Biogas from maize stalks and other biomass.

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Introduction

An alternative fuel for cooking is urgently required. Smoke generated by burning biomass has negative health impact on woman, especially when there is no chimney present. Wood is in many cases a scarce commodity and deforestation is in many countries a concern. Charcoal production is very inefficient, putting a strain on the remaining trees in bushes and forests. Fossil fuels are expensive and in many areas not available. Denatured alcohol has been proposed, but this is still expensive.

Biogas is an excellent fuel for cooking. Biogas consists of methane and carbon dioxide as a product of the transformation of biomass through the action of microbes into. It is a clean burning gas, suitable for cooking and as fuel in gas and diesel engines. As yet it can not easily be transported. The resulting waste slurry has all the nitrogen, phosphate and potassium from the incoming biomass and can be used as fertilizer. The remaining carbon in the slurry will improve soil fertility.

Small biogas plants using manure as biomass have been developed for (sub) tropical regions and many million installations are working in China and India. The large majority of families have not sufficient livestock to benefit from these plants.

Carver has developed a small biogas plant using kitchen and market waste as input. Also other waste material with a large content of sugar, starch and fat can be used. The ARTI compact biogas plant is made from two standard high-density polyethylene (HDPE) water tanks. More than a thousand of these systems have been installed.

Fig. 1 Ajit Gokhale with his biogas plant which he feeds with spoilt figs and food left over by the street dogs he rescues.

Biogas from maize stalks and other biomass

Waste materials are available in most rural areas which are burned in the fields as they are not compact enough to be used as a fuel. Examples are maize stalks and cobs, straw from rice, wheat, cotton, peanuts; husks from rice and peanuts; bagasse from sugar production; weeds, jatropha husks and press cake, water hyacinth and lots of other materials. These materials can be converted into biogas provided extra fertilizer is used so that the microbes that convert the material into biogas can multiply. For each kg of dry biomass a maximum of 40 g of urea and 20 g of phosphate are required. Human urine is a good source of nitrogen and phosphate.

Human faeces are also good but require storage for more than 100 days in order to prevent the spread of illnesses. Ecosan toilets separate urine and faeces, so that urine can be directly used and faeces stored for the required period.

Tests in the US (Wu, X et al 2010) showed that 25 % of the energy content of maize stalks could be converted into biogas, with swine manure as a source of nitrogen and phosphate. The experiments were done with finely ground maize stalks and lasted only one month.

Water jacket biogas plant

Maize stalks and most other biomass have a tendency to float on the water and form a scum layer. Tests in India have shown that these types of materials will generate biogas when they have been in contact with digester fluid for at least three days. This can be achieved by filling the digester with a quantity of wet compost. The compost will float. New material is added from the bottom of the digester. This material will push the compost upwards but will stay under the digester liquid as the compost being wet is relatively heavy. The resulting digested material forms a thick mat. The digested material can be removed a few times per year after opening the plant. This can be done by using a hand operated grab crane.

A plant suitable to convert maize stalks and other biomass into biogas is of the water jacket floating drum plant type. The floating drum can be removed and the digested material can be taken out from the top. The water jacket reduces the emission of methane. In fixed dome plants 10 % of the methane production is lost. Methane is a potent green house gas. The main modification is the use of a large 0.3 m diameter inlet pipe. Through this pipe the waste biomass can be pushed down into the digester proper.

