CHAPTER-2

LITERATURE REVIEW

Chapter - 2

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2.1 HISTORICAL BACKGROUND OF BIOMETHANATION

The phenomenon of biomethanation was first observed by Alessandro Volta of Italy in the year 1776. Volta observed that some bubbles are forming from the sediment of the lake in the vicinity of Como in Northern Italy [9]. In 1806, William Henry showed that Volta's gas was identical with methane gas. Humphrey Davy conducted the experiments in the year of 1808 to produce methane based on anaerobic fermentation of waste [10]. In1895 biogas from a waste treatment plant in Exter in England was collected and used to light nearby streets [11].

The industrialization of anaerobic digestion begun in 1859 with the first digestion plant in Bombay, India.By 1895,anaerobic digestion has made inroads in England where biogas was recovered from a well designed Sewage treatment facility and fuelled street lamps in Exeter.

Further anaerobic digestion advances where due to the development of microbiology. Research led by Buswell and others (Lusk, 1997) [12] in the 1930s identified anaerobic bacteria and the conditions that promote methane production.

Prior to 1920, most of the anaerobic digestion took place in anaerobic ponds. As the understanding of anaerobic digestion process control and its benefits improved, more sophisticated equipment and operational techniques emerged. The primary aim of waste stabilization in due course led to the basic municipal sludge digester. This design the spread throughout the world. Anaerobic digestion systems made a comeback during World War II with fuel shortage heating Europe but after the war anaerobic digestion was once again forgotten.

French scientist also showed the interest for installation of biogas plants in the French colony in Africa, during the Second World War.

Following the war several nation like U. S. A., U.K., Canada, Russia, Japan, Kenya, China, Uganda, South Africa, New Zealand and India showed interest in biomethanation. Realizing that the energy crisis will knock the door very soon, a large number of bio-gas plants based on community kitchen waste, M. S. W. and agricultural crops were installed mainly in the developing countries like China, India, Nepal, Philippines and also in Bangladesh.

China is the country with most installed units. More than 7 million units has been reported installed over the years with the peak in 1978 [13]. In these installed biogas plant, gas leakage was existing for 30-50 % of the total installed units which was the main bottle neck [14].

After 1975, 1.6 million digesters per year in China have been installed and up to 1982, more than seven million digesters were installed in China [15]. The methane fermentation has been known as microbe - based technology for producing biogas out of livestock manure and organic sludge. The two stage fermentation of methane, based on anaerobic microbes is expected not only to solve these problems, but also to contribute in obtaining renewable energy, reduced use of fossil fuels, suppression of carbon dioxide emission, lower the burden of waste disposal. B. R. Sauboll, a Belgian teacher at Godavari St. Xavier's School, had further developed the biogas plant in Nepal. He built a demonstration plant in 1955.In 1968 Khadi and Village Industries Commission (K.V.I.C.) built a plant for an exhibition in Katmandu. The department of agriculture installed 250 biogas plants during the fiscal year 1975/76. In 1974 Development and Consulting Services (D.C.S.) built forum biogas plants according to K.V.I.C. design.

Global Gas and Agriculture Equipment Development Company Pvt. Ltd., was formed in 1977. With investment of the United Mission of Nepal (U.M.N.), ABD/N and Nepal Fuel Corporation based on D.C.S. biogas extension organization. Biogas technology has been commercially introduced since the establishment of Gobar Gas Tatha Krishi Yantra Vikash (p) Ltd. in the year 1977.Various research has been carried out in designing and developing a biogas plant, biogas appliances of gas and slurry.

Many feedstock based on waste biomass [16-19] are already widely used as potential substrates for methane production. Cow dung, urban organic wastes, algae, vegetable wastes, human excreta and waste animal flesh are presently used as common substrates for methane generation [20-26].

2.2 BIOMETHANATION IN INDIA

The history of biogas introduction is divided into a number of phases, which are defined by occurrences and changes in society and programmed developments in Table no. 2.2 as follows: -

Table No. 2.2 Phases in the history of biogas technology in India

Year	Development
1960	First units constructed. Some research on the process and design
1950-1972	Industrial development of India and agriculture. First practical designs constructed, small projects, mainly one organization, involved, one design involved, one design disseminated.
1972-1975	Energy crisis attracts attention to the technology, start of national interests. Fossil fuel dependency identified.
1975-1980/81	National interests and research. National programmed developed.
1980/81-1985	Initiation of large national programmed relying on subsidized. Multi organization, Multi-design approach.
1985-1992	Improving designs, improving the organizations and results from dissemination
1992-1996	Decrease in subsidies, new structures of dissemination and extension.

Source: Mathias Gustav Sons, "Biogas Technology-Solution in Search of its Problem, Human Ecology Report Series 2000:1, PP –26.

Based on the series of investigations and experiments, all the scientists and engineers have developed and set up various types of biogas plants. Prof. N.V.Joshi of the Indian Agricultural Research Institute (IARI), New Delhi along with his other colleagues had conducted series of experiments in 1920 on bio-methanation based on anaerobic fermentation of various waste like banana skin, municipal waste including paper waste in order to produce biogas [27]. This process got more importance when Dr. S.V.Desai of IARI visited the sewage treatment plant in Dadar, Maharasthra in 1937. Later, Dr. S.V.Desai and S.C.Biswas of IARI produced bio-gas by fermenting the cattle waste through anaerobic process in the year of 1945.Further, in 1946, Prof. N.V.Joshi developed this process by making a small batch type bio-gas plant. Among these scientists, J. J. Patel (Agricultural College, Pune, Maharastra) had developed a well-known 'Gramlakshmi' Gas Plant in the year of 1951. Mr. Jasubhai. Patel is known as 'Father of Bio-gas' in our country for his pioneering contribution in this field. Scientist S.C.Dasgupta and C.N.Acharya along with Swami Vishwakarmanand had carried out enormous study and modified the earlier design of Gram- lakshmi gas plant in 1954 [28]. The modified design of grama- lakshmi gas plant became a major landmark for its suitability in various aspects and later it was adopted by Khadi and Village Industries Commission (K.V.I.C.) [29] throughout the country during sixties and seventies, There was another development took place with a Lucknow based agency named as Planning Research And Action Division (P.R.A.D.) based on modified design of "Gramlakshmi ".

The great scientist Dr. Rambux Singh has contributed lot in this field and promoted at Planning Research And Action Division (P.R.A.D.) the process of bio-methanation [30]. The K.V.I.C. and P.R.A.D. had tried to promote the gas plant of the Indian Agricultural Research Institute (I.A.R.I.) division. Khadi and Village Industries Commission (K.V.I.C.) also initiated the Research and developed activities during sixties and seventies and tried to remove all the existing problems faced in the design of digester based on floating type. Later on based on the Chinese design and field trials carried out at the Gobar Gas Research Station, Ajitmal, Etawah in U.P. Planning Research And Action Division (PRAD) has developed a gas plant based on fixed dome type of plant, which was later on called as Janata. Biogas Plant (J.B.P.) K.V.I.C. had launched in various places for setting up biogas plant from 1962 onwards and up to beginning of eights under the control of Department of Non-Conventional Energy Sources [31]. Swami Vimuktanand of Ramkhrishna mission at Belur, had developed a modified of Janata biogas plant and later on it was known as "Belur Math Model"[32].

Up to 1974 there had been about six thousand Biogas units installed in India. PRAD, Lucknow has developed an improved of fixed dome type digester at a cheaper price which is known as "Deenbandhu" model. During the period of 1980- 85, Govt. of India had set up National Bio-gas Development Board (N.B.D.B.) with a view to promote various bio-gas plants, To imparting knowledge, financial help mainly to the rural areas. It was planned to set up 15 lacs Biogas plant during seventh plan (1995-96) in our country. More than 24 lacs plant were already installed during 1985-86 under NPBD, which is equivalent of over 75 lacs tones of fuel wood amounting to rupees 375 cores per annum along with the generation of organic manure of 345lacs tones [33]. Based on the sources of implementation, eighth plan was revised and finally decided to install plant number over 25 lacs in the country [34]. The project on the development of high rate bio-methanation processes as means of reducing Green House gasses emission commenced in September 1994 for a duration of five years [35]. The National Bio-energy Board, a nodal body established under the chairperson ship of the M.N.E.S secretary, is implementing the bio-methanation project. Today, about fifteen such projects - in which biogas is generated from liquid as well as solid waste- have been completed in various industrial sectors while 17 are under way [36].

The major study carried out in 1992 by the National Council for

Applied Economic Research (NCAER) and estimates of the use of Biogas Plants installed between 1986 to 1989-90 was made 3600 villages spread in 251 Districts and 27000 units were monitored [37].

2.3 DEVELOPMENT STATUS OF ANAEROBIC DIGESTION TECHNOLOGY

Historical evidence indicates that the anaerobic digestion process is one of the oldest technologies. Biogas was used for heating bath water in Assyria during the 10th century BC and in Persia during the 16th century. Anaerobic digestion advances with scientific research and in the 17th century, Jan Baptista Van Helmount established that flammable gases evolved from decaying organic matter. The industrialization of anaerobic digestion began in 1859 with the first digestion plant in Bombay, India. By 1895, anaerobic digestion had made inroads into England where biogas was recovered from a well – designed sewage treatment facility and fueled street lamps in Exeter. Further anaerobic digestion was an advance due to the development of microbiology. Research led by Buswell and promotes methane production.

As the understanding of anaerobic digestion process control improved, more sophisticated equipment and operational technique emerged. The primary aim of waste stabilization in due course led to the basic municipal sludge digester. This design then spread throughout the world.

The energy crisis in 1973 [38] and again in1979 triggered renewed interest in development of simple anaerobic digestion system for methane production as an energy source. India, China and Southeast Asia responded to the crisis with marked expansion of anaerobic digestion. Most of the anaerobic digestion systems were small digesters using combined human, animal and kitchen wastes.

In the beginning lot of failures were they're in the development in the country like U.S., Soviet Union, China and in Europe but all those designs were succeeded furthered, the interest in research and development of anaerobic digestion. Apart from biogas production, anaerobic digestion found wider acceptance as an inexpensive technology for waste stabilization, nutrient recovery, reduction in biological oxygen demand (BOD), and sludge treatment.

2.3.1 Rural Energy

In the rural areas people are mainly dependent on biomass fuels, such as firewood, cattle dung and crop residues for meeting the basic energy needs for cooking and heating purposes. Direct combustion of biomass involves health hazards and lower efficiency of burning of biomass. Women and girls of the rural areas, who are generally involved in collecting and storing the biomass fuels in their kitchens, suffer a lot in terms of drudgery [39]. This also leads to deforestation.
To provide technological solution and institutional arrangements for ensuring adequate and sustainable clean energy system this has been adopted as one of the important activities of the Ministry of Non-conventional Energy Sources (M.N.E.S.). Biogas technology produces cheap and clean gaseous fuel from cattle dung and waste of other livestock and human beings, without destroying their manure value [40]. It has the potential to meet the energy needs of not only cooking and heating but also lighting in rural households.
Biogas technology has often been regarded as an energy-supply project [41-45]. After study it is indicated that more than 30% of the total households in the country own 3 or more cattle heads and, therefore, can benefit a lot by setting up bio-gas plants. It is beneficial to use the scientifically designed improved chulhas in rural and semi-urban areas and thus it is possible to reduce the present level of consumption of firewood by at least 50%.
Developing entrepreneurship at the local level and generating awareness can ensure the energy services. The Ministry of Non-conventional Energy Sources (M.N.E.S.) has implemented some important National schemes in National Project on Bio-gas Development (N.P.B.D.), catering to family type biogas plants and the

other is the National Program on Improved Chullas (N.P.I.C.), which is also covering the welfare of woman. Besides this to new pilot schemes, namely Rural Energy Entrepreneurship and Institutional Development (R.E.E.I.D.) and Woman and Renewable Energy Development (W.R.E.D.) were established during 2000-01 [46].

Production and utilization of biogas are beneficial in many ways. They have both direct and indirect economic benefits and social benefits .As a consequences anaerobic digestion process have been followed in many countries as an alternative to traditional energy sources [47].

A rural employment is generated through Biogas extension work had gained growing attention from the late eighties. In 1965 about 25% of the rural households in India received there major income from wages, in1988 this percentage had increased to 40% [48]. Thus biogas extension can be seen on a possible contributor to local employment [49-53].

When eco-development came alone biogas was adopted as a perfect technology to achieve the desired aims. From the appropriate technology side biogas technology can be seen as an almost perfect technology, easy to use and with high benefits, locally, manageable and profiting the rural households [54-56].

2.4 DEVELOPMENT OF BIO-REACTORS/DIGESTERS IN INDIA AND ABROAD

Bioreactors are classified on the basis of cubic meter of gas yield/ day/ unit volume of the digester as:

(a) Low yield reactors

(b) High yield reactors

In the following paragraph a brief description of various types of digester are presented to high light the development process.

