Environment

Water & Environmental Sanitation Network (WES-Net India)

Solution Exchange for WES-Net India Consolidated Reply

Query: Comparative Analysis of Biogas Digester Models, from WOTR, Ahmednagar (Experiences, Examples).

Compiled by Pankaj Kumar, Resource Person; additional research provided by Ramya Gopalan, Research Associate
18 July 2006

Original Query: Sheldon Mendonca, Watershed Organization Trust (WOTR), Ahmednagar

Posted: 28 June 2006

I work with the renewable energy department recently formed by Watershed Organisation Trust (WOTR). WOTR is looking to use renewable energy technologies to attempt solving the energy problems faced by communities in rural Maharashtra.

In this context, I would be grateful, if members of the community can share with me:

- Criteria to be used for evaluation of the best biogas digester model (efficiency, cost, social acceptability, etc.) to suit individual households in rural areas.
- Experiences and lessons learned by members while working with different biogas digester models.
- Do's and Don'ts identified by members while implementing household level biogas programmes at a large scale.

Responses received with thanks from:

1. **Digbijoy Bhowmik, GoI-UNDP Project 'National Strategy for Urban Poor,' New Delhi**
2. **Pankaj Kumar S., UNDP, New Delhi**
3. **Arunabha Majumder, All India Institute of Hygiene of Public Health, Kolkata**
4. **Sheldon Mendonca, WOTR, Ahmednagar**
5. **M. S. Gupta, Sarvangeen Vikas Samiti, Gorakhpur, Uttar Pradesh**
6. **R. Santhanam, Indian Society of Agribusiness Professionals, New Delhi**

Further contributions are welcome!

Summary of Responses

The potential of biogas as a source of clean, easily available energy is widely recognised. The query attempted to tap into members' experience regarding installation and maintenance of various types of biogas plants in India.

Participants shared their experiences with the three main types of biogas plants: the Floating Dome or KVIC model, Deenbandhu model and Plug Flow model. They noted that no single model can be universally applicable and thus every design must be adapted to the local conditions.

- **KVIC (Floating Dome) Model-** This model consists of a pit on which a mild steel or plastic dome rests. It is suitable for most areas except very cold climates. However, maintenance of the dome is sometimes a problem, members reported.
- **Deenbandhu Model**- The most rugged of the three models, it has an underground masonry structure. Members pointed out that this guards it against cold temperatures and households to use the land above it. However, excavation for the digester in hard bedrock areas is difficult and the investment needed to build it is high.
- **Plug Flow model** – This type of biogas digester is only comprised of a cylindrical HDPE film and is very easy to construct. It is suitable primarily for warm climates. The cost is very low and the gas production good.

Respondents discussed several **criteria for evaluating** the best biogas digester model for a specific location. One major point to consider is the **number of animals** within the household who can contribute to the digester. This is very important, as installation of an oversized plant would mean that the household would not get adequate quantity of dung, due to which the digester would be underfed and the gas production be inadequate. Another key criterion to consider are the **installation costs** of the digester. Members indicated that the KVIC model (Rs. 7,000 to Rs. 9,000 (current prices) for a two cubic meter plant) and Plug Flow type of digester (Rs. 2,000 for one cubic meter plant- according to 1990 prices) require the lowest initial investments. The Deenbandhu model is the most expensive (Rs. 8,500 to Rs. 11,000 (current prices) for two cubic meters).

A third criterion for evaluating the best type of biogas digester model, mentioned by discussants is **ease of excavation,** which depends on the soil depth and the nature of bedrock. In areas where excavation is not a problem, members suggested using the Deenbandhu model. However, in hard rock areas, where it is not possible to dig very deep, perhaps the KVIC and Plug Flow models would work better. **Climatic conditions** affect gas production and are another important criterion, participants noted. The Deenbandhu model gives the best results in cold temperatures, as it is underground. Respondents opined that where fluctuations in temperature are not too high it is possible to use any of the three models; based on other selection criteria.

The amount of **land available for installation**, members pointed out, also affects the type of digester ultimately chosen. In land-scarce areas or households, the underground Deenbandhu model makes more sense compared to the other two, since it requires the least above ground area. In addition to amount of land, the **number of family members** (and therefore the amount of gas required for cooking) is also a major criterion for deciding on the size of the plant. Another factor discussed is the **skill levels of local masons.** The Deenbandhu model requires the highest level of skills, the KVIC model a medium level and the Plug Flow type demands the least skills. Other criteria members mentioned were the **portability of biogas** and **biomass digestion**, which only the Plug Flow digester offers, and **durability**. Respondents felt that the Deenbandhu model is the most durable, the KVIC model fairly sturdy and the Plug Flow digester the least rugged of the three.