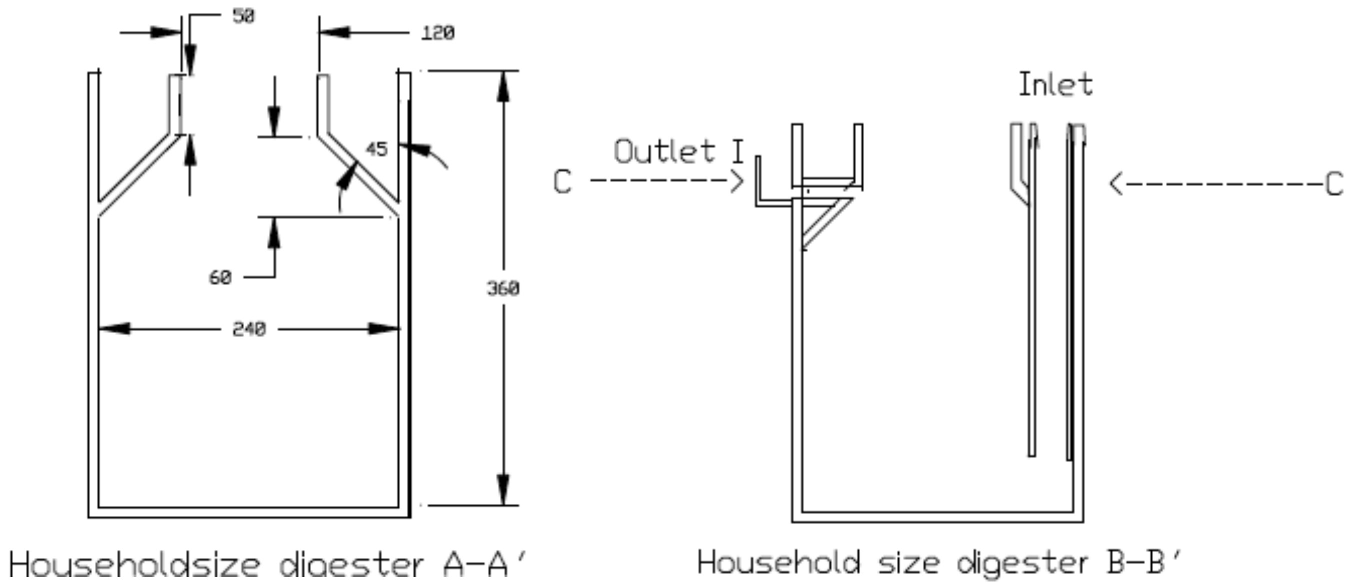

Fig II **Design of a water jacket biogas plant**

Fig III Gas dome in water jacket

fig IV Construction of a water jacket plant (In the foreground the large inlet).

The plant can be constructed from concrete using steel moulds (like the Puxin biogas plants).

The gasholder with an inner diameter of 1.5 m is the upside down bottom of a plastic water tank (3 000 l). This is an expensive option. For large scale dissemination a cheaper (waste) plastic or a fibre reinforced plastic should be used. The water jacket could also be made of plastic. This requires a smart design as the jacket has to be transported in parts and leakage has to be minimized.

A plant of this type using bricks as construction material has been built in Bangladesh. Only a few tests have been done due to difficulties encountered with the gas storage. The storage issues have been resolved with the ARTI plant as an example. Unfortunately the project was stopped due to lack of funds.

Other options are bag type plants and plants based on used IBC containers.

A demonstration plant

The next step is to build a demonstration plant. This could be done in Europe with external heating or in a (semi) tropical country. In Europe supervision is easier in a (semi) tropical country the demonstration is more relevant. Supervision is required only once a month after the plant has been started up, provided some one can feed the plant once a week. The nitrogen content of maize stalks in (semi) tropical countries is expected to be lower as less fertilizer is used there. This can be tested. In the Netherlands it is difficult to obtain maize stalks, as maize the climate does not allow maize to ripen and the whole plant is used as fodder.

- The design requires a rebar plan and the thickness of the concrete structures.
- A location for the demonstration plant should be selected, preferably close to other projects.
- A suitable water tank should be located in the country where the plant is build.

The costs for the demonstration plant is about 1 000 €. Supervision will costs about 12 000 €/y.
The costs of supervision depend much on the location (Travel costs) and the model of supervision chosen. Supervision should be preferably combined by other activities on the same or a close by location.

Litt: Wu, D., Yao, W., Zhu,J. And Miller, C. “Biogas and CH4 productivity by co-digesting swine manure with three crop residues as an external carbon source” Bioresource Technology 1001(2010)n 4042-4047