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PROJECT REPORT

# DOUBLE DIGESTER BIOGAS PLANT

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# 1. INTRODUCTION

In rural areas of developing countries more than 80% of energy consumption is for cooking. The energy is mostly derived from fuelwood/biomass, and because consumption exceeds regeneration rate, rural population faces severe hardships as in some cases villagers have to walk for miles to collect wood. Furthermore there is a serious threat of long-term ecological imbalance. To check this, we must intensify efforts in developing alternative energy sources.

One of these sources is the utilization of plant resources, animal and agricultural wastes to provide fuel gas. Biogas as it is called is obtained by the anaerobic decomposition of such wastes as cowdung, other animal manure, night soil, house-hold garbage, water-hyacinth, water weeds, etc. The technology is simple and well-proven, and can work on both small and large scale projects. It is without doubt that the biogas will provide substantial energy relief especially in the rural areas, and it is proven that the residue after gas evolution is a good fertilizer. Therefore, the process serves functions of energy production, waste disposal and renewal of soil nutrients which could improve agricultural yields.

## 2. BRIEF BACKGROUND

In countries like India, Bangladesh and Nepal biomass in the form of cowdung has long been used as an alternative to burning firewood.

The cowdung is dried into 'cakes' for ease of transportation and better burning. However, cowdung cakes burn inefficiently, produce lots of smoke and generally create an unhealthy cooking environment; also the full potential of the resource is not fully utilized. To provide a meaningful energy source, better utilization of the resource is obviously necessary. The biogas plant provides such.

Present biogas plant designs are mostly of Chinese and Indian origins. The Chinese design or fixed top gas holder plant is in widespread use in China and is now also being adopted outside China.

Perhaps more popular in developing countries is the Indian plant design. The main difference being that it has a floating gas holder.

Since biogas plant technology is meant for decentralized rural application, cost is probably the most dominant factor in controlling its widespread application. Presently on average, it costs about U.S. $650.00 to fabricate a biogas plant for a family of five. This estimate based on the Indian design, shows that most of the money goes towards building the digester with brick and cement.

Gas requirement for a family of five is in the region of 100 cubic feet per day. A digester of 200 cubic feet capacity could produce such an amount but in most cases only about 60-70 cubic ft. per day of gas is produced. Unless a bigger digester is used, the gas requirement cannot be met. Experience shows that such a digester would have to be 5 ft. diameter or more. In the Indian design such a digester creates special problems like 'channeling'. In effect not more than 4/5th of the digester serves a sueful purpose. Furthermore the digester cannot maintain the system cycle properly so important for a daily charged plant.

Attempts made to improve the operation of such large digesters have included partitioning or using baffles, but the problems have never been fully overcome.

## 3. AIM OF WORK

In the light of the problems highlighted in the previous section, the group tried to design a simple biogas plant which would maintain the system cycle properly and produce the required gas quantity.

With the experience from proposed trials on the system it is hoped that recommendations can be made for better practical application of the technology.

## 4. THE DOUBLE DIGESTER SYSTEM

Instead of building a digester of 5 feet diameter or more to meet the energy demands of 100 cubic feet for a family of five, two digesters each 3 ft. diameter and 12 feet long, and joined together by a short pipe could be made. The plant would also be expected to maintain the cycle of the system.

Because of the smaller dimensions, even vilagers can build the system using, such as, porters made mud rings. As a result the technology maybe completely adopted without dependency on bricks and cement. It is estimated that the system will also cut cost by about 50%.

### 4.1 DESCRIPTION OF THE SYSTEM (Fig. 1)

The plant designed by the group consists of two digesters each 15 inch diameter and 42 inch long. Each digester was made from two 30 gallon oil drums welded together one on top of the other. Union of the two digesters was achieved by using a 3 inch PVC pipe 8 inch long and at a point 6 inch below the top of the digesters.

Inlet and outlet points were provided by connecting 3 inch PVC pipes to points about 2 inch from the bottom of both digesters. The original design called for sloping inlet and outlet pipes, but because of fabrication problems the pipes had to contain 90° bends. The upright portions of the pipes was dependent on the intended level of the slurry within the digesters.

The two gas holders also made from oil drums required little work and measured 13 ½ inch diameter and 20 inch long. The group decided on close-fitting gas holders so as to minimize gas loss between digesters and holders.