2.4.1 KVIC Model

This is a floating dome type and is also called as "**Indian digester**" or "floating drum" plants. Fig. No. 2.4.1 shows the gasholder, mixing pit, inlet and out let pipe etc. of Khadi and Village Industries Commissions (KVIC) model. Most models have the basic design, which are similar to the design as shown in the figure no. 2.4.1. It is based on the continuous basis of feed material and is used for mostly cattle dung as input material. It has a partition wall mainly for the larger digester where volume is around 6 cu. m. and in this case the slurry material first take entry in the primary chamber. After digestion the slurry mixture reached to the top of the outlet chamber.

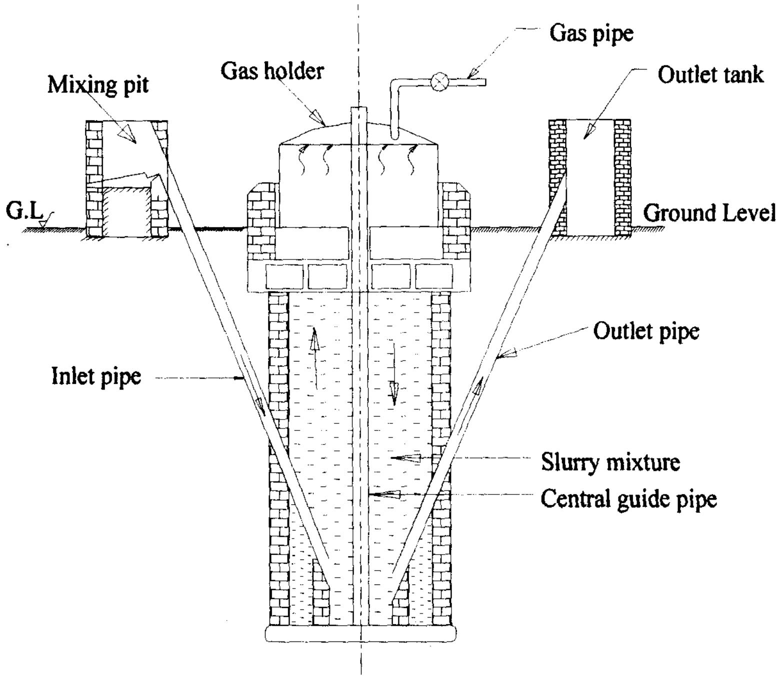


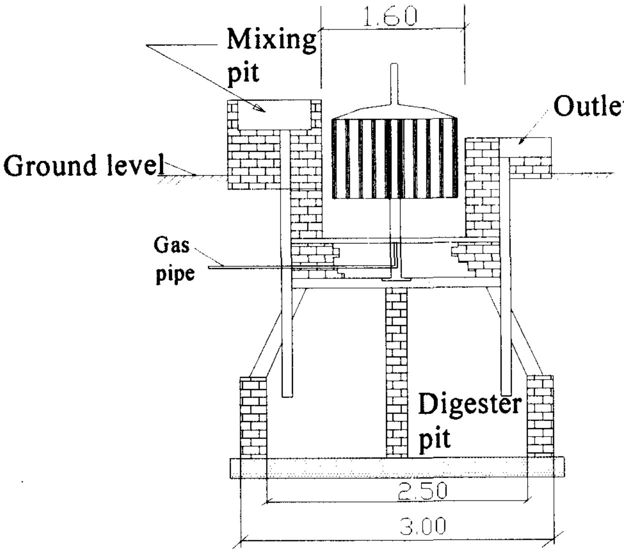
Fig. No. 2.4.1: Schematic Diagram of Floating Drum Digester (KVIC Model)

In the KVIC model retention ranges between 30-55 days, depending upon climatic conditions, and will decrease if loaded with more than its rated capacity, (KVIC, 1993) [57].

2.4.2 Nepal Model

In most Indian type biogas plants, the gas flow in to the users end is through a hose attached to the top of the gasholder, but these hoses are to be designed very carefully to withstand the gas pressure and to avoid deterioration and leakage since sometimes these hoses are responsible for gas leakage. These problems are avoided in Nepal's

Indian- type plant by the use of gas pipe as shown in Fig. No.2.4.2.



All dimensions are in m.

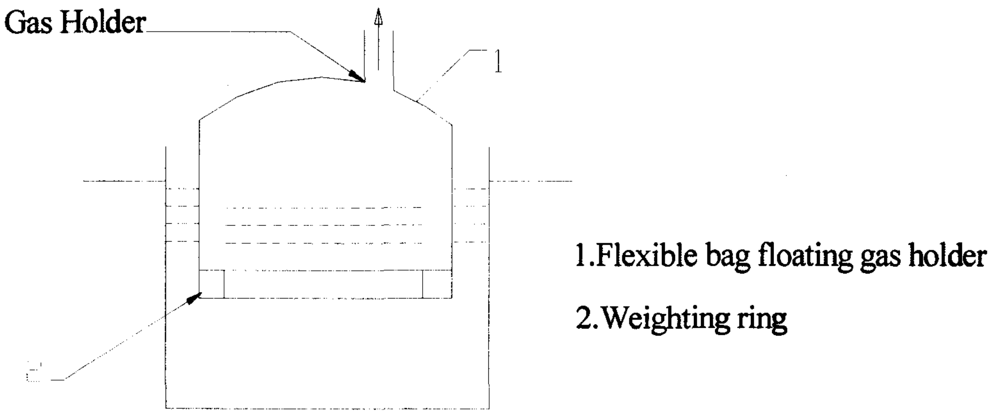
Fig.no.2.4.2: Nepal Model

2.4.3 Various Types of Indian Digester.

A few designs of these types are shown below in the following Fig. Nos 2.4.3 (a), 2.4.3 (b), 2.4.3 (c), 2.4.3(d), 2.4.3.(e), 2.4.3.(f), 2.4.3.(g) and 2.4.3.(h).

2.4.3.1 Separate Gasholder of Flexible Bag type

Detail of this type has been shown in Fig. No. 2.4.3. (a)



Seperate Gas Holder of Flexible Bag

Fig.no.2.4.3 (a): Separate Gas holder of Flexible Bag

2.4.3.2. Semi- Red Mud Plastic Bio gas digester

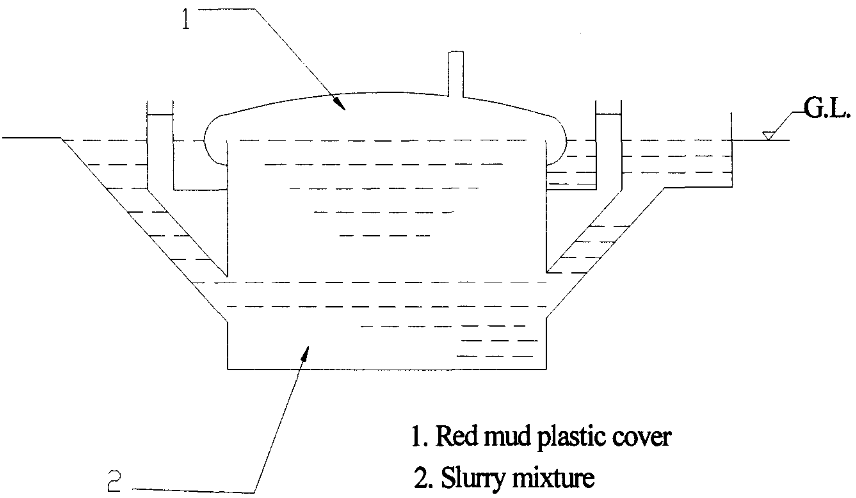


Fig. No. 2.4.3. (b): Semi-Red Mud Plastic Biogas Digester

2.4.3.3. Complete Red- Mud Plastic Bio gas Digester

This design was developed in 1960 s in Taiwan. It consists of a long cylinder made of PVC or Red mud plastic. The bag digester was developed to solve the problems experienced with brick and metal digesters [58-60].

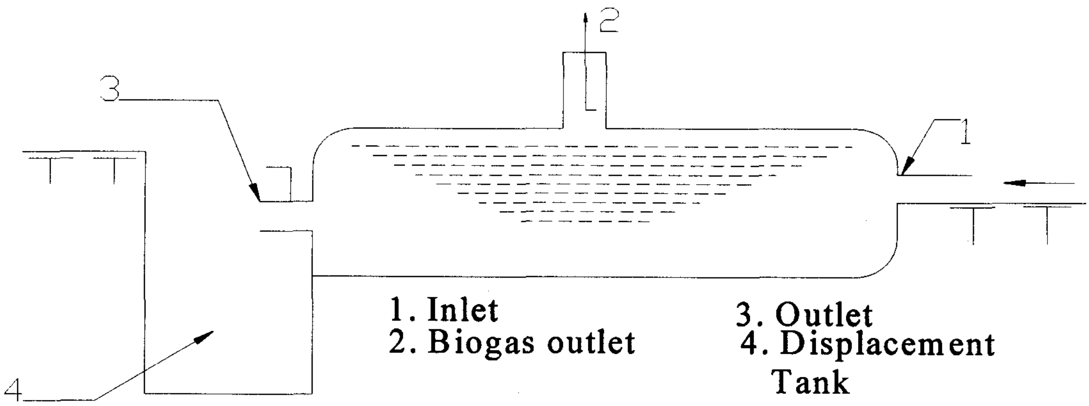
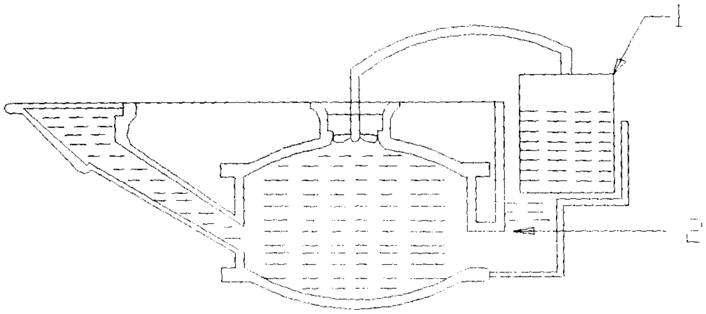


Fig. No. 2.4.3. (c): Complete Red Mud Plastic Bio Digester

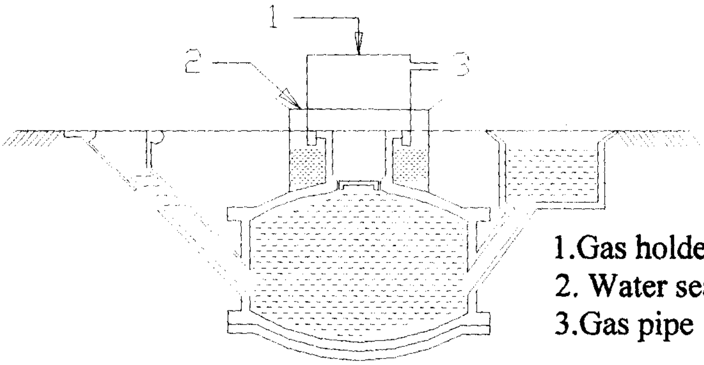
2.4.3.4 Separate Floating Gasholder Made from Ferro- cement



1.Seperate floating gas holder
2. Water sealing tank

Fig. No.: 2.4.3 (d): Separate Floating Gasholder Made from Ferro-cement

2.4.3.5 Gasholder Digester



1.Gas holder
2. Water sealing tank
3.Gas pipe

Fig. no.2.4.3. (e): Gasholder Digester

2.4.3.6 Biogas Digester With Separate Floating Gasholder

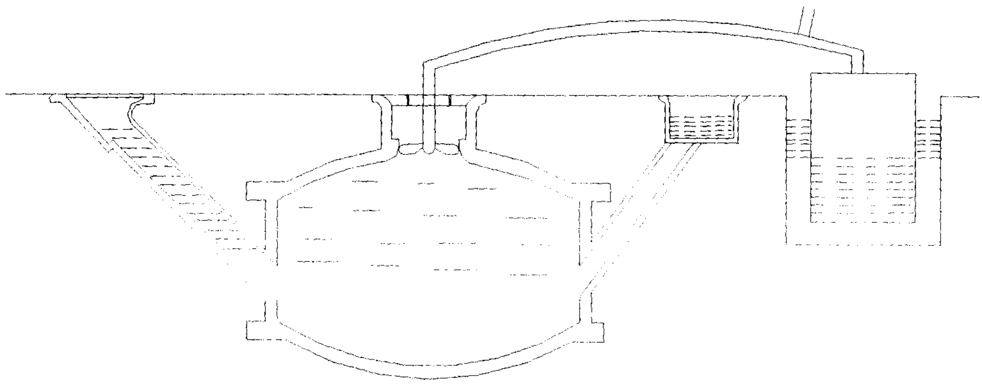
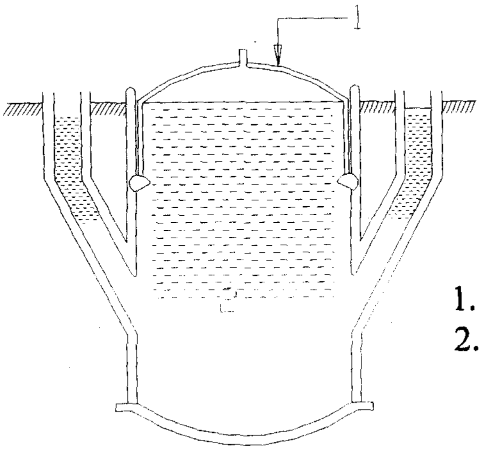


Fig. No. 2.4.3 (f): Biogas Digester with Separate Floating Gasholder

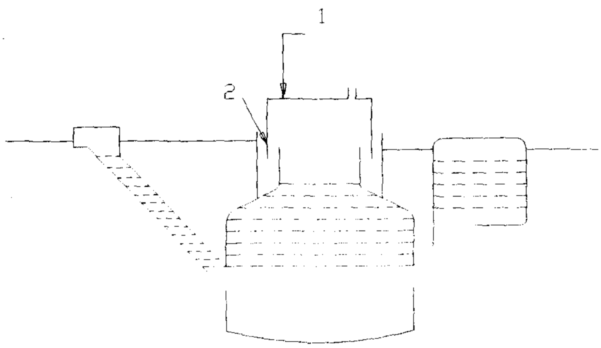
2.4.3.7 Top Floating Gasholder Digester Made of Glass Fiber



1. Floating gas holder
2. Fermentation tank

Fig. No. 2.3.4. (g): Top Floating Gasholder Digester Made of Glass Fiber

2.4.3.8.Biogas Digester with a cover for Collecting Gas



1.Cover for collecting gas

2.Water sealing trench

Fig. No. 2.4.3. (h): Biogas Digester with a cover for Collecting Gas

2.4.4 Ganesh Model

In this type of design, digester portion is made of an angle iron frame wrapped with a polythene sheet instead of a masonry structure. This design is similar to KVIC model, which has been shown in Fig. No. 2.4.4.