Members also mentioned a biogas project in **Haryana** for captive power generation and pointed out that in most cases, use of biogas for power generation had better social acceptability than biogas for cooking. They also suggested maintaining the optimal volatile acid and sulphate levels in the digester.

Respondents discussed the **dos and don'ts** of installation and maintenance of biogas digesters. They suggested a detailed daily, weekly, monthly, yearly and five-yearly maintenance schedule for biogas digesters. Members felt that the main points to keep in mind during installation and maintenance were site selection, regular feeding of the digester, incorporating gas saving methods (such as pre-cooking preparation before switching on the gas, maintenance of the gas pipeline) and covering inlet and outlet for safety. In addition, members mentioned that practices to avoid were selecting the digester size without taking the number of animals within the household, inappropriate digester feeding practices, failing to keep the pipeline water-free and not using the gas safely.

Along with issues related to various digester models, members also touched on **other uses of biogas**, such as lighting. They discussed the use of biogas turbines in **USA**, and pointed out that these required massive subsidies to be cost-effective. While respondents suggested designing digesters for composite waste digestion, they also cautioned that using composite wastes for biogas is complicated and does not deliver assured efficiency. In addition, they described scrubbing (removing hydrogen sulphide) of biogas through chemical means and by passing it through algae tanks, which improve the calorific value of the gas.

In conclusion, members examined the various criteria for selecting biogas digesters, based on members' experience. They also enumerated guidelines and precautions for installing and maintaining digesters and discussed the diverse uses of biogas.

Comparative Experience

Haryana

Establishment of Captive Power Generation through Biogas *(from Digbijoy Bhowmik, GoI- UNDP Project 'National Strategy for Urban Poor,' New Delhi)*
M/S Batliboi Industries has established captive power generation plants, using biogas in Punjab and Haryana. The power generated is enough to run an entire precinct. One plant managed to create one MW of sustained generation capacity from a dairy colony, which can run 60 to 70 dairy establishments with a load of 10 KVA each.

Karnataka

Biogas Plant Dissemination *(from Ramya Gopalan, Research Associate)*
In Sirsi block, all the biogas plants functioned satisfactorily and 85% produced enough energy for cooking. Multiple agencies helped disseminate information, and provide free servicing. However, most of the plants exceeded capacity with cost implications. The design shifted from a mild steel floating drum to a fibre reinforced plastic-based floating drum & later to a less expensive fixed dome model, which showed rural households' capacity to adapt to technological developments.

International

United States

Use of Biogas *(from R. Santhanam, Indian Society of Agribusiness Professionals (ISAP), New Delhi)*
In the US, they are using micro-turbines to run off landfill methane gas, which may be of poor quality with low levels of methane & also contain corrosive hydrogen sulphide. Where the gas supply is stable, such facilities enable revenue generation. Dairies generate methane gas from cattle dung that they use to generate electricity to sell. However, these micro-turbines require heavy subsidisation (mostly by the government), because they require heavy capital investments.

Nepal

The Biogas Support Programme (BSP) *(from Ramya Gopalan, Research Associate)*
As part of the BSP, it installed fixed-dome type biogas plants with a flat cement concrete bottom/floor, a brick/stone masonry cylindrical tank, a dome-shaped cement concrete roof, an inlet pipe connecting the digester with feeding tank, and rectangular outlet tank. The programme achieved both of its objectives (7,000 installations in the first two years and making biogas more attractive to smaller farmers) by providing a flat-rate subsidy to project beneficiaries.

