaust source. Fill just until the bag is smooth.

- If a diesel motor is not available thread a long piece of rope through the digester bag and secure ends to nearby trees. The bottom of the bag should sit on the floor of the trench and the top should be raised slightly. Fill the bag with water as described below.
- Fill the bag with air using a small hand or foot pump.

9. Attach one end a flexible plastic tube (do not glue) to the PVC pipe from the washer assembly and the other to a spigot. Fill the digester to 60%-75% capacity with water.

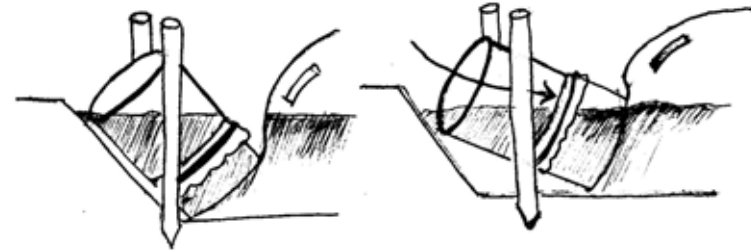
Below: Threading bags through the plastic bucket inlet tube. Only one bucket was used in this model.



NOTE: Water used to fill the digester must be clean and have neutral pH (not too acidic or basic). Ask your extensionist if your water source is suitable for filling the digester.

Completing Inlet and Outlet Tubes

10. Untie the ends of the digester bag and fold the remaining plastic over the top of the bucket. Reach your hand through to smooth the plastic along the insides of the bucket. Slide another plastic bucket bottom end first inside the first bucket through the plastic tube. The plastic should be sandwiched between the two buckets. Wrap rubber ties around the bucket to secure the extra plastic.



CORRECT

INCORRECT

Below: Placing and securing Inlet and outlet buckets. The bottom of the bucket should be submerged at least 6 inches below the water level.



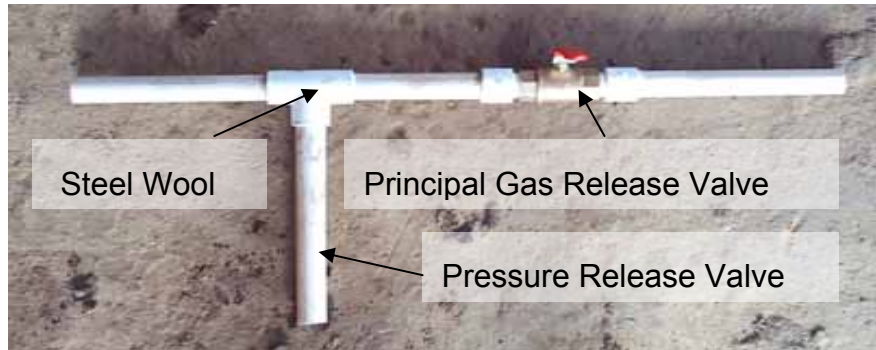
11. If necessary reposition the angle of the inlet and outlet tubes so the bottoms are well below water level and fluid can easily flow out of the digester. Tie a long piece of rope between the two vertical stakes to hold the tubes firmly in place.

VERY IMPORTANT: Bio-digesters rely on water seals to maintain an oxygen free environment. If oxygen is allowed to enter the bacteria that produce gas in the digester will die. To ensure a good seal inlet and outlet tubes must be secured so the bottoms are **AT LEAST 6 INCHES** below water level.

Assembling the Pressure Release Valve

12. Begin assembling the gas valve by rolling the steel screen or steel wool into a 1/2" tube. Push the tube into the PVC "T" as shown.

Below: Completed valve assembly.



13. Assemble PVC pieces and valve as shown. **VERY IMPORTANT:** Leave one side of the PVC "T" unglued to allow steel wool to be replaced every 6-7 months.
14. The flexible plastic gas outlet tube may now be attached to the filled biogas digester. The length of this tube will vary depending on the distance between the digester and the tree or stake where the pressure release valve will be located. Soften one side of the flexible plastic tube with a flame or boiling water. Coat with cement and push the PVC gas outlet tube firmly into the flexible plastic (3-4 inches). Wrap tightly with a rubber tie. Attach the other end of the flexible tube to the valve assembly using the same procedure.

15. Cut a 1" hole $\frac{3}{4}$ up the side of a large soda bottle. Insert the PVC T assembly into the bottle. Cut an additional hole using a hammer about 3 inches from the bottom of the T. Secure the bottle to the T assembly with a rubber tie. Locate a tree or tall stake that will hold the pressure release assembly. Secure the entire assembly with rubber ties. Fill the soda bottle with water. The water will maintain an airtight seal but will allow excess gas to escape before damaging the digester bag.

