Different Domestic Bio Gas Plant Prevailing in India

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Abstract

"Waste is becoming a great danger to our planet. Every country in the world is facing a great problem in disposing waste which is generated from different ways or by day to lifestyle, industries, livelihoods, houses, restaurants, hotels and many other types of activities."[1] Every country whether is developed / developing / under developed are working on the different ways of treating the waste but the best way to prevent the hills of waste is to treat the waste at the source itself. The waste can comprise of solid / liquid / gas, but the common classified as bio degradable and non-bio degradable waste. The bio degradable waste is very easy to treat and be converted in the usable substances, as compared with non-bio degradable waste. In India many laws are formed to treat the waste, segregation type, classification. Indian "Government says that before disposing the waste, the waste should be segregated in two main forms i.e. bio degradable waste (Green waste / Wet waste) and non-bio degradable waste (Dry Waste). The Green waste can be treated in two main ways i.e. by Methane or Composting (Organic Manure). In this case study we have study the different types of Composition techniques prevailing in Indian market, to get the best results depending on the waste generated per day by different sources."[1]

KEYWORD: Domestic Bio Gas Plant, Bio Gas, Compost, Bio Gas Plant, Portable Bio Gas plant, Bio degradable waste

Introduction

The waste generally categorized as bio degradable waste and non bio degradable waste, in this research we are finding and discussing on the different models of bio digester that can be used in household, whether they are to be used in a rural area or in urban area of the country. First step in treating of the waste or reducing it, is the segregation of the waste at the source, Waste treatment initially starts at the source by selecting what to be treated and how to be treated. Means if we discuss the waste from the house / residential apartments / mess / residential duelling the waste will consist of :

1. Food waste also known a bio degradable waste.
2. Metal waste (like iron, brass, etc).

3. Plastic waste (like PVC, packing material, Nylons, etc).
4. Paper / cardboard waste.
5. Foil / food wrapping waste.
6. Medical waste / sanitary pad waste.
7. Glass waste.
8. Cloth waste.
9. Sanitary waste/ waste water, etc.

Figure 1- Non Bio Degradable waste

Figure 2- Bio Degradable Waste

Treating more waste is easy and possible when the waste is been segregated at the local level or at the residential level. If we are segregating the waste at local level, the effective why to practise is to treat the bio degradable waste at the time of the segregation. It is best to treat the bio degradable waste at the local level/ residence/ house/ living space. And selling / hand over the non bio degradable waste, to the recyclers near to your approach or to the collectors or the waste pickers so that they can move the waste to the proper recyclers.

Treating of the Bio Degradable Waste generates two main products which is very useful in general or day to day life, and will also help in saving energy. This practise / process will decrease the waste quantity completely, the products from waste are:-

1. **Bio gas** – is a burnable gas with a calorific value of 4500 to 4713 kcal/m3.
2. **Compost** – is a good manure / soil conditioner enriched in NPK.

Bio gas

The history of bio gas plant is very old almost 19th century, and if we study the history we find as the years passed there is a drastic increase in the use of the family size bio gas plants, in the rural areas of the many countries. The bio gas plant are been used in the many country among which China and India are the top most country. Since 1990 many initiative have been taken by the Indian government to implant more and more of the bio gas plant in the rural area of the country by providing subsidy, spreading awareness, technical assistance and many more. But the bio gas plant in those days were only working on the cow dung as their raw material, this restricted the use of the bio gas plant in the urban area. As people presume that a bio gas plant only runs on the cow dung. Only the cow dung or animal dung can produce bio gas.

Constituents of Biogas

- Methane (50-65%)
- Carbon dioxide (30-40%)
- Hydrogen (1-5%)
- Nitrogen (1%)
- Hydrogen Sulphide (0.1%)
- Oxygen (0.1%)
- Water Vapours (0.1%)

Figure 3 – Constituents of Bio Gas

As the time passes and the researchers worked on the bio gas, they come to know that all the bio degradable material produces bio gas, but the production quantity/ yield of the bio gas varies depending on the waste. As described in the table - 1 below:

