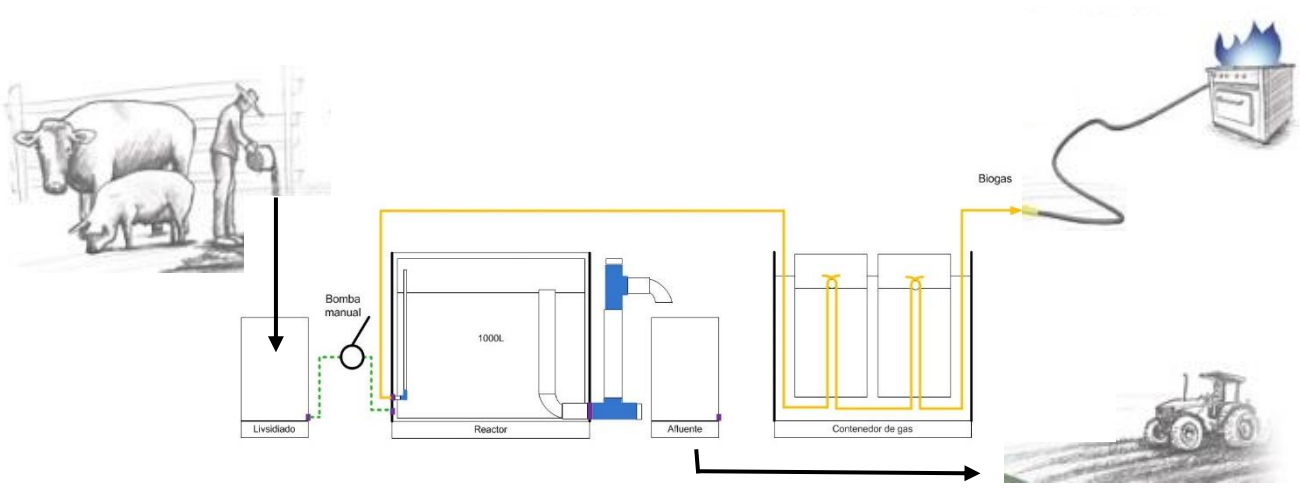
Course “Biogas para todos”

Educational Manual



24-26 October 2014
Anthakarana, Quindio, Colombia

Foundation Katalysator:
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NGO Mentes en Transición:
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Mentes en Transición
Impulsando el cambio

I Love Biogas

STICHTING KATALYSATOR

Project Biogas Para Todos (Biogas For All)

Welcome Amigos! It is great to see you here for the course "Biogas para todos" (biogas for all) in the community of Anthakarana, in the municipality of Salento, Quindio. During this practical course you will learn how to construct a biodigester from which you can produce your own cooking gas. The aim of the course is to teach you, as residents of rural areas, how to build a biodigester so as to later replicate the information in your own communities, and in this way save money, help the environment, and contribute to energy independence. This project will be provided by the Dutch Foundation Katalysator, in association with the NGO Mentes en Transicíon (Transitional Minds) and the community of Anthakarana from Quindio, Colombia. The project is co-financed by the two Dutch foundations Imagine and Katalysator.

And so to introduce the team:

The foundation "Imagine" is participating in this project by providing financial support. The foundation has the objective of working to support biotechnology projects in developing countries.

The Dutch foundation "Katalysator" aims to help local companies working for sustainability in developing countries. From this foundation we are joined by the following three representatives:
Jelmer Tamis is the expert on the theory of how a biodigester functions. Jelmer has a Master degree in Life Science and Technology. To Jelmer you can ask questions about the numbers, quantities and theory of the biodigester.
Coen van Gennep, with a Masters in Environmental Science, is the expert in the technical construction of the biodigester. To Coen you can ask practical questions about materials and construction.
Alain Simons is is the chairman of the foundation. Alain is a Human Kinetics Technologist and is in charge of the organisation the project and acquiring funding. Any questions regarding these topics can be addressed to him.

The NGO "Mentes en Transición"(Transitional Minds) is the local partner in Colombia and is dedicated to managing and supporting projects that promote transitions toward a more socially and environmentally responsible society. The representatives of this NGO are:
Thomas Macintyre, with a Norwegian nationality, has a Masters in International Development Studies and has worked with several sustainable initiatives in Colombia. He is knowledgeable about sustainable practices and will be the interpreter during the course.
Martha Chaves is a biologist with a Masters in Forest and Nature Conservation, and is currently pursuing a doctorate in Sociology of Rural Development and Change in

the Netherlands. Martha is helping with logistical support and translation during the course.