Constructional details of this model have been shown in Fig. No. 2.4.4. In this type of model a floating drum fitted on the top of the digester to accumulate the generated gas.

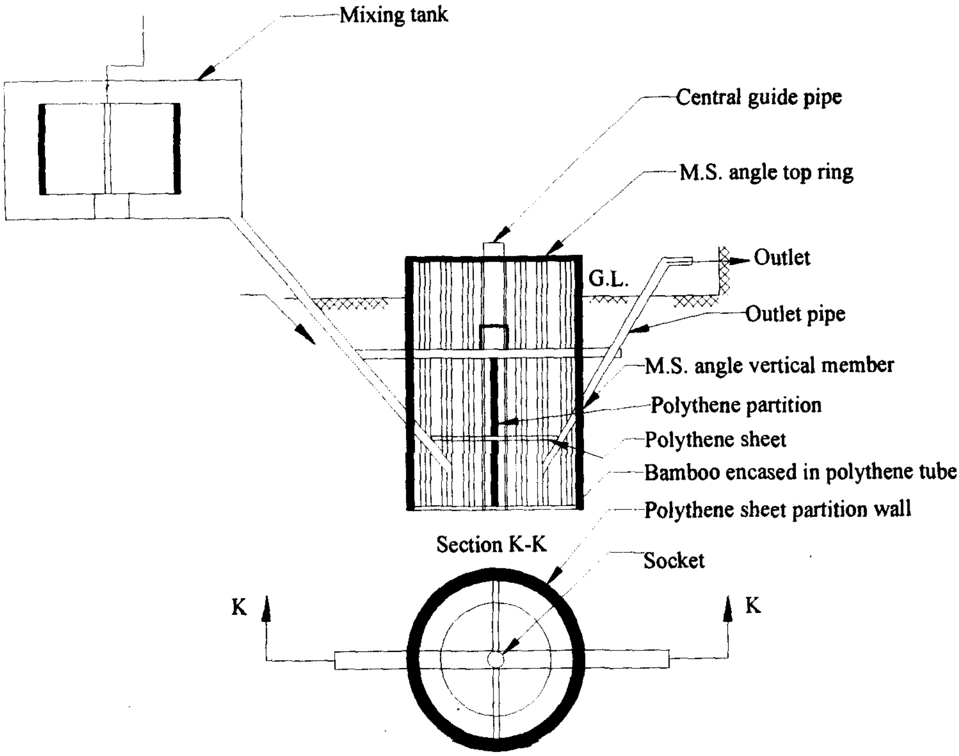


Fig No. 2.4.4 View of Ganesh model

2.4.5 Pragati Model

In this design height / diameter (H / D) ratio is less. The digester is hemispherical with slopping bottom slab. Fig. No. 2.4.5 shows the details of the digester of this model.

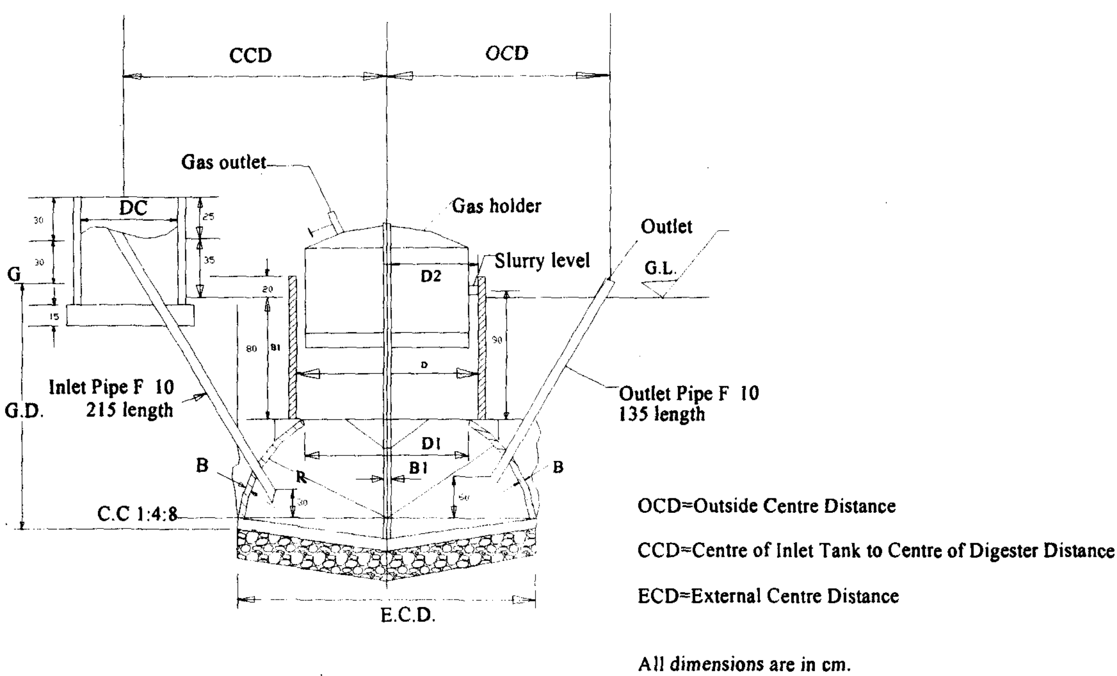


Fig. No 2.4.5: A Sectional view of Pragati model

2.4.6 Astra Model

In this type of model, a floating gasholder is incorporating with a solar water-heating device to maintain the slurry temperature. The merits of the ASTRA model are its reduced retention time, and reduced the cost and provision for maintaining the slurry temperature in a cold climate.

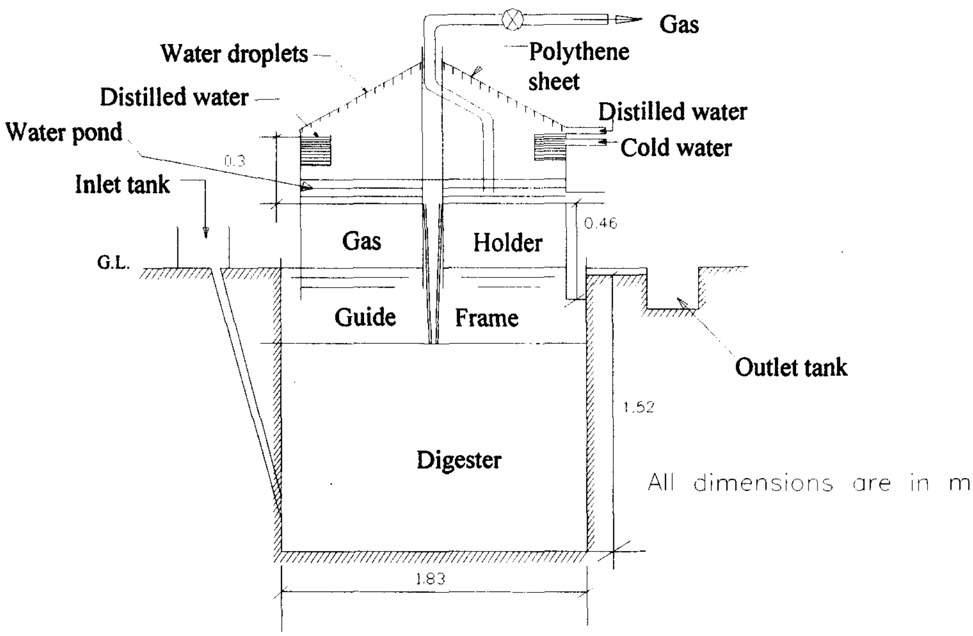


Fig. No. 2.4.6: A Sectional view of Astra Model

2.4.7 Jwala Biogas Model

In this model, the digester is of KVIC type, with a low-density polyethylene (LDPE) sheet together with a geodesic balloon constituting the gasholder. Scum breaking is achieved by means of a stirrer, which has both reciprocator and rotary motion. The Jwala model is considerably cheaper because no costly materials are involved in its construction. This model is being field- tested in a number of villages in Tamil Nadu, India. Fig. no.2.4.7. Shows the details of the construction.

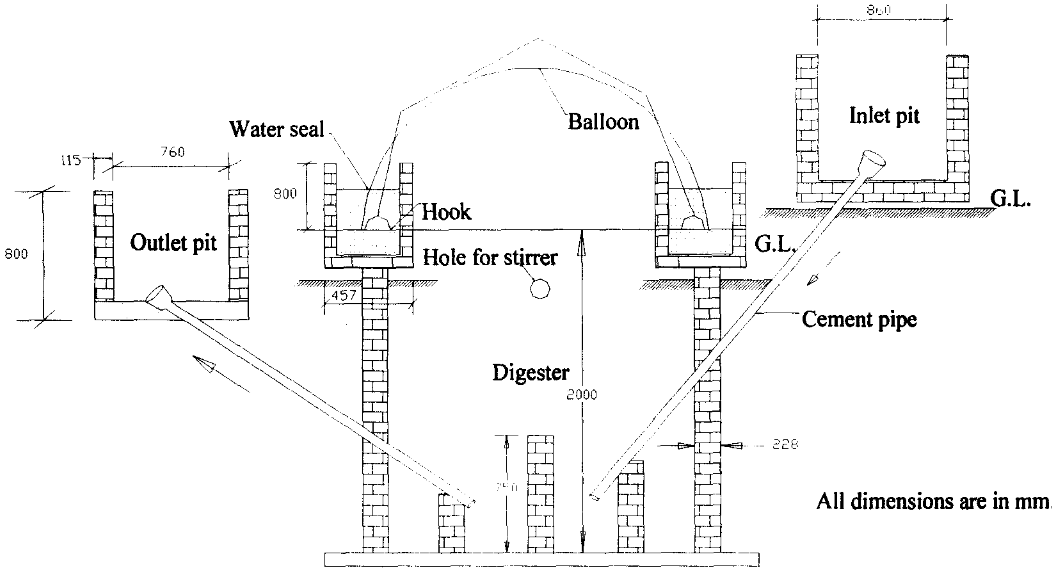


Fig. No. 2.4.7: Jwala Biogas Model

2.4.8 **Bostwana Model**

This model was designed by the Rural Industries Innovation Center in Botswana. The unit consists of one or more sealed steel drums functioning as the digestion compartment connected by piping to a gas collector storage tank. The gas collector is made of one 30-gallon drum upturned in a 45-gallon drum full of water with 1 cm steel bars used to guide the rise and falloff the collector. It is shown in fig. No.2.4.8.

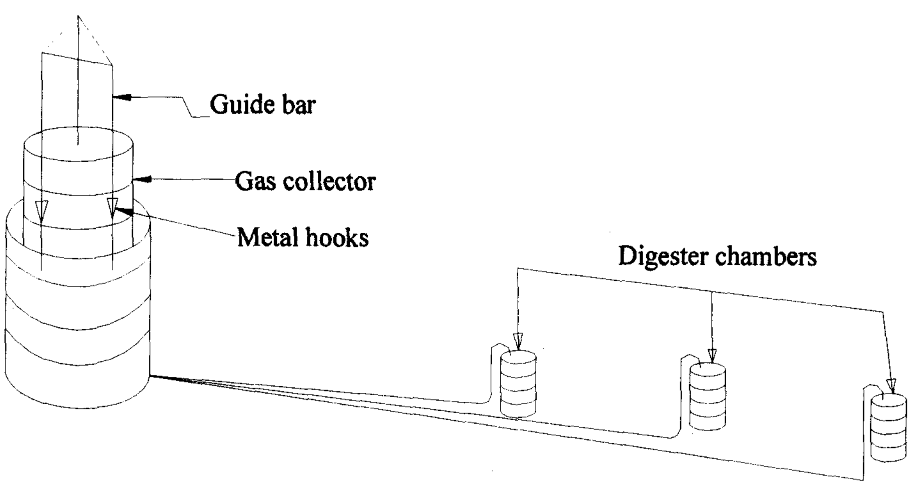


Fig. No. 2.4.8: Batch Fed Oil Drum for Biogas (Bostwana Model)

2.4.9. Guatemala-Olade Model

This is a batch-fed plant based on the separate gasholder design. To obtain regular gas production, two or more digester units with single gasholder can be used. This model is very expensive one; especially with its steel cover digesters and steel gasholder. The input materials used are cow manure plus agricultural waste like coffee and cocoa pulp. When loading the plant, the input material is put in the tank and then water is added to make a mixture of about 35% total solid. Generally the retention time in this model is 2 to 4 months.