Related Resources

Recommended Documentation

Where There's Muck There's Megawatts *(from Digbijoy Bhowmik, GoI-UNDP Project 'National Strategy for Urban Poor', New Delhi)*
By Susie Emmett; New Agriculturist Online
http://www.new-agri.co.uk/02-4/develop/dev02.html

> *Details an experience in Germany where electricity is generated by use of a biogas digester*

Compact Biogas Plant Making Waves *(from Pankaj Kumar S., Resource Person)*
Vinita Deshmukh, Energy/Economy, India Together, July 2006
http://www.indiatogether.org/2006/jul/env-karve.htm

> *Reports on Dr. Karve's new award-winning compact plant unconventionally requiring 1 kg of starch or sugar & 24 hours to produce 250gms of methane*

From Ramya Gopalan, Research Associate

Biogas Plant Models: Renewables in India
Tata Energy Research Institute and TERI, New Delhi; 1994
http://static.teriin.org/renew/tech/biogas/models.htm

Lists and details some of the biogas plant models under the NPBD programme, approved by the Ministry of Non-Conventional Energy Sources, GoI for implementation.

Biogas Production Technology: An Indian Perspective
By B. Nagamani and K. Ramasamy; Fermentation Laboratory, Department of Environmental Sciences, Tamil Nadu Agricultural University, Coimbatore
http://www.ias.ac.in/currsci/jul10/articles13.htm
Review aims at understanding microbial diversity in biogas digesters, their interactions and factors affecting biogas production, alternate feedstock, and uses of spent slurry.

Attempting to Fulfil Rural Energy Needs with Community Participation
Energy for Sustainable Development, Vol. 3 No. 1; May 1996
http://www.ieiglobal.org/ESDv3n1/ruralenergy.pdf (Size: 192 KB)
Details the village of Pura's (Karnataka) model community biogas plant operating, which offers a socially acceptable and economically viable way to meet energy needs

Biogas Plant Dissemination: Success Story of Sirsi, India
By P. R. Bhat, H. N. Chanakya and N.H. Ravindranath, Energy for Sustainable Development, Vol. 5 No. 1; March 2001
http://www.ieiglobal.org/ESDv5n1/biogasdissemination.pdf (Size: 95 KB)
The paper discusses the roles of various factors and their implications for future dissemination programmes of alternative energy technologies such as biogas

Evaluation Study of the National Project on Biogas Development (NPBD): PEO Study No.185
Programme Evaluation Organization, Planning Commission, Government of India; May 2002
http://planningcommission.nic.in/reports/peoreport/peoevalu/peo_npbd.pdf (Size: 571 KB)
Examines if implementation methods currently followed are contributing to increased adoption of family type biogas plants, reduced mortality and non-functionality rates

Evolving Biomass-Based Biogas Plants: The ASTRA Experience
By H. N. Chanakya, P. Rajabapaiah and J. M. Modak; Centre for Sustainable Technologies and Department of Chemical Engineering, Indian Institute of Science, Bangalore; October 2004
http://www.ias.ac.in/currsci/oct102004/917.pdf (Size: 224 KB)
An attempt to understand Research and Development efforts made by ASTRA Centre, to bridge some scientific and technological gaps in biomass-based biogas plants

Biogas for Household Use: The Case of Nepal
By J. F. M. de Castro; Energy for Sustainable Development, Vol. 1 No. 6; March 1995
http://www.ieiglobal.org/ESDv1n6/biogasnepal.pdf (Size: 210 KB)
Details the Biogas Support Programme, joint venture started in 1992/3, to install & disseminate biogas plants, in order to improve health and environmental conditions

Biogas Technology and Ecological Environment Development in Rural Areas of China
By Wang Mengjie; Chinese Academy of Agriculture Engineering Research; 2002
Click here to view PDF (Size: 35 KB)
Details different biogas development models, which have emerged in different areas of China according to the requirements of the local situation.

The Role of Biogas in Rural Development and Resource Protection in China: A Case Study of Lijiang Municipality, Yunnan Province, China

By Robert A. White; P.R.E.M.I.U.M. 2005 Research Experience for Undergraduates Sponsored by the National Science Foundation and Michigan State University; July 2005
http://forestry.msu.edu/China/New%20Folder/Bo%20White's%20Paper.pdf (Size: 249 KB)

Examines the capability of biogas as an alternative energy to help develop China's rural agricultural economy, also how to overcome barriers to greater biogas dissemination

Scope and Risks of the Asia Biogas Program (ABP)
By Wim J. Van Nes; Netherlands Development Organization, The Netherlands; October 2005
Click here to view PDF (Size: 195 KB)

Briefly examines the scope and risks of ABP with the objective of developing the market for biogas as an indigenous sustainable energy source in selected Asian countries

Recommended Organizations

Community, Institutional and Night Soil Based Biogas Plants (CBP/IBP/NBPs) *(from Ramya Gopalan, Research Associate)*
http://www.geda.org.in/bio/bio_community.htm