The Ecovillage Anthakarana is dedicated to bridging the gap between ancient knowledge, art and new technologies for the development of human processes friendlier to the environment. The representative of this ecovillage will be the resident *Osiris Alvarez*. Osiris is an expert in sustainability in practice, having been a resident for more than 4 years in the ecovillage. He is in charge of logistics, preparation, organization and finding course materials. He will be responsible for the maintenance of the biogas installation and supporting the investigation into its operation.

And so we begin:

What is a biodigester?

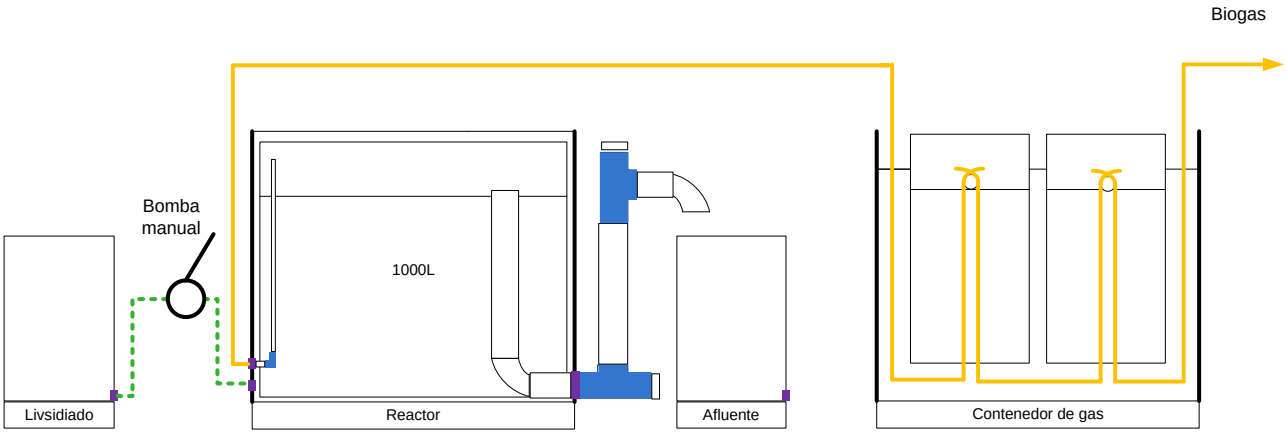
A biodigester is a system which converts organic waste into combustible gas. It is usually made up of a vessel, or vessels, in which organic materials react to produce gas. The gas collected can then be used to cook food on a primus, as is the purpose of this workshop, or modified to generate electricity or heat water. The left over material, known as the effluent, can then be used as natural fertilizer in the garden (though it should not be applied directly on the plants as high concentrations can burn the plants).

How does a biodigester work in general?

The production of biogas is a natural process, much like the human body production of gas (farts). Carbohydrates, proteins and fats are digested in the biodigester (like the digestive system of the human body) and produce gas. And just like you can light a fart, you can burn the gas of a biodigester to cook food. The heroes of this process are microorganisms. Like the yeast which ferments beer, and the Lactobacillus which creates yogurt, microorganisms found in animal manure and organic waste convert organic material into methane, CO2 and other compounds. This process only happens anaerobically, i.e. without oxygen.

How does the biodigester that we will construct work?

There are many different types of biodigesters. They are based on the same principles mentioned above, but differentiated by the the vessels used and how the reactor is fed. The version of this workshop is designed to produce gas at the household level and is made of three components (see diagram on the following page):



1. The containers in which the organic materials are mixed with water and where the acidogenic fermentation occurs, producing a liquid with concentrations of organic acids. This process is similar to putting a tea bag in a cup of water: the organic materials are diluted in water and begin to ferment.

2. The second step is pumping this “tea” into a second anaerobic vessel (i.e. where there is no oxygen) called the “reactor, in which the methanogenic reaction will take place. This process produces a biogas which contains methane (the burnable gas) which is then collected in a third component.

3. This is the gas container in which the gas is stored and ready for use.

Theoretically, this model can produce an estimated 2-3 hours of cooking gas per day. Compared to other digesters, this system has several advantages, such as decreasing the likelihood of any leakage of methane (which produces air pollution). Furthermore, its design is less likely to generate gas pipe blockages and holds more biomass in the reactor leading to greater gas production.

Who can build and use a biodigester?

The biodigester model which will be taught in this course involves simple materials which can be found at the local hardware store (see annex 1 for a list of materials and costs). Furthermore, the design is flexible enough to allow for “artisanal” modifications, using other second-hand parts which may be cheaper and easier to find. Its simple design also means that the biodigester can be used by anybody who wants to produce biogas and has access to animal manure or household organic residuals such as vegetable and fruit scraps. Its operation requires common sense, and a willingness to get a little dirty.

Where can a biodigester work?

In principle, this biodigester can work anywhere as long as it has a steady supply of organic material, micro-bacteria and temperatures above 5 degrees Celsius. However, there are some considerations to take into account.