Substrate	Substrate classification	Dry matter (%)	Biogas yield
Agricultural residues	Rice straw	91	0.55 – 0.62 m^3 kg TS^{-1}
	Wheat straw	91	0.188 m^3 kg VS^{-1}
	Maize straw	86	0.4 – 1 m^3 kg TS^{-1}
	Grass	88	0.28 – 0.55 m^3 kg VS^{-1}
	Coffee pulp	28	0.3 – 0.45 m^3 kg VS^{-1}
	Corn stalk	80	0.35 – 0.48 m^3 kg TS^{-1}
Manure	Cow	38	0.6 – 0.8 m^3 kg TS^{-1}
	Pig	20 – 25	0.27- 0.45 m^3 kg TS^{-1}
	Poultry	89	0.3 – 0.8 m^3 kg TS^{-1}
	Horse	28	0.4 – 0.6 m^3 kg TS^{-1}
Food waste	Vegetable waste	5 –25	0.4 m^3 kg TS^{-1}
	Egg waste	25	0.97 m^3 kg TS^{-1}
	Cereals	85 - 90	0.4 – 0.9 m^3 kg TS^{-1}

Table 1 – Different Material with Bio Gas Production/ Yield

"The economic development of a developing country Like India largely depends on the rural areas. Fuel is considered to be an important instrument for everybody not in urban areas but also in rural areas of the country, like for cooking, for burning, for lighting, for transportation and in many other uses."[2]

In this research paper we had tried to resolve and elaborate details of successful family size bio gas plant that can be used in rural as well in urban area to treat the bio degradable waste into useful bio gas & Manure. Now a days as researches are going on alternative source of energies the bio gas plant is also became a hot research topic. The Family size bio gas plant are small plants, starts from 1 cumtr to 10 cumtr (daily production of bio gas, generally). The selection of bio gas plant depends on following factors or points:

Components of a biogas plant

A biogas plant consists of the following parts:

i) Foundation

ii) Digester

iii) Gas holder or gas storage masonry dome

iv) Mixing tank

v) Inlet chamber/pipe

vi) Outlet chamber/pipe

vii) Gas outlet, pipe, gate valve, gas distribution pipeline, water trap, fittings, gas stove, lamp and similar appliances which can run on biogas.

Figure 4 – Components of Bio Gas Plant

1. **Type of bio degradable waste to be treated** – It is very important to first initialize the raw material (also termed as feed / bio degradable waste / bio mass) for the bio gas plant, i.e. whether the plant feed is cow dung / food waste / husk / any other bio degradable material. As each material has different digestion time period or the time taken to complete digestion is different for different material, i.e. this will effect or calculate the size of the digester / reactor. The time period for which the feed is to be kept in the reactor is HRT or "**Hydraulic retention time (HRT)** is defined as the average time interval over which the substrate is kept inside the digester."[3]

To Understand HRT we will take an example:

i. 25 kg of cow dung produces 1 cumtr of bio gas.

ii. To make the slurry to input in the digester

a. 25 kg of cow dung is mixed with 25 ltr of water = 50 ltr of slurry

iii. Retention time taken for the cow dung is 40 days,

iv. The size of the digester / reactor = 40 days x 50 ltr
= 2000 ltr

v. The size of the gas holder = 0.5 cumtr (single time)
= 1.0 cumtr (in 24 hrs)

2. Quantity of the bio degradable waste – it another important factor effecting the size of the plant and also the type of the plant.
3. Availability of the space.
4. Distance of the burner from the digester

Different types of Family size Bio gas plant

1. Fixed Dome bio gas plant –

a. **Deenbandhu Model** – This model was created in 1984 by AFPRO (Action for Food Production, New Delhi). Deenbandhu means friend for poors. The plant intake is mainly the animal waste and generally used in the village.

- Constructed below the ground.
- Requires skilled labour for civil construction.
- Construction on the site only.
- General size if 1 cumtr to 6 cumtr.
- Life span is 15 to 20 years.
- Cheapest model in civil construction.
- Approved for grants from central government as well as state government.
- Pressure of bio gas flow is low and comes from the top of the dome.
- HRT taken for design is 40 days (generally).
- No string option/scum removal option is not available
- Not practical/feasible to install in urban areas due to lack of space and underground construction.

