PLUG FLOW TYPE
BIOGAS UNIT CONSTRUCTION

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The plug flow biogas unit has been designed specifically to deal with solid organic waste that is generally not fed into more conventional biogas units that exist in Sri Lanka. Practical Action, South Asia is testing the design to assess its performance. The main focus is on solid waste management while biogas is a secondary consideration.

Biogas technology has been used in Sri Lanka for decades to produce biogas from organic material such as cow dung or other animal waste. The Chinese and Indian continuous type and Sri Lankan batch type are the main designs that have been used but these could not cater for the daily disposal of organic solid waste successfully.

Although biogas technology has been around for years there was no technology in Sri Lanka that could transform more solid organic waste into biogas on a daily basis.

Therefore, Plug Flow Type Biogas Units (PFTBU) have now been introduced to Sri Lanka to test whether they can effectively process organic waste such as market garbage, garden and kitchen waste, crop residues and paddy straw etc. on a regular basis. These systems aim to give additional benefits to environment, agriculture, energy and livelihood sectors. This technology can be of use to many people who have to deal with organic solid waste frequently. This would keep the environment cleaner with less waste dumping yards, while generating additional revenues, higher agricultural outputs and green energy.

The Plug Flow Type Biogas Units (PFTBU) is a solution that aims to transform this waste into useful compost while producing biogas as a by-product that can be used for applications such as cooking and lighting. Solid waste generated from home gardens, kitchen, and farm waste can be fed into the unit on a daily basis to produce biogas.

History
A national workshop was organised in Colombo promoting plug flow type biogas systems in January 2008 by the South Asia Energy Network Project of Practical Action in Sri Lanka which works with the Practical Action offices in Nepal and Bangladesh. Subsequently, as one of the activities of this project, a South Asian technology transfer programme on plug flow type biogas systems was organised by Practical Action and held in India. This was attended by representatives from India, Sri Lanka and Nepal. Although plug flow biogas systems are found in Europe, they operate with external energy inputs in order to maintain a higher system temperature. Its cost is prohibitive to developing countries. However, what was transferred to Sri Lanka from India (The Indian Institute of Science – Centre for Sustainable Technologies) was a low-cost technology, designed for tropical countries. This technology was tested and proven in India but needed to be adapted to local conditions and tested in Sri Lanka.
Construction
The following is a description of the construction of a PFTBU with a capacity of 5m³ (cubic metres).

Firstly the selected spot must be measured and a rectangular pit must be dug. The measurement should be: 11 feet in length, 5 feet 10 inches in width and 5 feet deep.

At the bottom of the rectangular pit dug a 4 inches thick (high) concrete layer must be laid using 10mm diameter steel rods to strengthen this layer of concrete. However if the soil consists of hard earth one can avoid using steel rods (used to support the concrete) and instead use a 2 inch thick concrete layer as the base which is adequate for the purpose.

The foundation for the ‘Digester’ and ‘inlet’ should be laid on top of the concrete based bottom. The side walls must be constructed 4 feet 6 inches in height, and strengthened with support of 9 inches thick columns. Clay bricks, previously soaked in water for a day, should be used to strengthen walls. The inner brick walls must be properly secured with a mortar consisting of cement, sand combination. These should be cemented with a layer of smooth cement. The cemented structure must be air tight.
The ‘digester inlet’ must be placed at mid length of the wall (where the inlet is supposed to be placed) and inlet pipe should rest 2 feet above the base on the wall and be placed at a 45° angle. The mouth of the inlet which will be used to feed in the solid waste should open above the ground.

The wall on which the digester will rest must be supported with a concrete beam that runs all around. The concrete beam must be constructed using a 5mm thick spiral iron rod (concrete supporting iron rod) for support.
The mould (digester mould) should be rested on the inside wooden support (used for concrete beam mould). The mould put in place will be used to make the vault (digester dome). This is made of bricks and secured with cement and sand mortar. The two sides of the digester should be closed up with a brick wall.
The mould has to be used 4 times to complete the basic digester structure.

Dried digester structure with gap in front as the outlet.

During construction of the digester dome a ½ inch width plastic pipe will be used to filter out the biogas that will be produced.

The structure has to be smoothed with mortar and a cement layer to secure it further.

After completing construction of the main structure (digester) a separate location
Plug flow type biogas unit construction

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nearby has to be selected to construct the gas storage tank.

The diameter of the pit to be dug for the gas storage tank should be 4 feet and 4 feet 6 inches deep.

Once the cylindrical shaped pit is dug, the walls and base must be constructed with brick, cement sand mixed mortar and smoothed with layer of cement mixture.

Once dried the constructed cylinder shaped gas tank securing structure is complete a 1000 litre plastic biogas storage tank should be inserted into the underground structure.
A 2 feet by 3½ feet tank must be built surrounding the inlet pipe mouth that is exposed above ground.
After completing the main structures for plug flow type biogas, water and air tests must be done to ensure that there are no leakages. It should be checked for safety and gas/water leakages. If any defect is located, it should be attended immediately.

After satisfactory checking of the unit, the digester is filled with a reasonable amount of inoculums (such as cow dung) and required amount of organic solid waste. If any defect is observed during the operation of the unit, immediate action should be taken to correct it. The common methods adopted for checking the biogas unit is described below.

a) Visual Observation
After completion of the construction work, it is recommend entering inside of the digester and inspecting visually and identifying any leakage in the form of cracks and holes. With the help of fingers or little wooden stick, tap the floor and walls, If a hollow sound is heard when tapping it may due to plastered layer has come away from the wall. In such locations the plaster should be removed and replaced by new plaster.

b) Water filling test
This is used to identify leakage from the walls and foundation of the unit through water infiltration measurement. It includes filling the fermenter and outlet tank up to the top level of fermenter (digester) and allowing it to saturate for 24 hours and mark the water level when it settles. Then filled water again up to the top of the digester and leave it for another 24 hours. If the water level has not dropped during this period, it indicates that the biogas unit is water tight, otherwise locate leakage and repair it.

c) Manometer Checking
First, the manometer is connected to the gas outlet pipe using a T-socket. Then its other opening end is fixed to a bicycle pump and increases the air pressure inside the vault by pumping air. When a noticeable differential pressure has been observed in the manometer, stop the pressure increasing and leave it for 2-3 hours, observe if there is any drop in pressure. If the change in the water column is nil or it indicates a negligible drop the vault seems to be airtight. However, if the pressure drop is more the vault has some leakage and it is needed to locate and repair the fault.

The pipe on the digester should connect to the storage tank through a rubber gas hose pipe and another gas outlet must be connected from gas storage cylinder through a rubber gas hose pipe will connect to the domestic gas cooker. The cooker should be able to control flow of gas.

If the tests come clear with no leakages of water and air, one can begin feeding solid waste into the feeder.
However the first feed into the new unit needs to be either some slurry from older biogas unit in order to transfer anaerobic bacteria as it otherwise takes a longer time to grow this bacteria which produces bio gas under this condition.

If this is not a possible option other option is to mix cow dung with water and feed in to the unit.

Three days after the first feed solid waste can be fed in to the digester.

The gas produced will be stored in the storage cylinder and can be used according domestic needs.
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Layout of plan used for construction

References and further reading

Biogas Practical Action Technical brief
A general introduction to biogas options
Plug Flow Biogas - Composting in Sri Lanka
A video (in Sinhala) showing the plug flow design of digester.
Experience of Biogas Implementation Practical Action Technical brief
Work from Practical Action, South Asia.
Using a Biogas Digester Practical Action Technical brief
A guide to using the Sri Lankan biogas digester

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