1. Distance of biodigester from the kitchen: The closer the hose which connects the biodigester is to the cooking stove, the greater the gas pressure at the stove. However, the organic material added to the biodigester, and the effluent which leaves, produces a smell, not always pleasant, so it should be far enough away from the kitchen so as not to be an inconvenience.

2. Temperature: The bacteria work faster, and hence produces more gas, when the reactor material is warmer. For this reason it is advisable to have the biodigester in a warm place, for example where the sun can heat it during the day.

Operation

1) Start up: To activate the reaction in the reactor, a starting material is needed. This starting material, called an *inoculum*, should be rich in micro-organisms that perform anaerobic fermentation. A typical inoculum has a volume of between 10% and 50% of the volume of the reactor (the higher the percentage the faster the biodigester will start working). The best inoculum source is the sludge from other biodigesters. If this is not available, then second best is manure from mammals. This step only needs to be done once.

2) Leaching: Organic waste should be collected in containers and fresh/rain water should be added until it covers the material. Then it should be left to ferment for between 5 to 10 days. Almost any organic materials can be used, but certain compounds have an inhibitive effect on the methane formation, such as coffee and bird droppings (like chicken manure) and should be limited or avoided.

3) Feeding the reactor: Only the liquid part of the leachate is pumped into the reactor. This prevents the biodigester from filling up with fibrous materials that may cause blocking of tubes. The maximum amount of liquid to be pumped in everyday is estimated at 200 liters for this model, or 25% of the holding capacity of the reactor. The left over solid material can be composted.

4) Effluent handling: When the biodigester reaches its maximum volume, then every liter pumped in will result in one liter flowing out through the overflow/effluent tube. This liquid is rich in nutrients such as nitrogen and phosphate after the methanogenic reaction. It can be used again to leach the next batch of organic material, or to fertilize the garden. Note: re-using the water to leach the materials will gradually result in a build up of salts and other inhibitory compounds in the liquid which will eventually kill the bacteria needed for the reaction. We therefor advise that at least every 5th time you remove the effluent from the reactor, you

remove it from the system (use this water for fertilizer!) and fill the new leaching container with fresh water.

5) Gas storage: The gas produced in the reactor flows to the upside-down gas storage container(s). As these fill with gas they become buoyant and begin floating upwards. To increase the gas pressure, weights can be placed on top of the containers creating more resistance for the containers to float upwards. The pressure required depends of the type of stove used, the length and diameter of the gas tube and a few other factors. The proper amount of weight can be best established empirically.

Important note! It can take up to 4 weeks to obtain burnable gas (gas can be produced earlier, but it does not have enough methane to burn as it is combined with the oxygen already in the tanks). To speed up the process we advise you to flush the system with bottled cooking gas (between 2 to 3 times) to remove all oxygen. The tanks are then only left with burnable gas, and any gas produced will be burnable. If you do not do this, then the first gas produced must be periodically released until a gas high enough in methane is produced which will burn.

Troubleshooting

The following are reasons why the biodigester is not producing burnable gas:

A *technical reason* could be that the gas tubes are blocked, or there is a gas leak. To solve this, first visually check if there is a problem with the pipes, for example, a bent pipe.
To find leaks in the pipes and connections make a mixture of soap and water and spray it on the system pipes and connections. If there is a leak with sufficient pressure then bubbles will be formed where the gas is leaking. Given the case that there is not enough gas pressure to produce bubbles then it may be necessary to pump gas into the gas container so as to generate the pressure needed to observe bubbles resulting from the leak. If this still does not solve the problem then it may be necessary to disconnect the tubes and pump water through them to clear any potential blockages. In this case it is important to afterwards pump air through the tubes to remove all the water.

On the other hand, there is the possibility that the digester does not work for *biological reasons*. If you do not start with an organic starting material (inoculum), or the inoculum does not have a high enough concentration of microbacteria, then the digester will take much longer to start producing gas. Be patient, the biodigester will eventually start producing gas. The optimum pH for the material of the reactor is between 7 to 8. If the material in the reactor has a pH of less than 6, then it is too acidic and will not produce gas. One solution to this is to add an alkaline substance such as lime (agricultural and construction) until the pH reaches the optimal range.

The pH can be checked using pH measuring tape sold in stores that sell chemical products.

Another reason for the malfunction of the digester can be an overload of leachate being added to the reactor will may cause the sediment at the bottom of the reactor to be expelled, thus removing the bacteria needed for the reaction. To solve this add more starting material and add less leachate. Reversely, it may happen that after a long period of operation the system has accumulated too much sediment. This can easily be solved by removing excess sediment through the same access where the leachate is added.