Programme consisting of various capacities/size biogas plants based on animal dung, night soil and alternative feed stocks

The Energy and Resources Institute (TERI), New Delhi *(from R. Santhanam, Indian Society of Agribusiness Professionals (ISAP), New Delhi)*
http://static.teriin.org/renew/tech/biogas/models.htm

Recommended for its research and development of an acid leaching technology, which converts wastes to generate methane

Related Past Consolidated Replies

Sanitation Schemes and Biogas Digesters, from B. K. Sharma, Gwalior Childrens Hospital, Madhya Pradesh (Comparative Experiences; Advice). Issued 28 December 2005
http://www.solutionexchange-un.net.in/environment/cr/cr-se-wes-28120501.doc (Size: 126 KB)

Provides experiences on community-based sanitation schemes using biogas digesters, and information on relevant technologies

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Responses in Full

Digbijoy Bhowmik, GoI-UNDP Project 'National Strategy for Urban Poor,' New Delhi

Some work has been done by M/s Batliboi Industries (also known for its work on sewage treatment systems) in Punjab and Haryana regarding establishment of captive power generation through bio-gas, that is enough to run the entire precinct. Most of such deployments have been with regards to dairy colonies (relocated from within city limits), such as a 2002 project wherein unauthorised dairies were relocated from within municipal limits of five towns in Haryana through the Slum Clearance Board. The relocation package included a dedicated space for a BG cogeneration unit.

Social acceptability is usually high in the case of projects wherein the BG digester is used for power generation, rather than being burnt as cooking fuel. One example (done by Batliboi as mentioned above) managed to create a 1 MW sustained generation capacity from a dairy colony. This is good enough to run a 60-70 dairy establishments with a load of 10 KVA each.

You may also wish to see this link for some international examples: http://www.new-agri.co.uk/02-4/develop/dev02.html.

Pankaj Kumar S, UNDP, New Delhi

The query raised by Sheldon is an interesting one since there are numerous models, which have been tried in various parts of India. I submit the following points for members' consideration:

It is my experience that there is no single model that can be universally applicable in a country like India with its diverse soil, rainfall and ecological conditions. Thus, every technical design must be adapted to local climatic and soil-water conditions. Thus, Plug-flow tunnel digesters that work so well in the sub-tropical climate in south India will definitely not work in the cold climates of Himalayas.

Models tried by me
I list below three types of biogas digester models on which I have worked and my experience with the same:

2.1. Floating Dome Type

I have seen this digester type being used quite extensively in Gujarat and Maharashtra.
Positives

- Quite robust in use. Easy to construct, use and repair.
- Allows user to increase gas pressure by loading the floating dome with weight.

Negatives

- The dome, generally of Mild Steel or Fibre Reinforced Plastic, generally develops leaks, which are difficult to identify and repair.
- In case gas production is high, leakages of gas take place from the side ring, where the dome rests.

2.2. Plug flow type tunnel digester

This digester was developed and used in Bhagavatula Charitable Trust, Vishakhapatnam.

Positives

- Very easy to set up as it consists of a Polypropylene tube that is sealed from both ends and inlet and outlet consisting of P trap and S trap.
- Very low cost – 1 cubic metre unit cost about Rs. 2000/- in 1990.
- Allows user to store biogas in "carry-away" HDPE sacks to make tea or heat food at farms.
- Inoculant consisting of bacteria culture developed to increase gas production.
- Could be used for batch processing (I used it for producing gas from mangrove leaves) or daily processing (daily cow dung based).

Negatives

- The digester had to be protected from cuts from below – a platform of bricks was prepared.
- The digester also had to be protected from dogs or other animals, who liked to sleep on it as it was soft and warm.

2.3. Deenbandhu model
I cite experience on these in Uttaranchal.

Positives

- Underground construction, so did not occupy open space, an important consideration in mountains.
- Not easily affected by temperature variations in the mountains, again as it is underground.
- Biogas availability a major input for drudgery reduction of women, especially in mountains.

Negatives

- Initial investment high and construction required trained masons.
- In extreme winters, dung had to be inputted with hot water, to ensure minimum gas production.