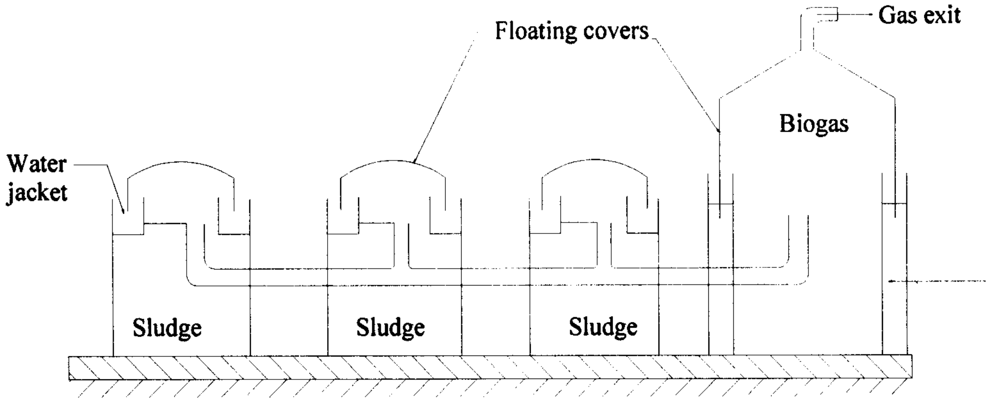
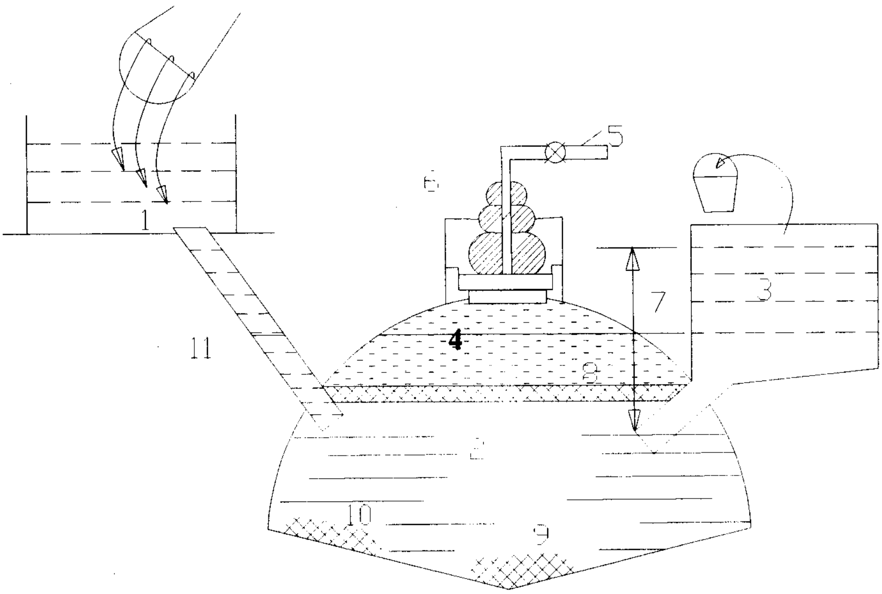


Fig. No. 2.4.9 Guatemala-Olade Model

2.4.10 Constant Volume Fixed Dome (CHINESE) Type Digester

These are fixed Dome biogas plants and are also termed as FED batch plants. Due to the continuous gas production and discontinuous flow of the digested slurry, they are classified under semi-continuous digester. A schematic figure is shown in fig. No.2.4.10. In this type of design, the digester is completely underground for better thermal insulation, avoiding cracking of dome frequently due to difference in temperature and moisture. The main digester is composed of a cylindrical shell wall with dome and bottom being segments of spherical thin shell.

The digester has two- fold function: accommodating digestible material as well as storage of gas. It is fully covered by affixed dome and it will be in perfect sealed condition to maintain anaerobic digestion

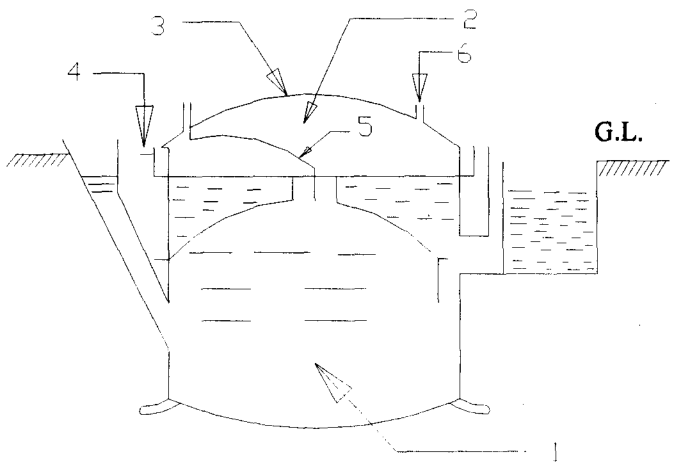


1. Mixing tank with inlet pipe,
2. Digester,
3. Compensating and removal tank,
4. Gasholder,
5. Gas pipe,
6. Entry hatch, with gas tight seal and weighted,
7. Difference in level = gas pressure in cm water column,
8. Supernatant scum; broken of by varying level,
9. Accumulation of thick sludge,
10. Accumulation of grit and stones,
11. Zero line filling height with out gas pressure

Fig. No. 2.4.10: Fixed–Dome Plant

Some of the variations in the basic Chinese type plants are the incorporation of spherical, oval and circular geometric are schematically shown in the following models:

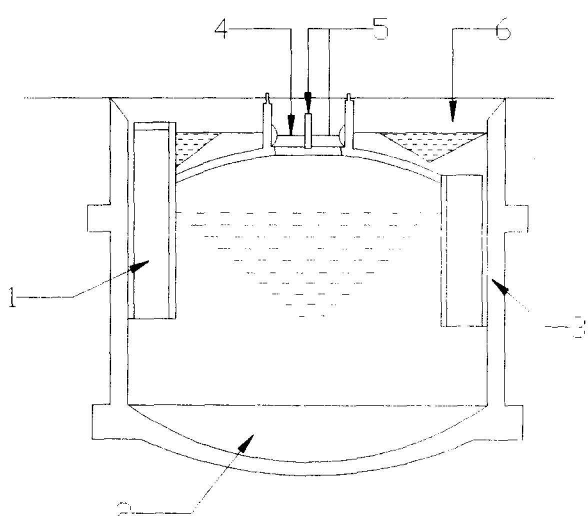
2.4.10.1 The Red Mud Plastic Biogas Digester for Dry and Wet Dual purpose



1. Wet Fermentation
2. Dry Fermentation
3. Gas Holder
4. Water Seal
5. Gas Outlet from Wet fermenter
6. Gas outlet from dry fermenter

Fig. No.2.4.10.1: The Red Mud Plastic Biogas Digester for Dry and Wet Dual purpose

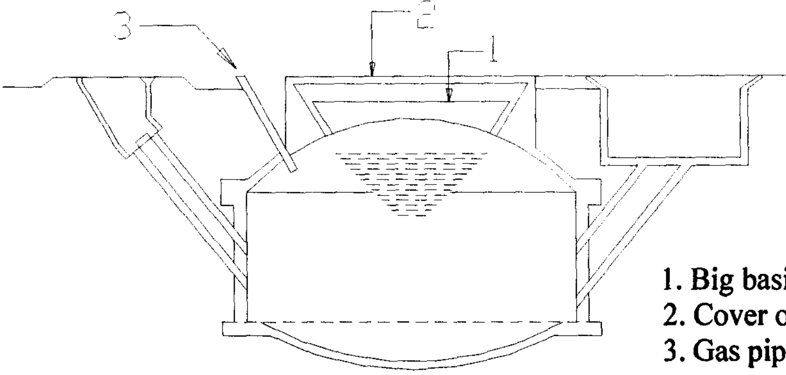
2.4.10.2 Top Water Pressure Biogas Digester



1.Inlet pipe 2.Fermentation digester
3.Connective pipe 4. Removable cover
5.Gas pipe 6.Top water pressure compartment

Fig. No. 2.4.10.2: Top Water Pressure Biogas Digester

2.4.10.3 Hydraulic Biogas Digester with a Big Basin- Shaped Removable Cover



1. Big basin-shaped removable cover
2. Cover of water container
3. Gas pipe

Fig. No. 2.4.10.3: Hydraulic Biogas Digester with a Big Basin-Shaped Removable Cover

2.4.10.4 Siphon Discharging Hydraulic Biogas Digester

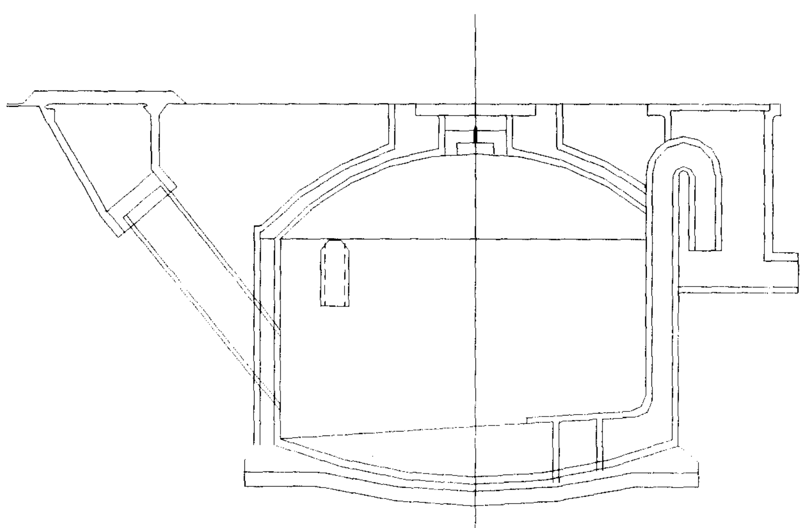
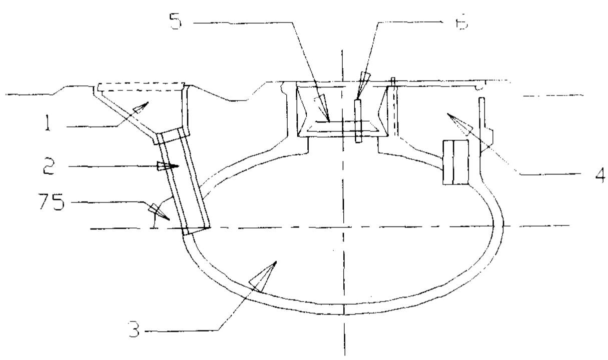


Fig. No. 2.4.10.4: Siphon Discharging Hydraulic Biogas Digester

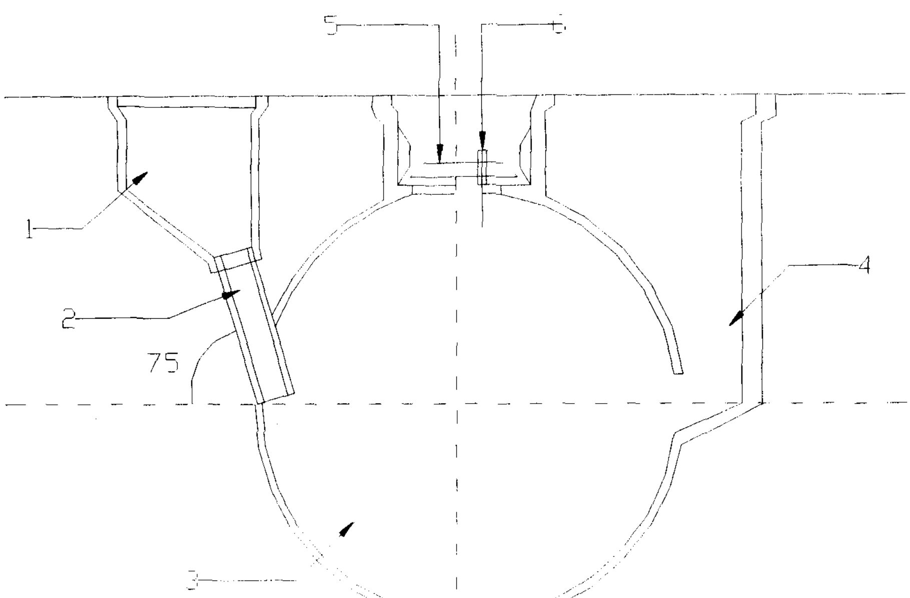
2.4.10.5 Elliptically ball-shaped Bio gas Digester