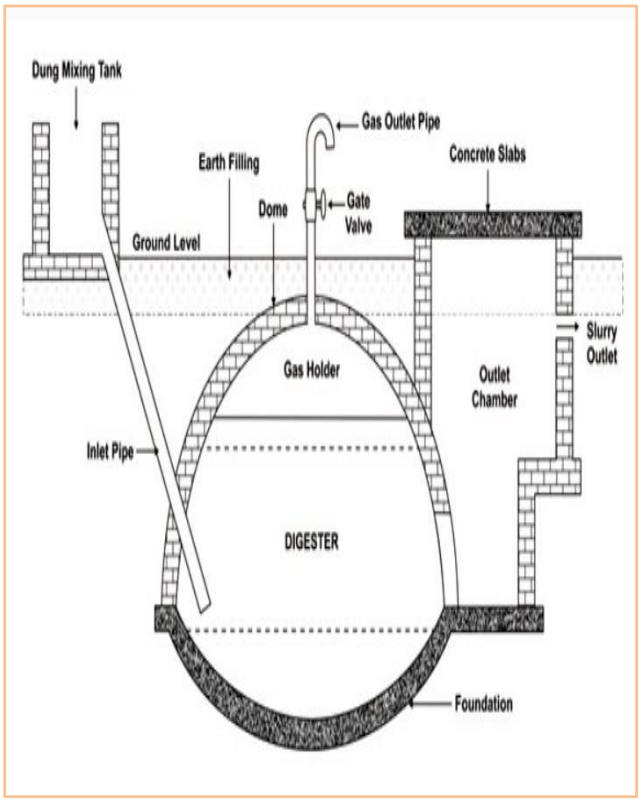


Figure 3 -- Site pick of Deendanbhu Model

Figure 4 - Sketch of a Deenbandhu model

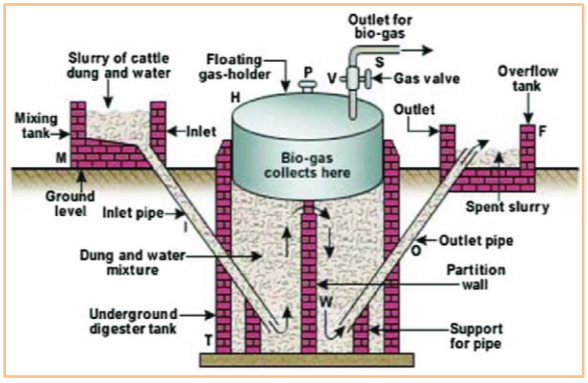
2. Floating Dome bio gas plant

a **KVIC Model** – The KVIC full form is Khadi Village & Industrial Commission plant and was standardised in 1962 and since then it was in very common use till know. This plant is having a underground well shaped digester / reactor with a buffer wall in its centre. A inlet and out let pipe is connected at the bottom of the digester with the top of the pipes connect with the inlet system and other pipe is connected with the outlet system. The gas holder is made of mild steel and is placed inverted on the digester supported by a centre pipe guiding as well as holding the gas holder. The gap between the gas holder and the digester is protected by a water jacket (plays an important role to capture the bio gas inside the floating dome). The weight of the floating drum creates a pressure on the outcoming gas in the supply line, as shown in the fig 7.

Sr. No.	KVIC
1.	The digester of this plant is a deep well shaped masonry structure. In plants of above $3m^3$ capacity a partition wall is provided in middle of the digester.
2.	Gas holder is generally made of mild steel. It is inverted into the digester and goes up and down with formation and utilization of gas.
3.	The gas is available at a constant pressure of about 10 cm of water column.
4.	Inlet and outlet connections are provided through A.C pipes
5.	Gas storage capacity of the plant is governed by the volume of gas holder and is 50% of gas produced per day.
6.	The floating mild steel gas holder needs regular care and maintenance to prevent the gas holder from getting worn out because of corrosion. It also has short life span.
7.	Installation cost is very high.
8.	Digester can be constructed locally but the gasholder needs sophisticated workshop facilities.