Arunabha Majumder, All India Institute of Hygiene of Public Health, Kolkata

My comments on Biogas Plants:

1. Biogas Plant should be designed for composite waste digestion, in rural areas.

2. Composite waste may be Vegetable waste of village market (Hat), animal excreta, water hyacinth, human excreta (Latrine connection) and household garbage, agricultural waste etc.

3. Two cubic metre of biogas is required per family per day for cooking.

4. Temperature of the digester is very important for bio gas generation. Higher temperature is preferred.

5. Volatile acid need to be monitored. It must be at optimum range. Performance of methane forming bacteria is a key factor for a digester.

6. Presence of sulphate in the feed of the digester should be minimum.

7. Since latrine connection has been considered with the digester, issue of social acceptability may play an important role.

8. Ratio of Methane and Carbon dioxide production need to be monitored.

Sheldon Mendonca, WOTR, Ahmednagar

I thank Digbijoy for his informative mail regarding the use of biogas for the purpose of electricity generation. We have been looking at the possibility of using small dual fuel engines to generate electricity for individual households. So far we have not been able to find a viable model.

We too believe that social acceptability is better when used for electricity generation. Thank you again.

M. S. Gupta, Sarvangeen Vikas Samiti, Gorakhpur, Uttar Pradesh *(response abstract, full response)*

Please find herewith a document (http://www.solutionexchange-un.net.in/environment/cr/res14070601.doc) giving detailed responses to the query on biogas.

The comments pertain to:

1. Comparative analysis of Deenbandhu and KVIC models.
2. Criteria for selection of digester.
3. Quantity of dung required.
4. Consumption of gas.

Members may get in touch with us for any further clarifications.

R. Santhanam, Indian Society of Agribusiness Professionals (ISAP), New Delhi

I would like to share with you the findings of my "research" from secondary sources on the responses received so far.

It has been suggested to use composite wastes
However continuous smooth functioning of a digester with heterogeneous wastes could present difficulties, since methane forming bacteria may not be equally efficient when non homogeneous substrates are used. TERI has done some research and developed an acid leaching technology of such wastes. The liquid leacheate is then used for methane generation. However such processes tend to make the process more and more complicated and process efficiencies and costs are questionable. Composite wastes are better stabilised with other appropriate technologies and used as compost.

Use of Biogas
In USA they are using micro turbines to run off landfill methane gas which may be of poor quality with low levels of methane and having corrosive H_2S also. Where the gas supply is stable, such facilities enable revenue generation. Dairies generate methane gas from cattle dung, which they use to generate electricity for sale. However they require heavy subsidisation, since micro turbines, although commercially available, require heavy capital investments, which in USA are mostly coming from Government subsidies.

Improving the calorific value of Bio gas
One technique for gas scrubbing uses simple chemical means to remove H2s. This is required to ensure that IC gas engines are not corroded by sulphate formation.

In another technique used for reducing CO_2 content, bio gas from the digester is bubbled through saline brackish water in glass covered tanks. The tanks are exposed to sunlight and have useful algae like spirulina blue green algae (a high quality protein) growing in them. The bubbling of the gas stirs up the microscopic plants, helping improve the overall algae production by bringing up bottom layers of the algae to the surface, where greater solar radiation is available. The CO_2 gets absorbed in photo synthesis of the algae, improving algae yield. The gas output from the algae tank would therefore has reduced CO2 levels and improved calorific value, due to higher ratio of methane gas. Hence a useful by product, gets manufactured with simple steps and overall better process efficiency.

Additional Material

M. S. Gupta, Sarvangeen Vikas Samiti, Gorakhpur, Uttar Pradesh *(full response)*

Refer to your E-mail dated 28.06.06 which we have received from Sri P.S. Sodhi, N.C. SGP, seeking some clarification regarding use of biogas plants to solve the energy problem. In this reference we are sending herewith point wise clarification regarding selection of size & model of biogas economically suitable for a particular family.

Model:

There are mainly two types of biogas model namely KVIC type & Deenbandhu Model which are more common and rural area. depending upon various factor and prevailing situation of concerned beneficiaries. The details of comparative suitability is being presented herewith for your kind reference.