1. Inlet opening
2. Inlet ppipe
3. Fermentation compartment
4. Hydraulic compartment
5.Removable cover
6. Gas pipe

Fig. No. 2.4.10.5: Elliptical Ball-Shaped Biogas Digester

2.4.10.6 Ball Shaped Biogas Digester



1.Inlet opening
2.Inlet pipe
3.Fermentation compartment
4.Hydraulic compartment
5.Removable cover
6.Gas pipe

Fig. No. 2.4.10.6: Ball Shaped Biogas Digester

2.4.10.7 Separated Hydraulic Biogas Digester for Dry Fermentation

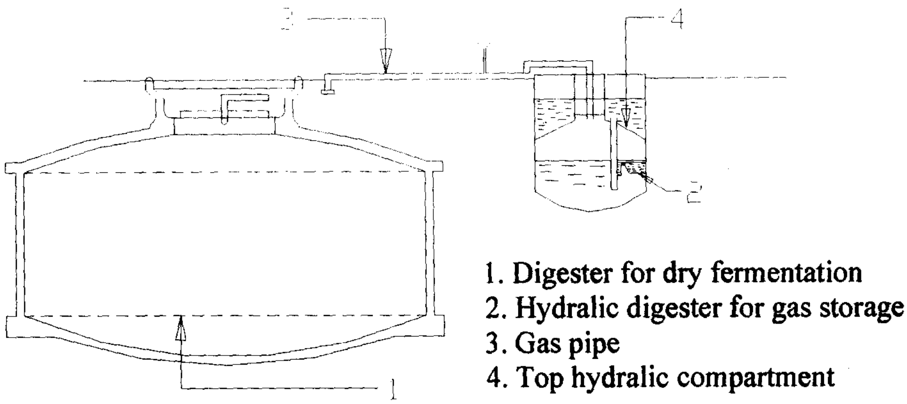


Fig. No. 2.4.10.7: Separated Hydraulic Biogas Digester for Dry Fermentation

2.4.10.8 Combination of fixed Dome and Floating Drum Plant

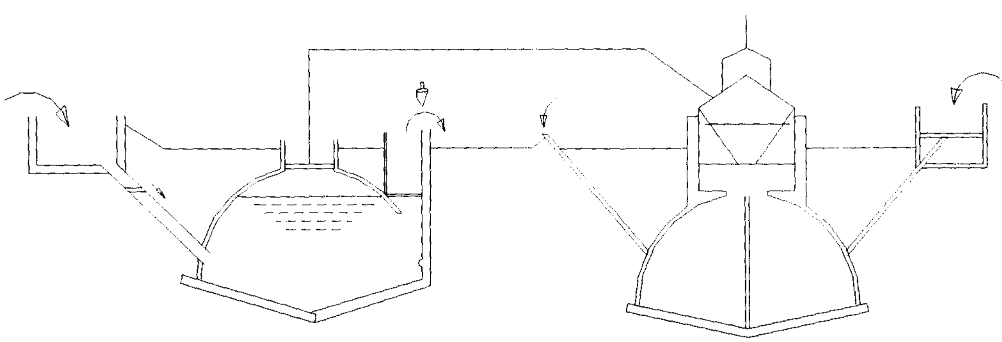


Fig. No. 2.4.10.8: Combination of fixed Dome and Floating Drum Plant

The above schematic figures have shown various types of fixed dome type digester.

2.4.11 Ball / Spherical Digester

The spherical biogas plant, a fixed- dome type low–cost model, has been developed by the Tata Energy Research Institute (TERI), New Delhi. In this design digester and gasholder together form a complete sphere, in which the top portion serves as the gasholder. The mixing tank and outlet are on either side of the digester. Fig. No. 2.4.11 shows the detail of the model.

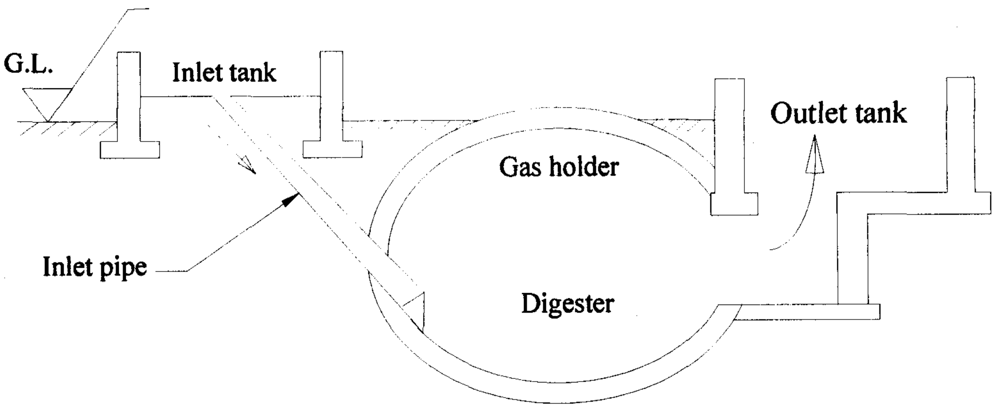


Fig. No. 2.4.11: Ball Digester

In this model the slurry inside the digester may contain higher particle, which may float on the top surface of the slurry and forms a thin-hard layer of scum. This hard layer will prevent to gas escape during digestion. To avoid this problem, nylon net has been spread on the top layer of the slurry. During digestion process gas accumulated in the gasholder. The slurry level of the digester goes down due to the pressure of gas. Thus slurry movement will be through the nylon net and as a result the formed scum will break.

2.4.12 Fixed Dome Type Janatha Biogas Plant

This plant developed in India is similar to the Chinese unit, except the manhole cover has been completely eliminated.

Dung slurry is allowed to ferment in the digester. When gas is formed, it rises upwards and gets collected in the dome. Fig. No 2.4.12 shown of this model.

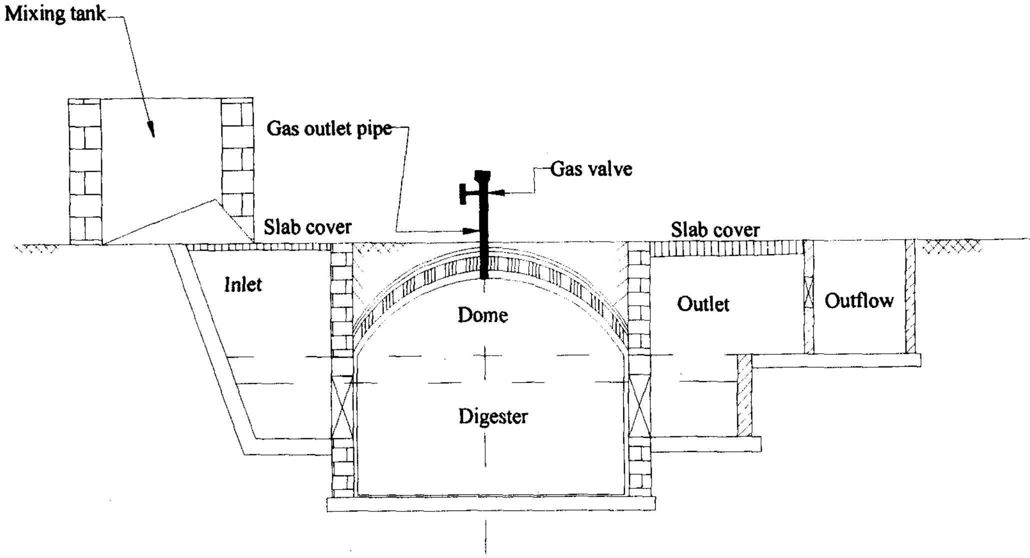


Fig. No. 2.4.12: Janatha Biogas Plant

2.4.13 Deenbandhu Biogas Plant

This model was developed in 1984, by Action for Food Production (AFPRO), New Delhi. Deenbandhu has probably been the most significant development in the entire biogas program of India as it reduced the cost of the plant to almost half that of KVIC model and this became popular in the poorer section of the people. Component of the bio gas plant of this model has been shown in Fig. No. 2.4.13.

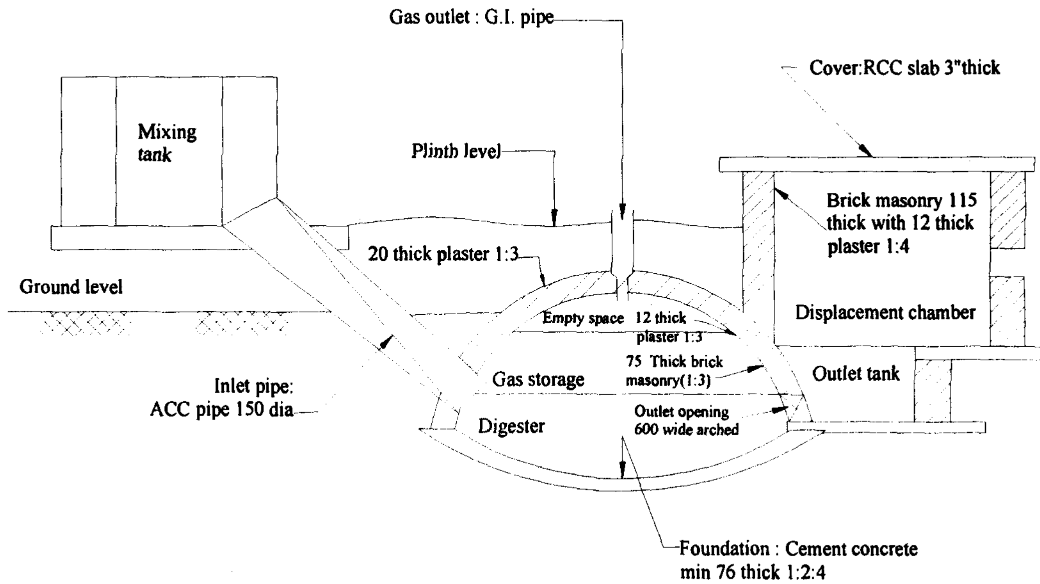


Fig. No. 2.4.13: Deenbandhu Biogas Plant

This model of biogas plant harboured higher methanogenic population than other model like KVIC, Ganesh, and Gayathri model of biogas.

2.4.14 Batch Digester

Very recently Chinese type reactors are being fitted with plastic storage bags to reduce the gas pressure and thus leakage problem is also reduced. This will also facilitate the maintenance work. Fig, no.2.4.14 shows the schematic view of this batch digester.

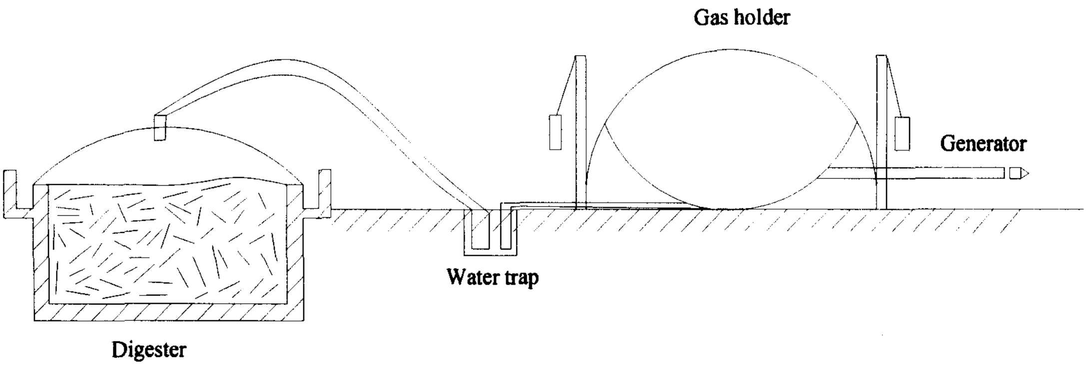


Fig. No.2.4.14: Batch Digester

2.4.15 Manawat Modified Chinese Type Digester

The National Research center in Egypt has developed the design with a few changes of the outlet chamber to reduce the loss of gas generated from slurry that is pushed in to the out let chamber. They have redesigned the out let chamber to minimize the movement of the slurry. Fig. No. 2.4.15 Shown illustrates the modification.