- Constructed below the ground, well shape.
- No skilled labour required for civil construction.
- Construction on the site only, including civil construction and Mild Steel floating dome (by fabricating Angles, MS plate 3mm, with one opening, gas valves, gas pipe)
- Domestic size of 1 cumtr to 6 cumtr, can be constructed up to 500 cumtr or more.
- Life span is 20 to 25 years.

- Costlier model due to MS welded dome, digging and making of digester as compared with other type of bio gas plants.
- Pressure of bio gas flow is high due to self-weight of the dome and also remain constant, no electricity is required for boosting the gas pressure.
- HRT taken for design is 40 days (generally).
- Scum removal is easy as the floating dome can be rotated clockwise and anticlockwise manually (when filled with bio gas / when the dome is up).
- Approved for grants from central government as well as state government.
- Feasible to install in urban areas also as space required is less.



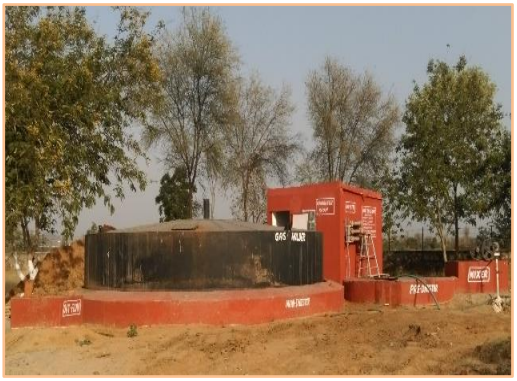


Figure 7-- Floating dome / KVIC model

Figure 8-- Site view of SNRE KVIC model- 120 cum*t*

b. FRP Model – This model is based on the KVIC pattern i.e. having floating dome design of bio gas, due to time consumption and hard to manage the labour for construction of KVIC on the site. SNRE & many other companies has created a prefabricated bio gas model by using FRP as the manufacturing material, also for the commercialisation of the bio gas plant on a larger scale. The Fibre Reinforced Plastic based bio gas plant are light in weight and can easily shifted from one place to another without involving skilled labour, also at no extra cost. The FRP based are easy to install and low cost as compare with the civil construction plants.

- These plants have good architecture view, and that why can be used in urban areas.
- No skill labour is required, self installation can be done.
- Ready to use, after placing one can start feeding the waste in the digester.
- Fast fermentation, as no time is spent in construction.
- Low feed is required.

- General size easily available starts from 0.5 cumtr to 6 cumtr.
- Life span is 10 to 15 years.
- Low cost as compared with civil plants.
- Can be install above the ground or by digging the pit.
- Cow dung or food waste can be used as the raw material.
- The digester size varies with the raw material for fermentation.
- Some plants have spring on the top to pressure the flow of bio gas for cooking, pressure can also increase by use of booster pumps as required.
- Thickness of the digester wall is 5 mm to 10 mm.
- Different models available depending on the Cow dung and Food waste.
- Also approved for grants from central government as well as state government.

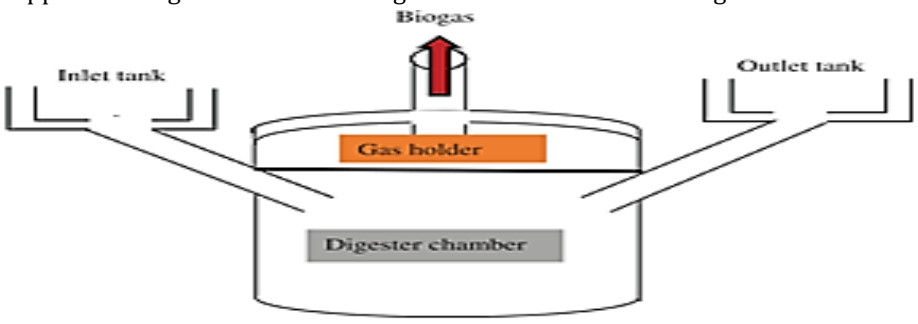


Figure 9 – Diagram of Domestic Bio Gas Plant

Figure 10 - SNRE, FRP Bio gas plant

Figure 11 - Syntex, Floating bio gas plant

c. **Metal Model –** This model is based on the KVIC pattern i.e. having floating dome design of bio gas, due to time consumption and hard to manage the labour for construction of KVIC on the site. SNRE & many other companies has created a prefabricated bio gas model by using Metal (MS sheet, with light weight MS angles) as the manufacturing material. The Metal based bio gas plant are heavy in weight as compared with FRP but can easily shifted from one place to another without involving labour, also at no extra cost. The metal-based bio gas plant are more durable as compared with FRP based but they are much costlier as compared with FRP based. To prevent the metal from corrosion the Metal plants are been coated with 0.5 mm of FRP / epoxy paints. SNRE & some of the companies are now a days making stainless steel bio gas plant to overcome with the corrosive nature of the waste and the slurry but these plants are very costly but good looking.