S.No.	KVIC Types	Deenbandhu Model
1.	This is floating gas holder type.	This is fixed dome type masonry structure.
2.	It is made above the ground level.	It is under ground masonry structure.
3.	Space above ground is used for fitting of movable drum.	The space above ground can be used other beneficial purpose.
4.	Initial investment is low.	Initial investment is high.
5.	It requires some cost of maintenance to maintain the steel structure.	No. cost of maintenance.
6.	Effect of low temperature during winter is more.	Effect of low temperature is less.
7.	Gas is always produced at constant pressure.	Gas pressure is variable.
8.	Required less excavation.	Required more excavation comparatively.
9.	Any skilled mason can construct the plant.	It requires specially trained mason to construct the plant.
10.	Well suitable for plain as well as for hilly areas where temperature variation goes to very low level.	Suitable for plain area.
11.	Suitable for Rocky area also.	It is not suitable for Rocky and hard soil area.

Based on above comparison one can select the appropriate model of the biogas, keeping other requirement necessary for its installation. How ever for your Ahmednagar area the both model will be suitable for the rural community if the ground condition is not very hard and rocky. The cost estimate varies from Rs. 7000 to 9000 for KVIC of 2 M^3 capacity while for Deenbandhu model it varies from Rs. 8500 to Rs. 11000 of 2 M^3 plant capacity.

The cost may range even low or higher depending upon the local prevailing cost of the construction material in the surrounding area.

For selection of size following aspects should be considered by a particular family.

A. Availability of Dung :

The potential gas production from the available feedstock can be calculated from the table given below.

Potential gas production from different feed stocks

Type of Feedstock	Gas yield/kg (m^3)	Normal manure availability per animal per day (kg)	Gas yield per day (m^3)
Dung :			
Cattle	0.036	10	0.36
Buffalo	0.036	15	0.54
Pig (approx 50 kg)	0.078	2.25	0.18
Chicken (approx 2 kg)	0.062	0.18	0.011
Human excreta (Adult)	0.070	0.4	0.028

The Quantity of cattle dung required for feeding of different sizes of biogas units can be calculated from the table given below.

Quantity of cattle dung required for feeding of different sizes of biogas units

Size of plant (m^3)	Amount of wet dung required daily (kg)	Approximate number of adult cattle heads
1	25	2
2	50	4
3	75	6
4	100	8
6	150	12
8	200	16
10	250	20
15	375	30
20	500	40

In order to decide a suitable size for a biogas unit actual availability of cattle dung should be assessed. Factors such as type and size of cattle quantity of feed given and time period for which cattle are stable-bound, etc, should be considered to determine the daily availability of dung. Two calves maybe taken as equal to one adult for arriving at the number of cattle heads.

Consumption of Biogas

The requirement of biogas for different purposes is being presented here bellow.

Quantities of biogas consumed for different application

Use	Specification	Quantity of gas consumed (m^3/hr)

Cooking	2" burner	0.33
	4" burner	0.47
	6" burner	0.64
	per person per day	0.24 m^3/day
Gas lighting mantle lamp of	100 Candle Power	0.13
Duel fuel engine	75-80% replacement of diesel oil per B.H.P.	0.50
Electricity	1 kWh	0.21

Example : Appropriate size of a plant for a family of six members owning two cows, one buffalo and two calves can be worked out as under : (The availability of dung should be assessed exactly).

Suppose : 2 cows give 20 kg dung daily.
1 bufaflo gives 25 kg dung daily.
2 calves give 10 kg dung daily.

Then, the total dung available is 55 kg.

* Consumption of gas is worked out from above Table as follow :
* Cooking for 6 persons daily requires 1.44 m^3 gas.
* One lamp for 2 hours daily requires 0.26 m^3 gas.
* Total consumption of gas = 1.70 m^3

As the average requirement of gas daily is only 1.70 m^3 and the quantity of available dung is 55 kg, it is seen from above table that an appropriate size will be of 2 m^3 biogas plant.

Conclusion :

The capacity of a biogas unit suitable for a family should be determined by matching the daily availability of dung and the estimated consumption of gas. In case the requirement of gas is more than the gas which can be produced from the available quantity of dung, then the selection of size should depend only on the quantity of dung. This means that over-size plants should not be set up as the plant would remain underutilised.

Maintenance and Care of Biogas Plant

The Deenbandhu plant is simple to operate and handle as far as the beneficiaries are concerned. The following simple guidelines for general care and maintenance will increase the operational life and working efficiency of the Deenbandhu plant several-folds.