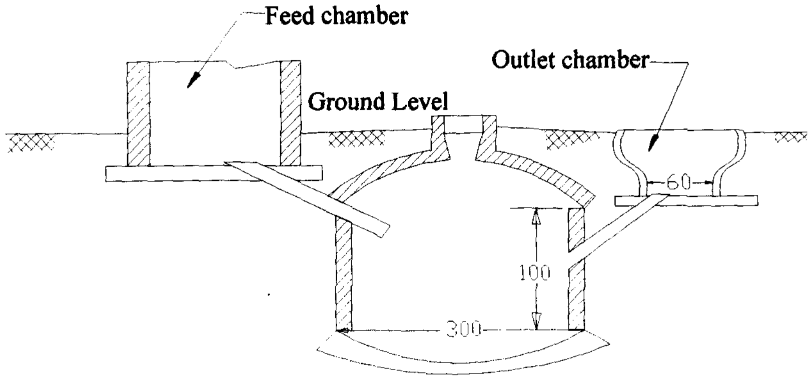
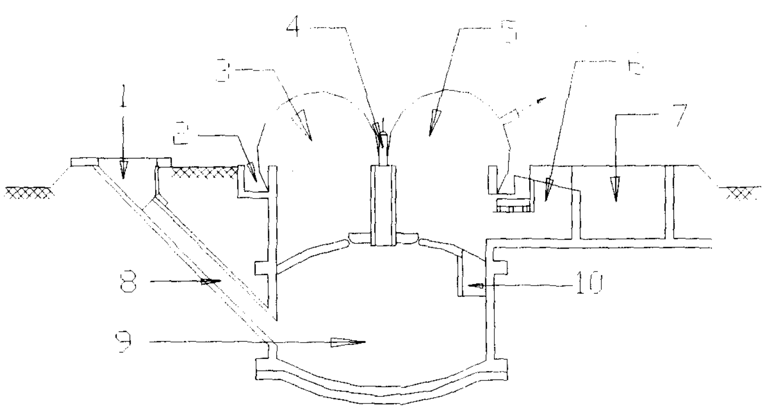


Fig.No.2.4.15: Manawat Modified Chinese Type Digester

2.4.16 Chinese Test Digester (Red- mud Plastic Gasholder Digester)

Fang Gouynan Chengdu et.al, Biogas Research Institute, China, conducted research on using the red –mud plastic film gasholder. The red-mud plastic chamber has the multi- functions of water pressure, gas storage, fermentation and heat absorption. Fig. No.2.4.16 shows the schematic diagram of the TEST Digester. Many plants of this type are circular with doomed roof.



1. Inlet
2. Water-sealing groove
3. Red mud plastic gasholder
4. Gas guiding pipe,removable cover
5. Second fermentation chamber
6. Overflow
7. Manure storage chamber
8. Inlet tube
9. First fermentation chamber
10. Water return tube

Fig. No. 2.4.16: Chinese Test Digester (Red- mud Plastic Gasholder Digester)

2.4.17 Borda / Sasse Digester

This type of digester is widely used in Germany Fig. No.2.4.17 Shows the fixed dome type plants. This type of fixed dome plants is recommended only under the close supervision of experienced technical experts.

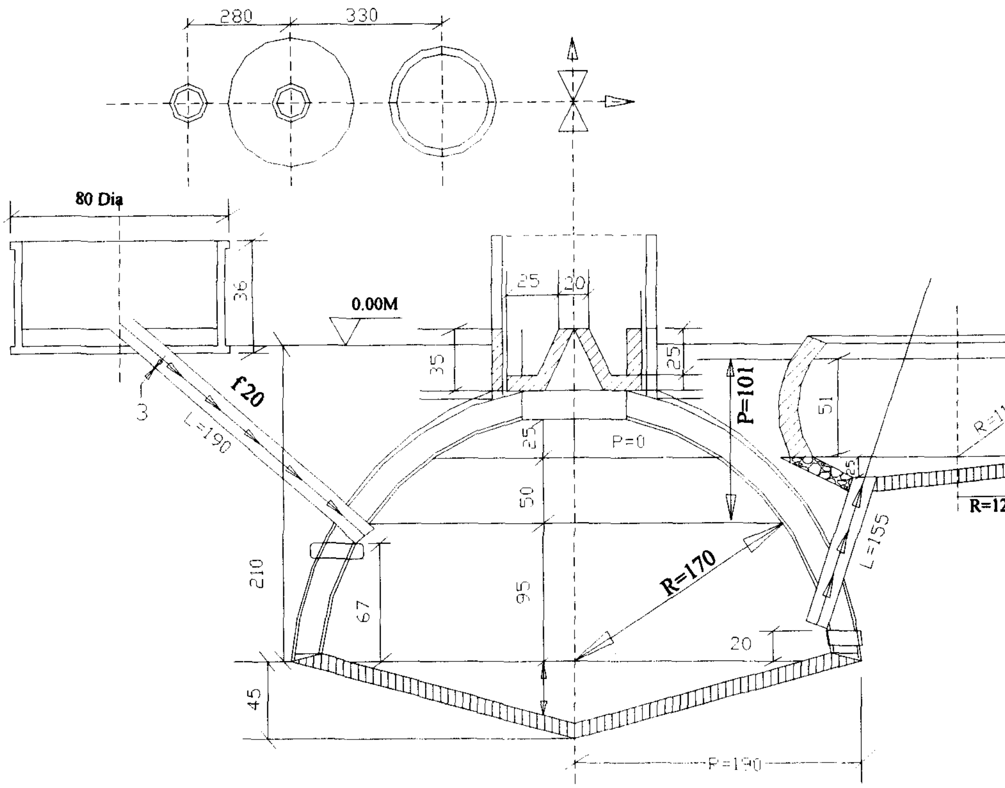


Fig. No. 2.4.17: Borda / Sasse Digester

2.4.18 RMP Model Digester

The most common type of digester is developed in Union Industrial Research Laboratories (UIRL) in Hsinchu, Taiwan, in 1974. "UIRL" developed a new material Red Mud Plastic (RMP), which is a mixture of new / used PVC, red mud waste from aluminum production, engine oil, etc. Its cost is very low.

Following Fig. No.2.4.18 Shows the RMP model.

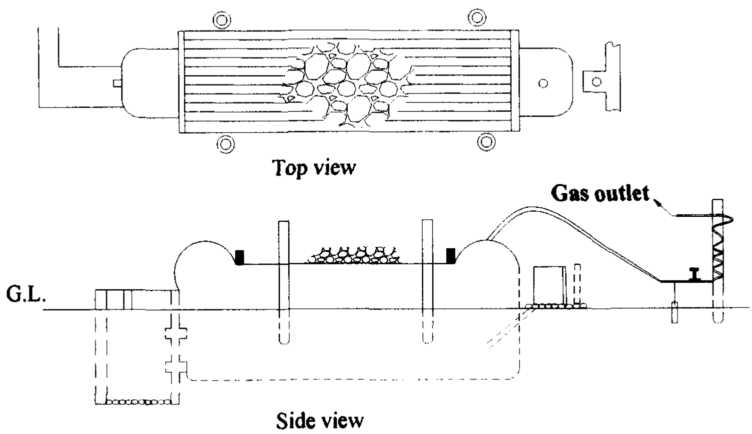


Fig. No. 2.4.18: Red Mud Plastic (R M P Model)

2.4.19 Bag or Tube Digester

Sanamatic Tanks Manufacturing Corporation, Australia, has developed large bio gas reactors made of butyl rubber The balloon plants in general consists of a plastic or rubber digester bag, in the upper part of which the gas is stored. These are placed on a sand base and supported by a steel cage, with rigid foam insulation and shown in fig. No.2.4.19.

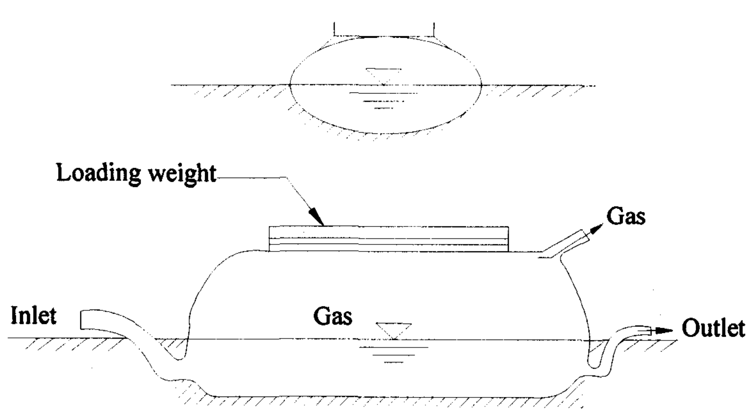


Fig. No. 2.4.19: Bag or Tube Digester

2.4.20 Portable Prefabricated Biogas Digester

This is a small-prefabricated portable digesters give better yields than conventional Indian or Chinese plants. Fig, no 2.4.20. Shows a view of a Pre- fabricated steel digester.

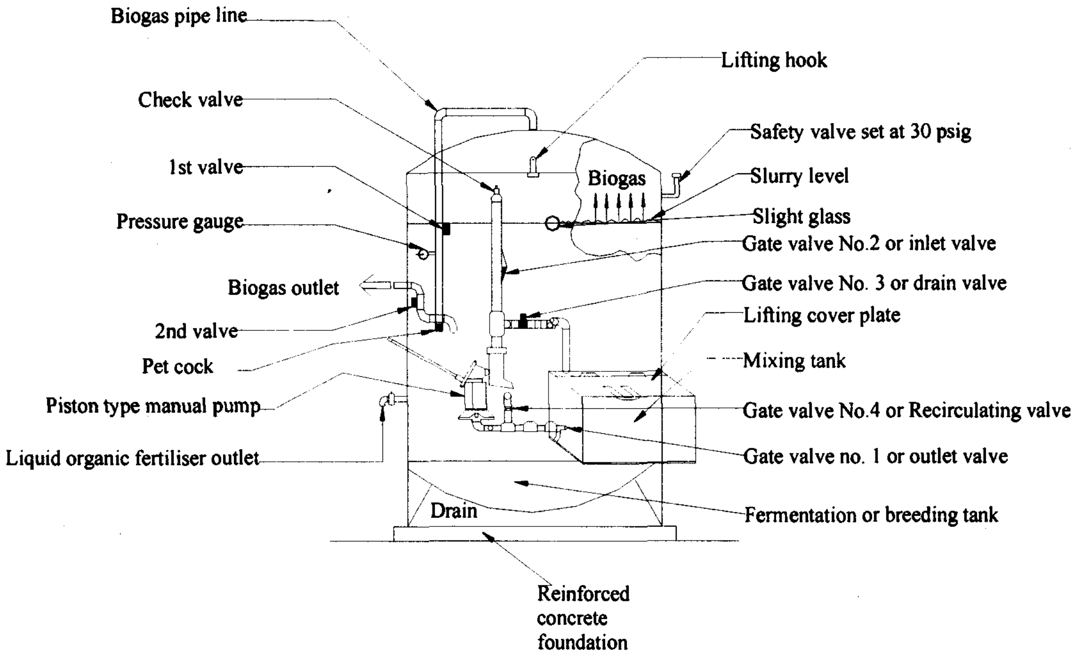


Fig. No. 2.4.20: Portable Prefabricated Biogas System

2.4.21 KHIRA Pre- Fabricated Steel Reactor

In this design the gas holders are made of thin mild steel sheet pre-treated with anti corrosion coating of phosphate and chromate passivation. The main advantages of this reactor are that it is more compact, economical, portable, does not necessitate cleaning and maintenance is easy, and it has no leakage problems or seepage problems. KHIRA digesters have been shown in fig. No. .4.21

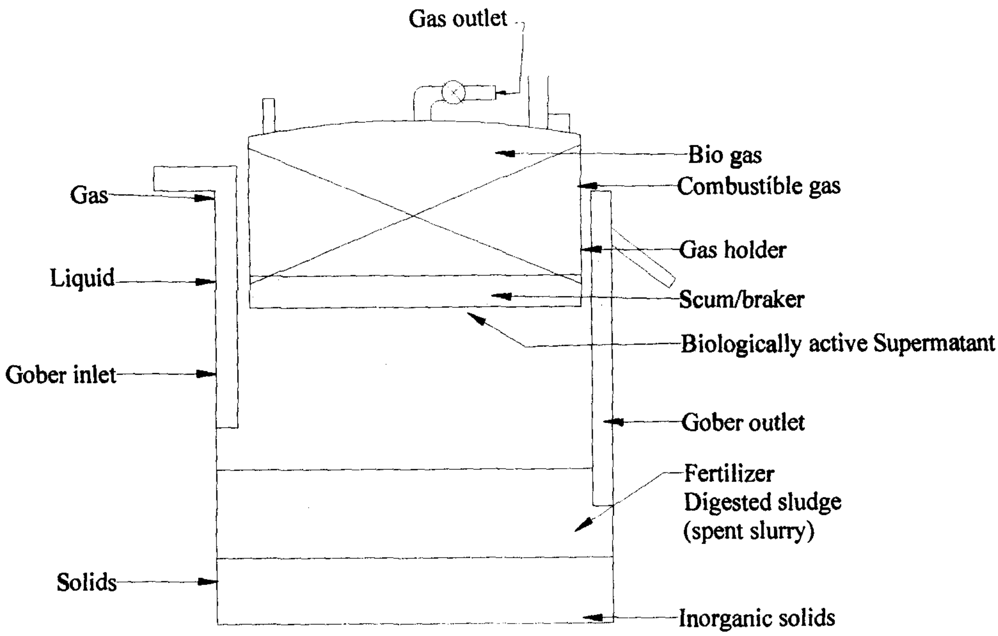


Fig. No. 2.4.21: KHIRA Pre- Fabricated Steel Reactor

2.4.22 Model (V- shaped Trough Reactor)

The Institute for Electrical Research (**I I E**) in Cuernavaca, Mexico, has developed a 10 cu.m. family version consisting of a 7m long V-shaped trough covered by a domed roof. The unit designed for use with dilute manure with about 8% total solids. The Reactor has a very little storage space; it is recommended that the gas be used on a steady state basis. Fig. No. 2.4.22 shows a V- shaped trough reactor.