- Same as FRP these plants can be placed above the ground or below the ground.
- These plants do not have baffer wall in between.
- The inlet and out let pipes are been 6" to 9" raised from the bottom of the digester.
- General size easily available starts from 0.5 cumtr to 6 cumtr.
- Life span is 20 to 25 years.
- Metal does not get effected with atmosphere, but due to metal some times the temperature inside the digester varies a lot (colder in winters and hotter in summers – temperature may vary from 5°C to 50°C, need to care of the temperature)
- Architecture good looking.
- The plant is connected with the PVC outlet and inlet pipes with PVC inlet system, the flowing dome is been pivoted with in the centre MS hollow pipe with Epoxy coating.
- The main advantage is that the plant is leakage proof, if it exists it is easy to repair by use of epoxy or the grouts or simply by M-seal.
- To increase the pressure of the bio gas the weights can be placed on the top of the floating dome as shown in the fig – 11. Or we can also use the boosters to increase the pressure of the bio gas for cooking purpose.

Figure 12 - SNRE, Metal domestic plant

Figure 13 - SNRE, Metal bio gas plant - 60 cumtr capacity

3. Flexible bio gas plant

Now a days as more awareness is there in the society and the willingness of treating the waste or the increasing price of the LPG and fossil fuel. Rural as well as the urban population of the country are finding cheaper ways / technology of bio gas plants and that's why more and more of the population are using flexi balloon-based bio gas plants, as these bio gas plants are far cheaper as compared with other types of bio gas plants, easy in transportation, low-cost transportation, based on DIY (Do It Yourself) technologies.

The balloon called bio gas plant is very simple in nature i.e. it is a single unit is acting as the digester as well as the gas holder. Flexible / balloon type bio gas plant is some what works on the basis of Deenbandhu bio gas model.

The characteristic of balloon material must be resistance to the corrosion of the waste material that will be present in the digester portion of the balloon also the base of the balloon that will in contact with the surface of the soil or the platform where the balloon will lay / rest. The balloon must also be rodent, insects, and other insect retardant. The detoration of the balloon material will be very harmful as this may reduce the life of the balloon material, leakage may be there.

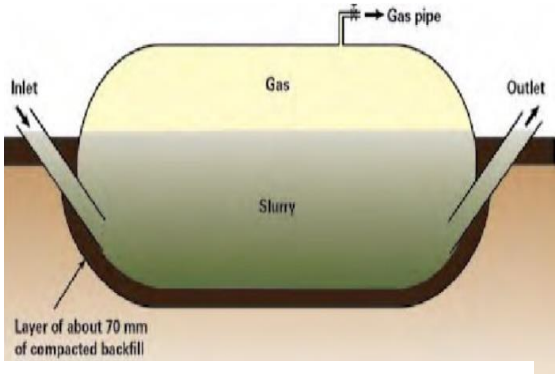


Figure 14- Balloon bio gas plant details

The material of the Balloon must be at least 1000 to 1200 GSM and it must be fibre reinforced. The inlet and outlet of the plant is been connected with the PVC pipe of 2" to 5" dia as per the size of the balloon. The gas out let pipe is at the top of the balloon with brass / PVC fitting with the valve fitted at the top. The main point to remember is that the bio gas cannot travel easily from the balloon so booster is to the installed to take the bio gas from the balloon.

The pasting of the balloon must be with good sealent / heat welding / laser welding, as the balloon once filled with bio degradable waste in its half of the portion. The waste will exert a pressure from inside that is very high and to resist that pressure the joints of the balloon must be properly welded/ pasted. The pasting material must be acid proof as the digester will have sulfuric formation inside it. The inlet and outlet and the gas nozzle must be leak proof at the point of contact with the balloon.