Advantages and considerations of this biodigester

Economic advantages: Apart from material and maintenance costs, there are no costs involved in producing the gas. If you can produce enough gas for your household needs, then you do not need to buy or transport gas from the city or town.

Ecological benefits: This system produces gas from renewable materials such as cow manure and kitchen residuals whose by-products can be used as fertilizer, giving energy to plants, whose fruit and vegetable residues can then be used again for the biodigester. This creates a closed loop where nothing is wasted. Purchased gas, on the other hand, is not a closed circuit as is extracted from non-renewable sources, in other words, it is not being replaced and it will one day run out. Furthermore, its extraction involves a lot of damage to the environment. By generating and using biogas we also avoid chopping down rainforests for firewood, whose burning also impairs our respiratory health.

The good life (El buen vivir): If you are like the people giving this course, then it excites you to know that you are taking responsibility for your own waste and are creating your own energy from the resources around you. It is a creative and responsible everyday activity, giving you more independence to your way of life. Remember that the money you are not spending on gas can used to improve your quality of life and that of your family.

Responsibility: Despite all the advantages of a biodigester, it is important to remember that its construction involves initial costs, patience and responsibility in its maintenance. One first has to acquire the materials for a biodigester, build it, be diligent in feeding it organic materials, and still it will take around 4 weeks before it will start producing gas. Like us humans, the biodigester is a living system which will work differently depending on the number and type of microorganisms in the system, the type and frequency of the organic material being fed.

Contact Information

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Material Costs: Annex 1

	COMPONENTE (ES)	COMPONENT (IN)	CANTIDAD	PRECIO/UNIDAD	PRECIO	SUBTOTAL
LIVSIDIADO/ AFFLUENTE	caneca 140l	drum 140 liter	4	35000	140000	
	malla zaranda	netting big	2	12500	25000	
	Incertos PVC 1"	Adapter pipe to hose 1"	4	2000	8000	
	Flanche pvc 1"	Tank connector 1"	4	5000	20000	
	Adaptadores Machos 1"	Male adapters 1"	4	1000	4000	
	Llave pvc 1"	Tap pvc 1"	4	7000	28000	225000
REACTOR	tanque 1000l	container 1000l	1	200000	200000	
	flanche de brida 4"	Tank connector 4"	2	20000	20000	
	Tee 4"sanitario	T piece 4"	2	18500	37000	
	Codo 4"pvc	PVC elbow 4"	2	5500	11000	
	Tubo 4"pvc	PVC pipe 4"	4	17500	70000	
	adaptor 4 limpie	Endpiece with screw 4"	2	11900	23800	
	Llave pvc 1"	Tap pvc 1"	1	7000	7000	
	Flanche pvc 1"	Tank connector 1"	1	5000	5000	
	Adaptadores Machos 1"	Male adapters 1"	1	1000	1000	
	Incertos PVC 1"	Adaptor pipe to hose 1"	1	2000	2000	
	Incertos PVC 1"	Adaptor pipe to hose 1"	7	2000	14000	
	Adaptadores Machos 1"	Male adapters 1"	2	1000	2000	
	bomba succion manu	Handpump	1	33900	33900	
	manguera cristal 1"	Tranparrant hose 1"	10	4500	45000	
	manguera cristal 1 1/2"	Tranparrant hose 1 1/2"	3,5	4850	16975	
	Tee 1"	T piece 1"	1	12000	12000	
	Flanche 1/2"	Connector 1/2"	1	4000	4000	
	Codo pvc 1"	PVC Elbow 1"	1	1500	1500	
	Buje de 1"a 1/2"	Adapter 1"to 1/2"	1	1500	1500	
	Adaptador macho 1/2"	Male gas adapter 1/2"	1	4500	4500	
	Tubo 1"pvc	PVC Pipe 1"	2	1500	3000	515175
CONTENEDOR DE GAS	caneca 220l	drum 220 liter	3	50000	150000	
	tanque 1000l	container 1000l	1	200000	200000	
	manguera gas 1/2"	Gas hose 1/2"	20	2000	40000	
	Tee 1/2"metalica	Metal T piece 1/2"	1	5000	5000	
	Adaptador macho 1/2"	Male gas adapter 1/2"	3	4500	13500	
	Llave metalica 1/2"	Tap metal 1/2"	2	10000	20000	428500
MISC	Teflon industrial	Gas tape	1	5000	5000	
	candellas	bolts+nuts			21823	
	Silicona	Silicon kit	1	14000	14000	
	Pistola silicona	Silicon pistol	1	8000	8000	
	Abrazadera 32mm	clamp 32mm	20	1500	30000	
	Pegante pvc 240 cm3	PVC Glue 240cm3	2	20000	40000	
	Abrazaderas 1/2"	Clamp 1/2"	10	700	7000	125823
TOTAL						1294498