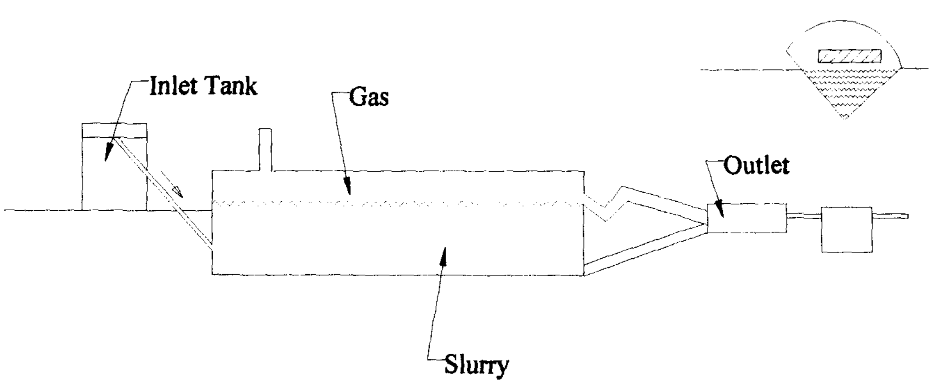


Fig. No. 2.4.22: I I E Model

2.4.23 Horizontal Digester

The Central American Research Institute for Industry (CARII) in Guatemala has developed many versions of horizontal digesters. Fig. No 2.4.23. Shows a horizontal reactor with a sloping floor and walls made of poured concrete beams filled in with concrete blocks; the slightly domed roof is of reinforced concrete. This behaves as a constant volume unit and actual gas volume to 20% of the reactor volume from the initial 10%. The capacity of the plant is 15 m3 capacity and shown in fig. No.2.4.23.

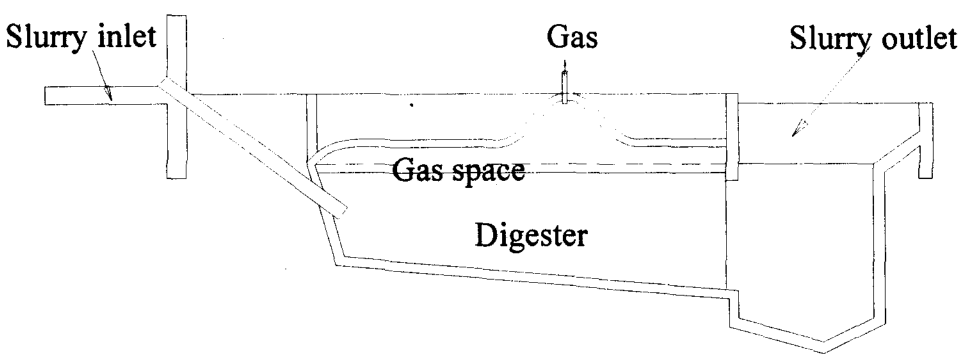
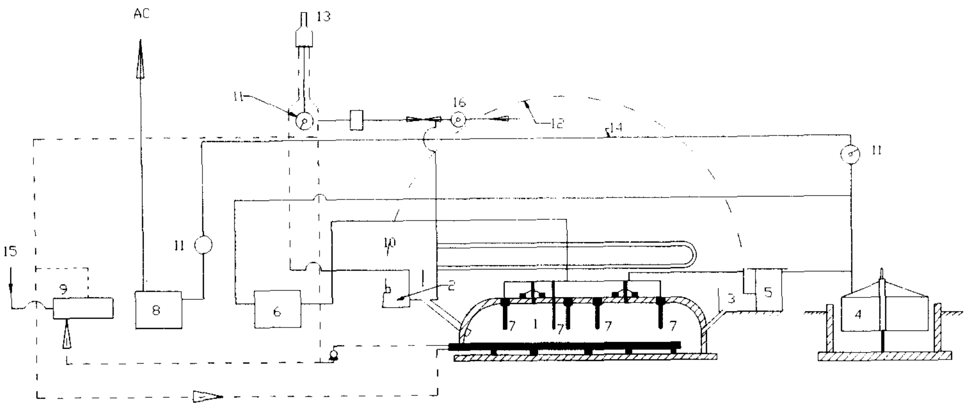


Fig No. 2.4.23: Horizontal Digester

2.4.24 Tunnel Type Digester (Shubrakass Village)

NRC of Egypt has constructed a specifically designed tunnel- type digester with arched roof with a separate floating gas collection system. In this model gas and slurry re circulation has been provided to obtain more efficient means of mixing and scum breaking.

This tunnel type digester is shown in Fig. No.2.4.24.



1.Tunnel digester
2.Feed chamber
3.Effluent outlet
4.Gas holder
5.Gas scrubber
6.Gas compressor
7.Gas mixing distributors
8.Electrical power generator
9.Engine waste-heat recycle
10.Solar water heater
11.Gas meters
12.Green house
13.Gas heater
14.Main Boigas line
15.Flue Gases
16.Water meter

Fig. No. 2.4.24: 50 m^3 Tunnel type Digester

2.4.25 The MAYA Farms Model

Mr. F.D.Maramba, Sr., Maya Farms Division of Liberty Flour Mills, has designed the Maya Farms Model; Philippines .The model is basically designed of separate gasholder to suit large-scale application. The model is shown in fig. No.2.4.25

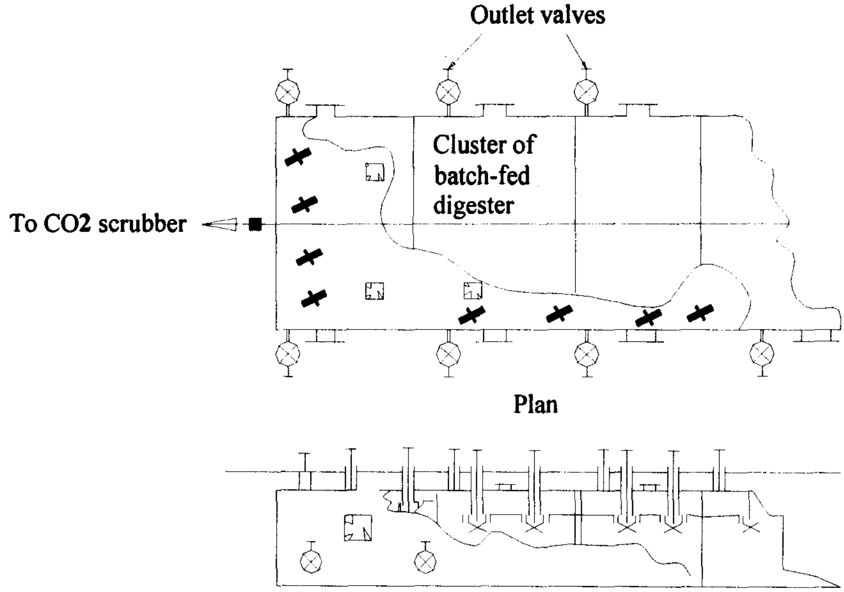


Fig. NO. 2.4.25: The MAYA Farms Model

2.4.26 Up flow Anaerobic Sludge Blanket (UASB) Digesters

This UASB design was developed in 1980 in Netherland.In this design no packing medium and the methane forming bacteria are concentrated in the dense blanket, which covers the lower part of the reactor. The feed (liquid) enters the bottom and releases biogas as the liquid flows upwards [61,62]. Some of the plants working on UASB Models are shown in the fig. No.2.4.26.(a) and 2.4.26(b)

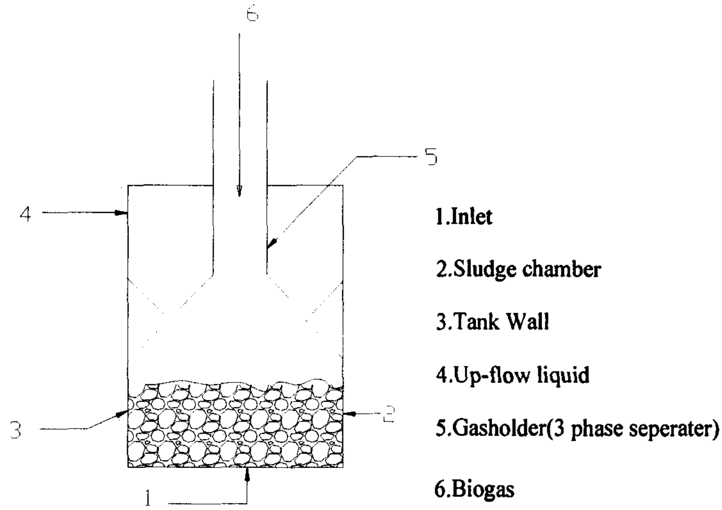


Fig No. 2.4.26(a). Up flow Anaerobic Sludge Blanket (UASB) Reactor

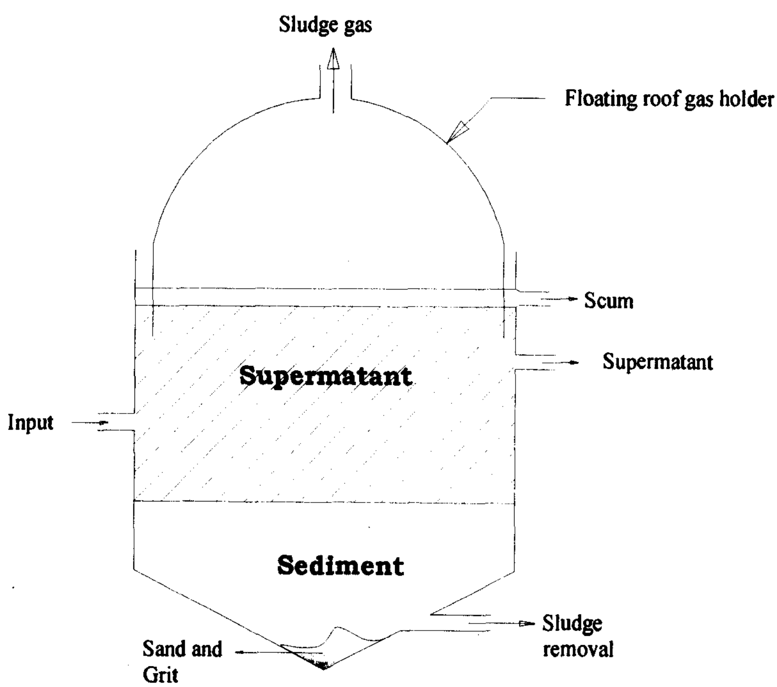


Fig.No.. 2.4.26(b) A Conventional Sewage Sludge Digester

2.4.27 Anaerobic Filter Reactors

These were developed in the 1950 s and are suitable for very dilute waste waters with low levels of suspended solid matter i.e. this type of digester is suitable for feedstock with low concentration. These include industrial organic wastewater, city sewage, and slaughterhouse sewage. Fig. No. 2.4.27 shows Anaerobic Filter Reactor.

A few other design of the Anaerobic Filter Reactor shown in Fig. No 2.4.27(a) and Fig. No.2.4.27 (b).