There are different ways to use the balloon as bio gas plants, cylindrical shape balloon, sphere shape balloon, cubic shape balloon, cuboid shape balloon.

Figure 15 - Different shapes of Balloon for bio gas plant

Here we have used some of balloon based bio gas plants for study, the data have been collected and availed for the study some of them have been studies by us and discussed here.

a. Balloon base under the ground –

- This balloon bio gas was installed at the farm of Rupesh Yadav, Sirsi Road, Jaipur, Rajasthan, feed on Cow dung
- The capacity of the balloon is 10,000 ltr = 10 cumtr
- The balloon having 80% of the waste and 20% of bio gas, i.e. 100 kg of cow dung daily producing 4 cumtr of bio gas
- 100 kg of cow dung + 100 ltr. of water = 200 ltr daily
- HRT = 40 days => 200 x 40 = 8000 ltr. cap of digester
- Bio gas produced per day = 4 cumtr.
- Balloon size left for bio gas = 10000 ltr. – 8000 ltr.

  = 2000 ltr. = 2cumtr.
- Daily he use the bio gas 2cumtr + 2 cumtr = 4 cumtr
- So the total balloon capacity

= 8000 ltr digester + 2 cumtr of bio gas

= 8000 ltr digester + 2000 ltr bio gas = 10000 ltr balloon capacity.

- The bio gas is used in the cooking of the family food as well as the making cattle feed, the booster is attached with the balloon.

Figure 16- SNRE Balloon Bio Gas Plant

b. <u>Balloon base over the ground</u> –

- This balloon bio gas was installed at the residence of Ram Dev Saini, Sanganer, Jaipur, Rajasthan, feed on Food waste
- The capacity of the balloon is 3000 ltr = 3 cumtr
- The balloon having 90% of the waste and 10% of bio gas, i.e. 10 kg of food waste daily producing 1 cumtr of bio gas.
- 10 kg of food waste + 10 ltr. of water = 100 ltr daily
- HRT = 25 days => 100 x 25 = 2500 ltr. cap of digester

- Bio gas produced per day = 1 cumtr.
- Balloon size left for bio gas = 3000 ltr. – 2500 ltr.
  = 500 ltr. = 0.5cumtr.
- Daily he use the bio gas 0.5 + 0.5 = 1 cumtr
- So the total balloon capacity
  = 2500 ltr digester + 0.5 cumtr of bio gas
  = 2500 ltr digester + 500 ltr bio gas = 3000 ltr balloon capacity.
- The bio gas is used in the cooking of the family food, the booster is attached with the balloon and the gas is travelled to 3rd floor.

Figure 18 – Different types of balloon Bio Gas Plant- with different methods/ styles of placement & usage

MNRE approval & guidelines of family type / portable Bio gas Plants & their approval

6. MODELS OF BIOGAS PLANTS AND APPLIANCES

6.1 Approved Models of Family Type Biogas Plants/ Small Biogas Plants

Appropriate size and models of biogas plants would be selected on the basis of preference / choice of the beneficiaries and shall be installed keeping in view the technical requirements such as location, distance between kitchen and cattle-shed, availability of water and main feed-stock cattle dung and other biodegradable organic biomass wastes and sanitary toilets. Approved models for such plants are available from 1 to 25 M^3 capacities for fixed dome design and floating Gas holder KVIC design models of plants. In addition, the Ferro-cement and Brick-masonry biogas plants, prefabricated models of Deenbandhu biogas plants made of High Density Polyethelene (HDPE) and KVIC Model and Deenbandhu Model of plants made of Fiber-glass Reinforced Plastic (FRP) and Reinforced Cement Concrete (RCC) material based approved biogas plants would be covered under the scheme. **Only the MNRE approved specifications / ISI marked models of biogas plants as approved by BIS will be eligible for CFA under NNBOMP.**

The MNRE approved models of biogas plants are available for 1 M^3 to 25 M^3 per day capacities for fixed dome design and floating Gasholder KVIC design type biogas plants. The commonly used and approved models of biogas plants are as given under:-