- The gate valve should be opened only when the gas has to be actually used.
- Before opening the valves, one must ensure that tall the preparation for cooking have been made. This would avoid the unnecessary, wasteful consumption of gas.
- The air injector should not be closed very tightly on the side of the burner. The inflow of the air should be adjusted properly in the injector.
- The outlet tank of the plant should never be left uncovered. In addition to the above, the daily, weekly, monthly, yearly and five yearly care and maintenance should be done as per the schedule given below.

Daily

- Add the recommended quantity of raw material.
- Use proper slurry mixture.
- Use clean feedstock, free from soil, straw, etc.
- Clean the mixing tank before and after use.

Weekly

- Use a long bamboo pole for stirring the slurry through the outlet tank.
- Clean gas burners and other appliances.
- Open the tap of the manual moisture trap to drain off moisture condensed in the pipeline.
- The nozzle of the biogas lamps should be properly cleaned.

Monthly

- Remove digested slurry from the slurry collection tank to the compost pit.
- If compost pits are provided next to the outlet tank, then check the level of slurry in it. If filled, divert the slurry to the next compost pit.
- Check gate valve, gas outlet pipe and gas pipes fittings for leakage.
- Check the pipe of the moisture trap (water removal system) for any possible leakage.

Annually

- Check for gas and water leaks from pipe and appliances.
- Repair the worn-out accessories.
- Replace damaged or non-working accessories. Open the gate valve and remove all the gas from the plant. After this, check the level of slurry in the outlet chamber. If the slurry level is above the second step counted from the bottom in the outlet chamber, (i.e. above the initial slurry level), remove it up to the second step.

Five Yearly

- Empty the plant and clean the sludge and in organic material from the bottom of the plant.
- Give a through check to the entire gas distribution system for possible leakage.
- Repaint the ceiling of the dome and gas storage chamber with black enamel paint.
- Recharge (reload) the plant with fresh slurry.

Do's and Dont's

Do's

- Select the size of the biogas plant depending on the quantity of dung available with the beneficiaries.
- Install the biogas plant at a place near the kitchen as well as the cattle shed as far as possible.
- Ensure that the plant is installed in an open space, and gets plenty of sunlight for the whole day, all round the year.
- Feed the biogas plant with cattle dung and water mixture in the right proportion-add 1 part of cattle dung to 1 part of water by weight to make a homogeneous mixture.
- Ensure that the slurry (mixture of dung and water) is free from soil, straw, etc.
- For efficient cooking, use good quality and approved burners and gas lamps.
- Open the gas regulator cock only at the time of its actual use.
- Adjust the flame by turning the air regulator till a blue flame is obtained-this will give maximum heat.
- Light the match first before opening the gas cock.
- Cover the top of the inlet and outlet tank opening with wooden, stone or RCC cover, to avoid accidental falling of cattle and children.
- Purge air from all delivery lines allowing gas to flow for a while prior to first use.

Dont's

- Do not install a bigger size of biogas plant if you don't have sufficient cattle dung or any other feed-stock to be used for gas production.

- Do not install the gas plant at a long distance from the point of gas utilization to save the cost of pipeline.
- Do not install the plant under a tree, inside the house or under shade.
- Do not compact soil loosely around the plant; otherwise it may get damaged.
- Do not add more than the required quantity of either dung or water -- doing so might affect the efficient production of gas.
- Do not allow soil or sand particles to enter into the digester.
- Do not allow the scum to form in the digester; otherwise the production of gas might stop.
- Do not burn the gas directly, i.e. from the gas outlet pipe even for the testing purpose as it can be dangerous.
- Do not use burner in the open; otherwise there will be considerable loss of heat.
- Do not leave the gas regulator (valve) open when the gas is not in use.
- Do not use the gas if the flame is yellow. Adjust the flame by the air regulator till it is blue in colour.
- Do not let any water accumulate in the gas pipeline; otherwise the required pressure of gas will not be maintained and the flame will sputter.
- Do not make digested slurry pit more than 1.0 m (3 ft) deep.
- Do not inhale the biogas as it may be hazardous.

Do not hurry to get gas after initial loading of slurry, as it may take 10-25 days for gas production in freshly loaded plants. No foreign material should be added.

Many thanks to all who contributed to this query!

If you have further information to share on this topic, please send it to Solution Exchange for WES-Net at se-wes@solutionexchange-un.net.in with the subject heading "Re: [se-wes] Query: Comparative Analysis of Biogas Digester Models, from WOTR, Ahmednagar (Experiences, Examples). Additional Response."