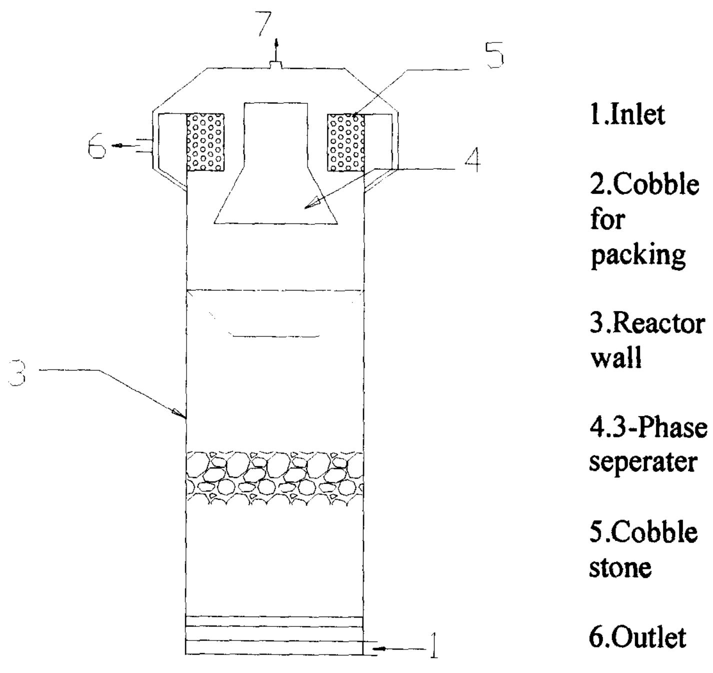
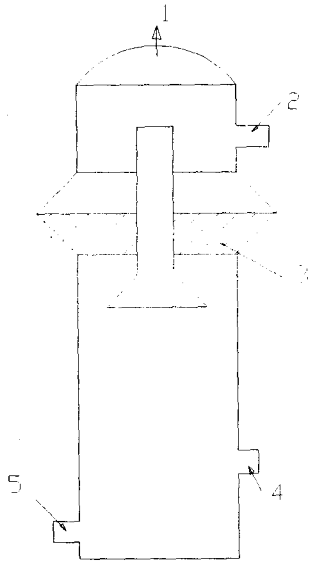


Fig.No.2.4.27 (a) Combination Type of Reactor of Pinsha Sugar Plant, Guangdong



1. Gas
2. Outlet
3. Honey comb
   plastic
4. Inlet
5. Sludge disposal

Fig.No.2.4.27 (b) Combination type of Reactor of Lougquandistillery, Liaolin

2.4.28 Flexible Top plug flow digester

The most common type of biogas system in U.S.A. Is an unmixed PLUG - FLOW System using an inflammable plastic gasholder. Schematic Fig. of the same type is shown in Fig. No. 2.4.28 (a) and Fig. No.2.4.28 (b)

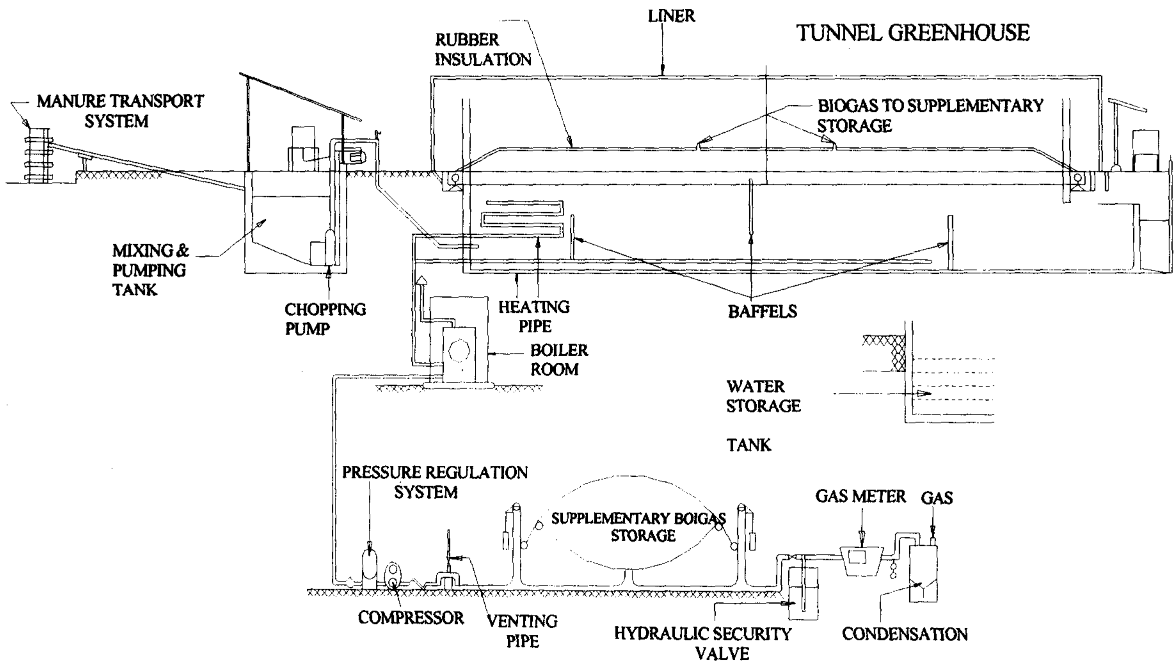


Fig. No.2.4.28 (a): Flexible top plug flow Digester

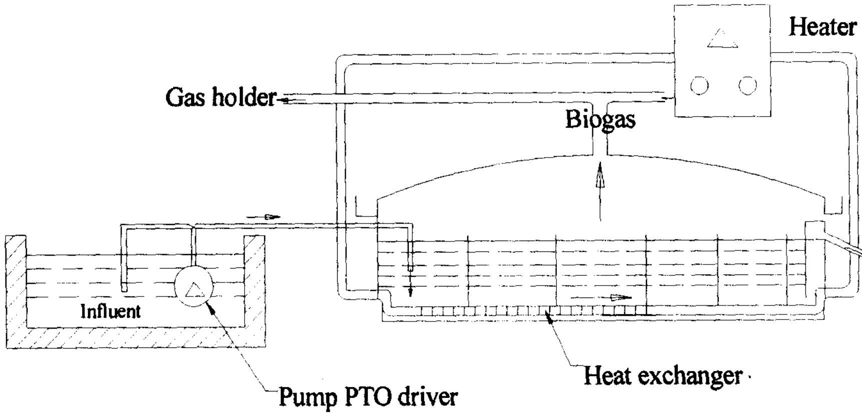


Fig. No.2.4.28 (b): Schematic view of the plug flow Digester

2.4.29 Bio-Funnel Reactor

This is an expanding, radial- overflow digester for continuous high solids loading. Fig. No2.4.29 shows the design of the same.

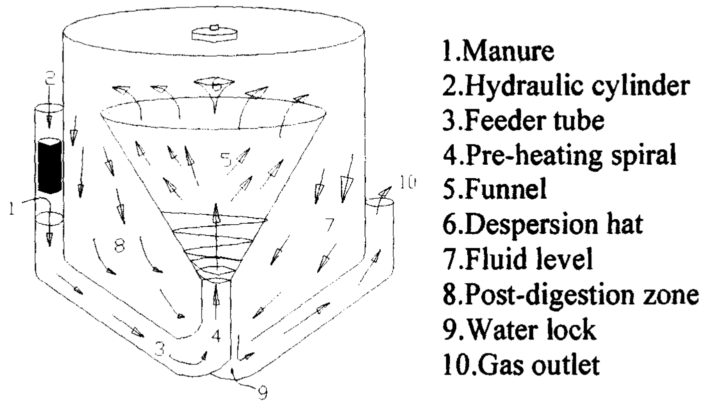


Fig. No. 2.4.29: Bio-Funnel Reactor

2.4.30 Anaerobic Baffle Reactor

Bachmann and McCartly at Stanford University evolved the design, which is very recent. The reactor is a simple rectangular tank, with physical dimensions similar to a septic tank, and is divided into 5 or 6 equal volume compartments by means of walls from the roof and bottom of the tank as shown in Fig. No.2.4.30.

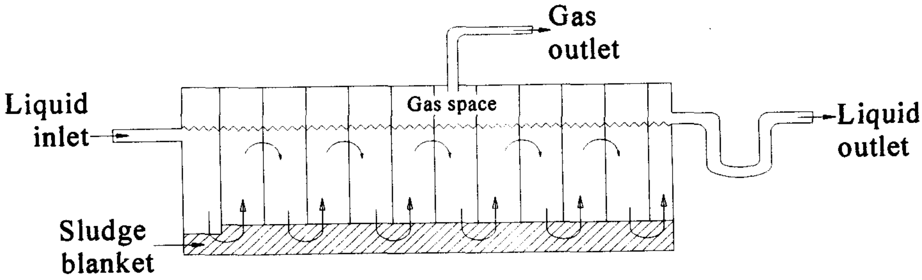


Fig.No.2.4.30.Anaerobic Baffle Reactor

2.4.31 Two Stage Digester with Internal Heat-Exchanger

This digester is designed based on two-stage reaction in digester with internal Heat Exchanger for 2000-3000 cu.ft. per day.

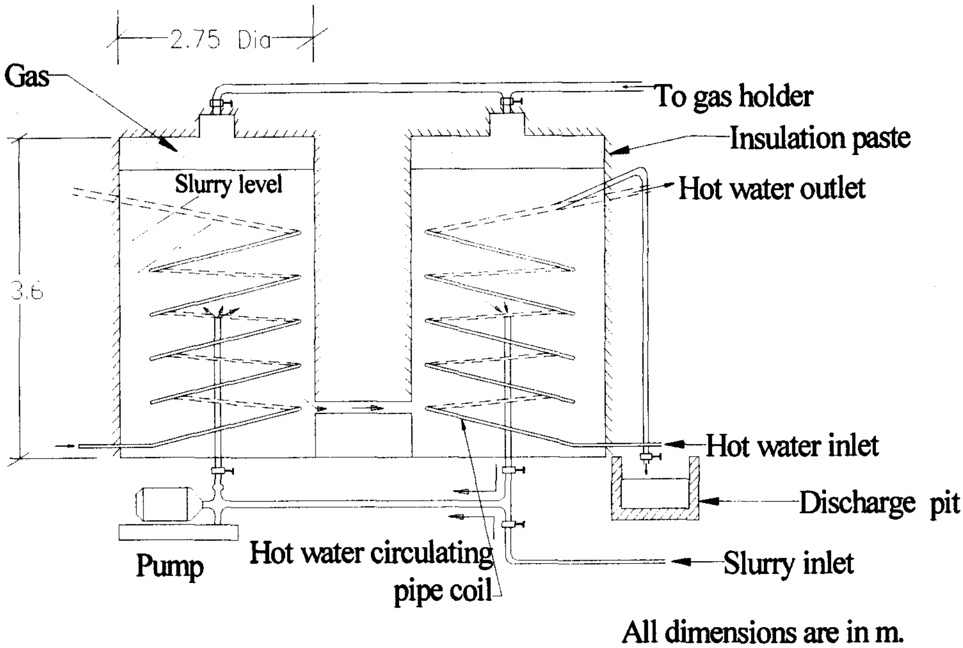


Fig. No. 2.4.31: Two Stage Digester with Internal Heat-Exchange

In the above figure no.2.4.31. hot water is circulated through the coils, regulated by a thermostat, the fermenting process may be kept at an efficient gas producing temperature. In fact, circulation only for a couple of hours in the morning and again in the evening should be sufficient in most climates [63].

2.4.32 Biogas Plant for Fibrous Feed Material

Depending upon the nature of the feed materials, biogas reactor is designed. For example, for long fibre feed material like banana stems the construction of biogas plant has been shown in figure no 2.4.32. In this type of biogas reactor a larger outlet diameter to cope with this is fitted. The feed material is light but hard fibrous content accumulate on the surface and form a floating scum. Scum breaker can break this deposited scum. It has been observed that one kg. of fresh banana stems (moisture content 95%) generates 25to 30 litre of biogas .One kg. of sun dried banana stems (moisture contents 15%) generates 330 litre to 350 litre of biogas.

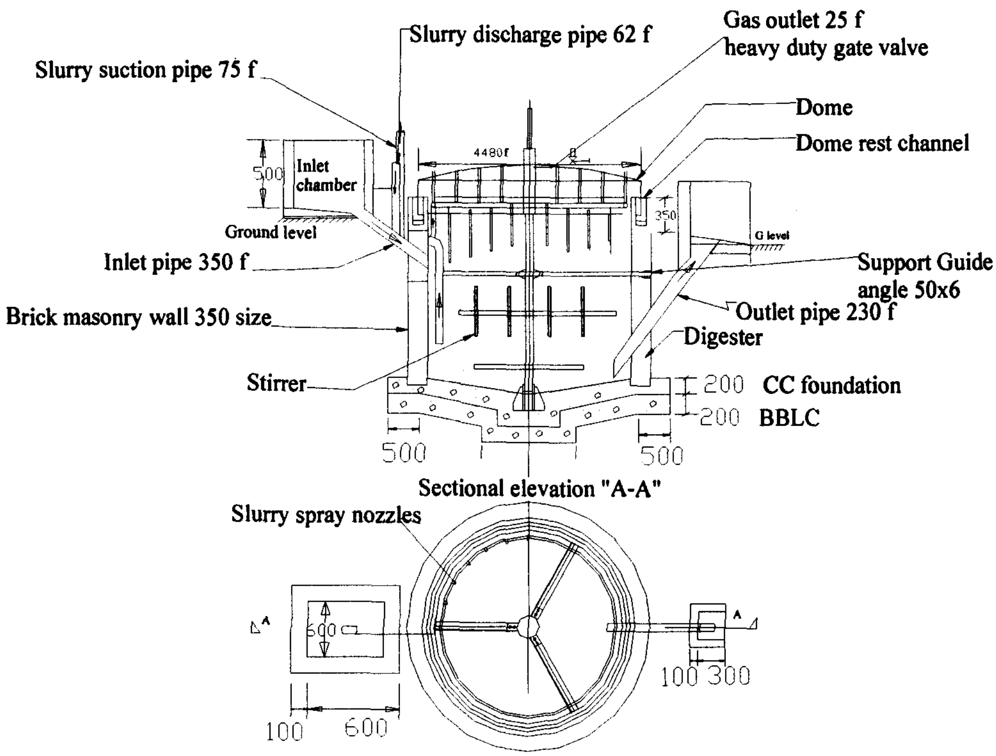


Fig. No. 2.4.32:Constructional drawings of a floating drum plant with Filter Funnel Long fiber feed material (Sasse)