Sl. No.	Biogas Plant Models*	Specifications/ Ministry's letter Nos .and date and date of approval.
1.	**Fixed Dome / Gasholder Biogas Plants:** (i) Deenbandhu fixed dome model with brick masonry construction. (ii) Deenbandhu ferro-cement model with in-situ technique. (iii) Prefabricated RCC fixed dome model. (iv) Solid-state Deenbandhu Fixed Dome	-Ministry's letter No.13-10/96-BG dated 10-1-2002. -Code of Practices (Second Revision), IS 9478:1989 of the BIS, New Delhi. -Ministry's letter No.13-11/99-BG dated 5-3-1999 -Ministry's O.M.No.13-5/2016-BG(NBMMP) , Dated 07.11.2016

2.	**Floating Dome Design Biogas Plants:** (i) KVIC floating steel metal Gasholder with brick masonry digester. (ii) KVIC floating Gasholder type plant with Ferro- Cement digester. (iii) KVIC design Biogas Plant with Fibre Glass Reinforced Plasic (FRP) and Digester. (iv) Pragati Model Biogas Plants. (v) KVIC design type digester with floating Gasholder, made up of HDPE/PVC/ FRP/RCC etc. material plant	-Code of Practices (Second Revision), IS 9478:1989 of the BIS, New Delhi. -Code of practice IS-12986:1990 of BIS, New Delhi. Specifications of FRP Gasholder should be as per IS-12986:1990 -Code of Practices (Second Revision), IS 9478:1989 of the BIS, New Delhi. -MNRE O.M.No.18-1/2014-BE(NBMMP) Dated 26.11.2014
3.	**Prefabricated model Biogas Plants:** (i) Prefabricated Reinforced Cement Concrete (RCC) digester with KVIC floating drum/ gasholder.	-Ministry's O.M.No.18-1/2014 BE (NBMMP), Dated 26.11.2014
4.	**Bag Type Biogas Plants (Flexi model)**	Ministry's letter No.7-39/89-BG dated 14.7.95

6.2 In addition to above the plants of KVIC design only in the size range of 1 cubic meter to 25 cubic meter implemented in the field on large scale basis earlier would be eligible under the new scheme NNBOMP.

6.3 Innovative, cost effective and high efficiency new designs models of biogas plants will continue to be added following MNRE approval procedure/ policy for approval of new design / material based biogas plants. The approval of such new designs of biogas plants would be based on the design based on specific feedstock(s) and combinations of Organic Wastes/ feed-stocks, the innovations, technology development, their field evaluations and worthiness brought out through laboratory / pilot field trials/ demonstrations & verifications as well as satisfaction and acceptance of the same by the potential beneficiaries of biogas plants in the country.

Suggestion and Recommendations

The suggestions given by the researcher based on the present study are given below:

- The best way to overcome the problem of organic waste is to treat the waste at the source and the best out of the waste.
- The user must first study the characteristic of his waste from which he wants to generate the fuel for his use. Also he must check with the finance involved and the calculation of the ROI.

- The residents, urban or rural can select the domestic/ portable bio gas plant as per their bio degradable waste.
- The Government and NGO's should also help in spreading the awareness of treating the organic waste.
- The Ngo's and Government bodies to come forward and educate for the techniques of composting.
- Ngo's and Government bodies to fund or provide subsidy on the portable bio gas plants.
- Ngo's, CSR's and Government bodies to provide portable bio gas plants in the rural areas and this will help in overcoming the cooking fuel problem.
- There should be meeting to educate the Residential and society to maintain the bio gas plants.
- There should be the provision of loan by banks for the purchaser of the bio gas plant, on a subsidies rate of interest.

Conclusion

This study on the different types of portable bio gas plant available in India or one can after studying this can select the bio gas plant to treat his or her bio degradable waste at the source itself, that will not only reduce the waste of the surrounding, but also it will help the environment by preventing the emission of the CO_2. Also in reducing the use of the fossil fuel. This will also help waste generators and the society to select the appropriate method of bio methanification depending on their needs and the quantity of the waste. This will help the Country and the world to treat the bio degradable or organic waste into useful burning gas as well as compost – reducing the waste and enhancing the soil fertility.

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