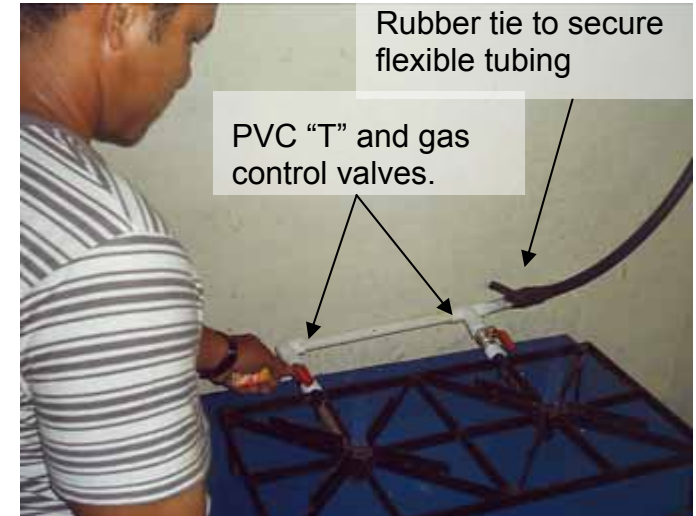


Above: Pressure release valve secured to a tree.

Completing the gas line

16. Run a piece of flexible plastic tubing from the pressure release valve to the location where the gas will be used (this distance will vary). Secure the gas line to the valve assembly as in step 14.
17. If your gas line will be attached to a gas stove, create a secure PVC assembly as shown in the picture below. The gas control valves located on your stove should be closed securely. Connect the gas line to the PVC assembly on the stove using the method described in step 14.

*Right:
Attaching the
stove to the
plastic gas
tube.*



Charging and preparing the digester for use

18. Be sure the gas valve is closed before charging. The digester should be initially charged with about 20 buckets of manure and water mixture for the first day only. **IMPORTANT:** After the initial charge, your digester will require only **TWO BUCKETS** of charge each day. Use any of the following mixtures:
 - 1 shovel of cow Ganado manure: 1 bucket of water
 - $\frac{1}{2}$ shovel of pig manure: 1 bucket of water
 - 1-2 lbs banana, coffee, or other biodegradable plant waste: 1 bucket of water. **IMPORTANT:** Never use sharp or very hard materials such as bone or wood.

IV. Operating and maintaining your bio-digester

Bio-digesters take 50-70 days to begin producing gas regularly. If maintained properly your bio-digester will last for about 7 years. Polyethylene plastic degrades in the sun. If your digester is located in a sunny area constructing a simple roof made of plastic, bamboo, or leaves may increase the life of your digester by several years. A solid plastic cover functions well because it will trap the sun's heat and could improve gas production in your digester.

Construct a fence around your digester if there is any chance of damage by animals.

Daily maintenance: Charge your bio-digester with two buckets of manure or plant wastes and water mixed to the ratios above. Check the inlet and outlet buckets to ensure that the level of water in the bag is adequate. Check the pressure release valve to ensure that the bottle is filled with water up to the small water hole. If the water in the pressure release valve is bubbling then the digester is functioning properly. Check inlet and outlet buckets to be sure no air is entering. Check for damage to the digester bag. Clean off any mud, stones, or foreign material on the bag.

Periodic maintenance: The steel wool inside the PVC "T" assembly must be replaced every 7 months. Check gas lines for cracks and leakage.

The discharge from your digester is a clean organic fertilizer. Do not divert this discharge directly into lakes or streams. Consult your extensionist for more information about best uses for this fertilizer.

Contact your extensionist if you note any problems with your bio-digester.



Left: Initially charge your bio-digester with up to 20 buckets of manure mixed with water. After this the digester requires only 2 buckets of charge each day.

V. Common Questions and Problems

The bio-digester does not seem to be producing any gas.

Bio-digesters take 50-70 days to begin producing gas regularly. If your bio-digester is new, wait and continue charging with 2 buckets of manure and water mixture each day.

Gas production may drop or cease for many reasons including the entrance of air into the bag, changes in temperature, water pH, and contamination in the wastes used to charge the digester. Check to be sure that no air is entering the bio-digester from the inlet or outlet tubes. Next check the digester for any bag damage from foreign objects or animals that may allow gas to enter. If necessary increase the water level inside the bag.

Some producers have noted a drop in bio-digester gas production in winter months and during long periods of rain.

Soil around the bio-digester is washing onto and compressing the bag.

When soil or mud fall on the biodigester they can deflate the bag, seal off the inlet, destroy the trench, and cause sedimentation to occur inside the bag. To avoid this problem construct a barrier to keep mud, rain, and soil out.

Many producers have constructed simple fences or barriers to prevent erosion from damaging the bio-digester bag. These may be constructed from wooden stakes and slats of wood. Any mud that washes onto the bag must be cleaned off daily.

There appears to be gas in the bag, but there is no gas coming out of the stove/lamp outlet.

Check to be sure the gas valve is open. Occasionally pipes crack causing a leak in the gas line. Regularly inspect your gas lines for damage. Seal any damaged lines securely with glue and rubber ties.

Animals are damaging the digester bag

Animals can quickly cause permanent damage to your biodigesters. Be sure that your bio-digester is well protected from animals.

Do I have to use the same type of waste in my digester every day?

No. Bio-digesters work best with pig waste but you can use any clean, biodegradable material mixed with plenty of water.

Sedimentation is occurring inside the biodigester. Is this OK?

No. Over time sediment can destroy the bag, reduce the production of gas, and reduce the gas storage capacity of the bag. Be sure that the charging mixture is free of heavy hard materials and that inlet and outlet tubes are not blocked by sediment.