The plant, therefore, had a single digester volume of 4.3 cubic feet giving a total volume of 8.6 cubic feet, and expecting to produce some 4.3 cubic feet of gas per day. The gas holders are each 1.66 cubic feet giving a total volume of 3.32 cubic feet.

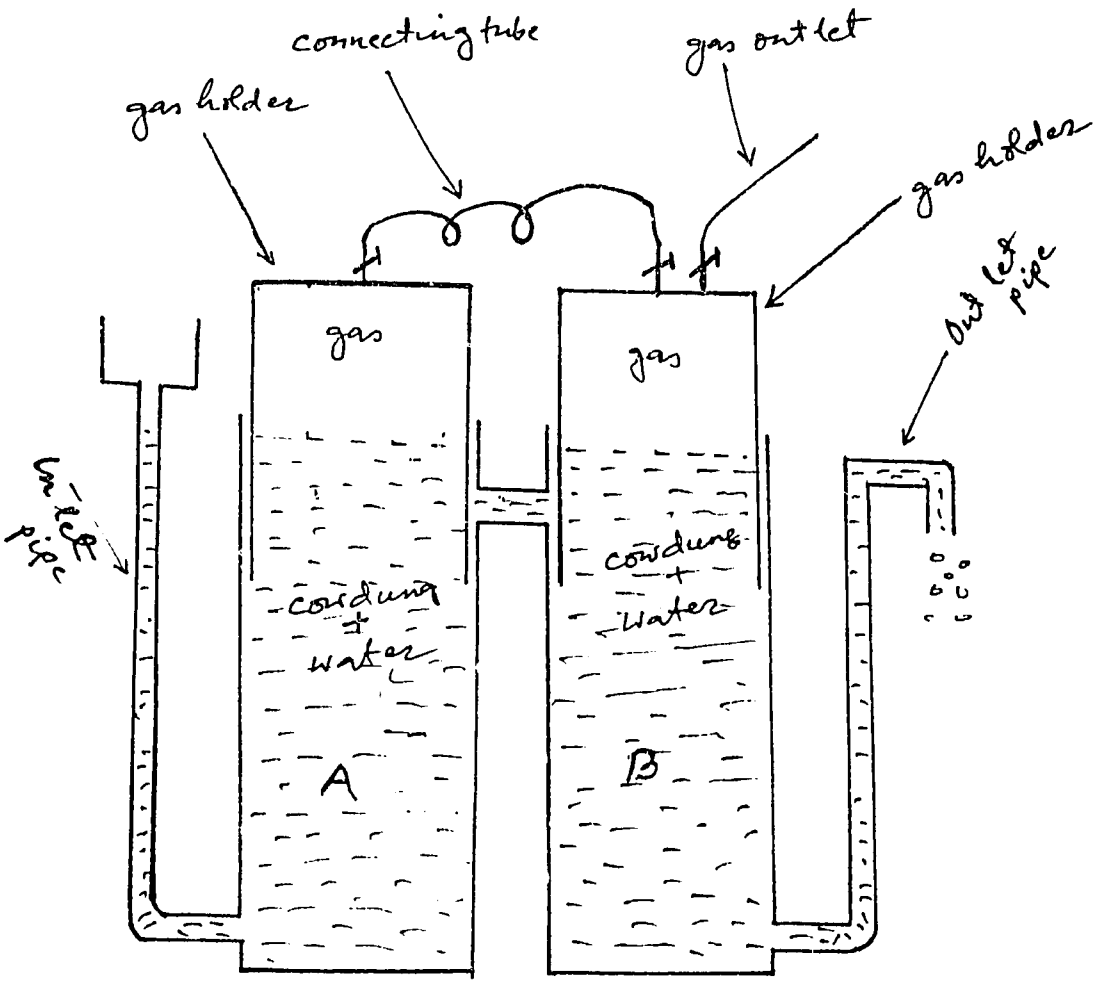


Figure 1

The sizing of the digesters was limited by the availability of cowdung. It is important that a fixed amount of cowdung be available to maintain a daily charged system.

## 4.2. HOW THE DOUBLE DIGESTER WORKS

The system as shown in Figure 1 consists of two digesters A and B. In digester A cowdung and water in the ratio of 1:1 will be charged daily through the inlet pipe. After digester A is filled, the slurry will pass through the junction pipe to the digester B. Excess slurry from the digester B will flow through the outlet pipe to an 'overflow bucket'. The daily charging should be maintained in such a way that the retention time of the slurry is not less than 40 days. As gas production is maximum after 30 days, this would allow maximum evolution of gas from the dung.

The gas evolved will be collected in the two gas holders which are connected by a plastic tube which helps to maintain equal pressure in the holders. Another pipe with a simple valve can lead to a water manometer or point of use.

## 5. FACTORS AFFECTING GAS PRODUCTION

Before any tests are run on any biogas system, it is worth noting that the plant is susceptible to environmental and other conditions.

The rate of gas production depends largely on the nature of the cowdung or more generally the biomass resource available. For cowdung, the type of feed the cow gets controls the nature of the dung. If the cow is fed on straws and a lot of dry material, the dung will contain a lot of undigestible material which produces less gas and may cuase sedimentation as well as floatation. System cycle may not be maintained. On the other hand, if the cow is fed on fresh grass, oil cakes and the likes, the dung produces a more homogeneous mixture with water and keeps the cycle in order.

Temperature is another factor which needs to be closely watched. It has been found that the maximum gas production occurs at an optimum temperature of 36°C. Decrease in temperature results in decrease in gas production, and for temperatures below 10°C it is negligible.

The carbon-nitrogen content of the biomass usually referred to as the C:N ratio is also an important factor. A lot of research work has been undertaken in this direction and most workers agree on an optimum of 18:1 for good gas production.

## 6. OBSERVATION OF THE SYSTEM

Due to lack of time, no detailed tests could be done on the system. However, initial observations showed that some gas was evolved only after 10 days. Of course most of this gas was carbon dioxide and small amount of air which was left in the gas holders during first charge. The gas subsequently bled off in anticipation of some good quality gas.

After another 4 days more careful observation was undertaken to reveal the following:

| DAYS AFTER FIRST CHARGE | CUMMULATIVE QUANTITY OF GAS (CUFT) | DAILY GAS PRODUCTION (CUFT) |
|---|---|---|
| 14 | 0.819 | 0.403 |
| 15 | 1.222 | 0.533 |
| 16 | 1.738 | 0.436 |
| 17 | 2.174 | 0.326 |
| 18 | 2.50 | 0.336 |
| 19 | 2.825 | 0.315 |
| 20 | 3.151 | 0.388 |
| 21 | 3.541 | 0.346 |
| 22 | 3.888 | |

TABLE: I

On the twenty-third day, a simple cooking stove was connected to the gas outlet. We had decided to burn the gas because:

1) the gas holders were getting high up in the slurry and needed to be reset.

2) we needed to see whether the gas would burn.

We observed that the gas could burn, but the flame was unsteady and gas pressure very low. This is nothing unusual especially with small

systems. In most cases weights are placed on the gas holders to maintain a reasonable pressure.

Tests for gas quality were not done but the gas flame was a clear blue which was almost invisible in bright sunlight.

Observation of the system was interrupted for several days and since a daily check could not be guaranteed, no further attempts were made.

## Comments on Observations

Gas production being maximum usually after 30 days, it is evident the figures presented in the Table I are not of real consequence. However, it can be noted that gas evolution was an average of 0.35 cubic feet per day, well below the expected rate. Also, the expected daily increase in gas production is not quite evident. These happened because the temperatures were always below 22°C and the dung was full of undigestable big strawy materials which were a worst quality of dung.

## 6.1 PROBLEMS EXPERIENCED WITH THE SYSTEM

During the observation periods, if the gas holders were not agitated daily, the slurry tended to sediment and solidified. Floatation of strawy material was also observed; this had to be removed occasionally.

The presence of floating material eventually caused a major problem. With the system unobserved for several days most of this material found its way into the junction pipe and blocked it. With the result that transfer of slurry from digester A to B was prevented during daily charging attempts.

The 90° bends contained in the outlet and inlet pipes seriously hampered a smooth flow of slurry.

## 7. CONCLUSIONS AND COMMENTS

The lessons learned from the experience of observing the Double Digester biogas plant include:

a) That some device for agitation of slurry, maybe a stirrer, should have been included in the design.

b) A T-Junction would have worked better than a simple pipe junction. In this way any blockage could be better dealt with.

c) The occurrence of 90° bends should be kept to an absolute minimum.