

BIOGAS PLANT

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BIOGAS

- It's a mixture of gas produced by the microorganisms during the **anaerobic fermentation** of biodegradable materials.
- Anaerobic fermentation is a **biochemical** process in which particular kinds of bacteria digest biomass in an oxygen-free environment resulting in production of CH_4 , CO_2 , H_2 and traces of other gases along with decomposed mass.

COMPONENTS OF BIOGAS

Name of the gas	Composition in biogas (%)
Methane (CH₄)	50-70
Carbon dioxide (CO ₂)	30-40
Hydrogen (H ₂)	5-10
Nitrogen (N ₂)	1-2
Water vapour (H ₂ O)	0.3
Hydrogen sulphide (H ₂ S)	Traces

MICROBIOLOGY OF BIOGAS PRODUCTION:

- The production of biogas from organic material under anaerobic condition involves sequence of microbial reactions.
- During the process complex organic molecule present in the biomass are broken down to **sugar, alcohols, pesticides** and **amino acids** by acid producing bacteria.
- The resultant products are then used to methane by another category of bacteria.
- The biogas production process involves three stages namely:

1. Hydrolysis

2. Acid formation and

3. Methane formation

- **Hydrolysis**

- The complex organic molecules like **fats**, **starches** and **proteins** which are **water insoluble** contained in cellulosic biomass are broken down into simple compounds with the help of **enzymes** secreted by bacteria.
- This stage is also known as **polymer breakdown stage** (polymer to monomer).
- The major end product is **glucose** which is a simple product.

- **Acid formation**

- The resultant product (monomers) obtained in hydrolysis stage serve as input for acid formation stage bacteria.
- Products produced in previous stage are **fermented** under anaerobic conditions to form different acids.
- The major products produced at the end of this stage are *acetic acid, propionic acid, butyric acid and ethanol*.

- **Methane formation:**

- The acetic acid produced in the previous stages is converted into methane and carbon dioxide by a group of microorganism called "Methanogens".
- In other words, it is process of production of methane by methanogens.
- Methanogens utilise the intermediate products of the preceding stages and convert them into methane, carbon dioxide, and water.
- It is these components that make up the majority of the biogas emitted from the system.
- Methanogenesis is sensitive to both high and low pH's and occurs between pH 6.5 and pH 8.

The process of biogas formation through different stages is depicted in figure.

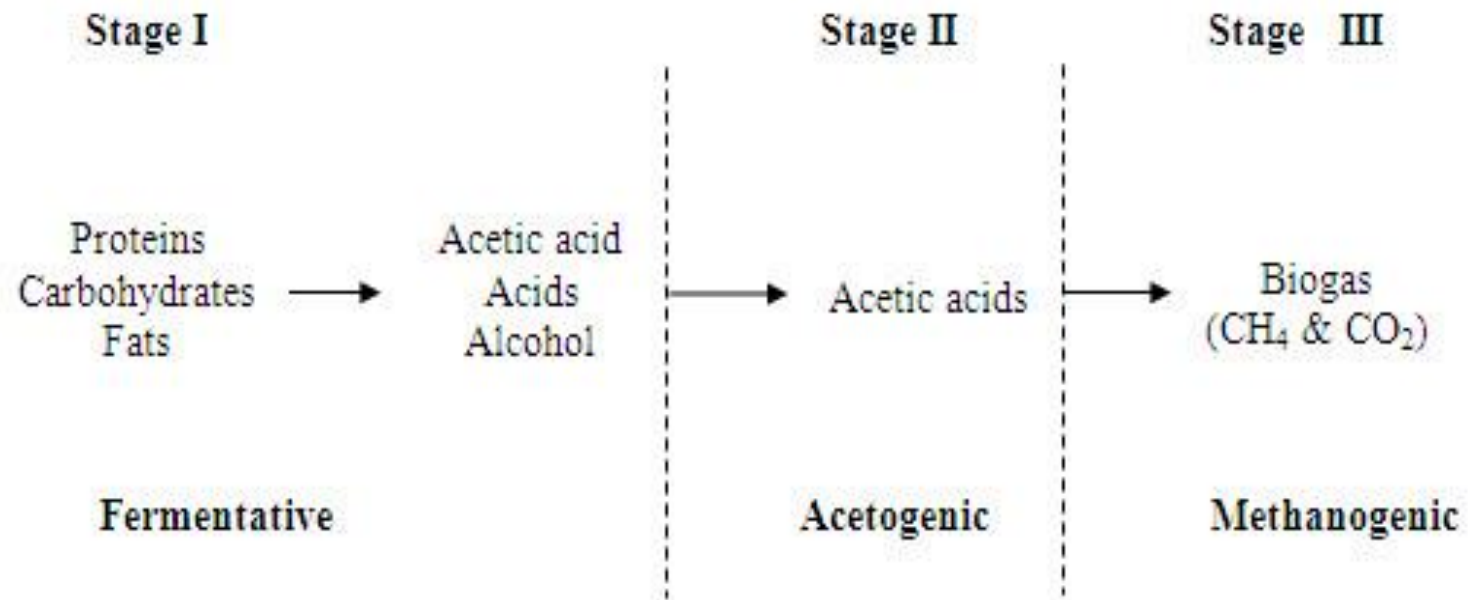


Figure: Stages of biogas formation

THE METHANE CONTENT DEPENDS ON THE FEED MATERIAL.

Cattle manure	65%
Poultry manure	60%
Pig manure	67%
Farmyard manure	55%
Straw	59%
Grass	70%
Leaves	58%
Kitchen waste	50%
Algae	63%
Water hyacinths	52%

Biogas plant and its components:

Mixing tank	Cow dung is collected from the shed and mixed with the water in equal proportion (1:1) to make a homogenous mixture (slurry) in the mixing tank
Feed inlet pipe/tank	The homogenous slurry is let into the digester through this inlet pipe (KVIC biogas plants)/tank (Janatha biogas plants)
Digester	The fed slurry is subjected to anaerobic fermentation with the help of microorganisms inside the digester.
Gas holder	As a result of anaerobic fermentation, gas produced is stored in gas holder (Drum in the case of KVIC and in dome in the case of fixed dome biogas plants)
Slurry outlet tank/pipe	The digested slurry is let out from the digester through slurry outlet pipe (KVIC biogas plants)/tank (Janatha biogas plants)
Gas outlet pipe	Stored gas is released and conveyed through the gas outlet pipe present at the top of gas holder.

BIODIGESTER

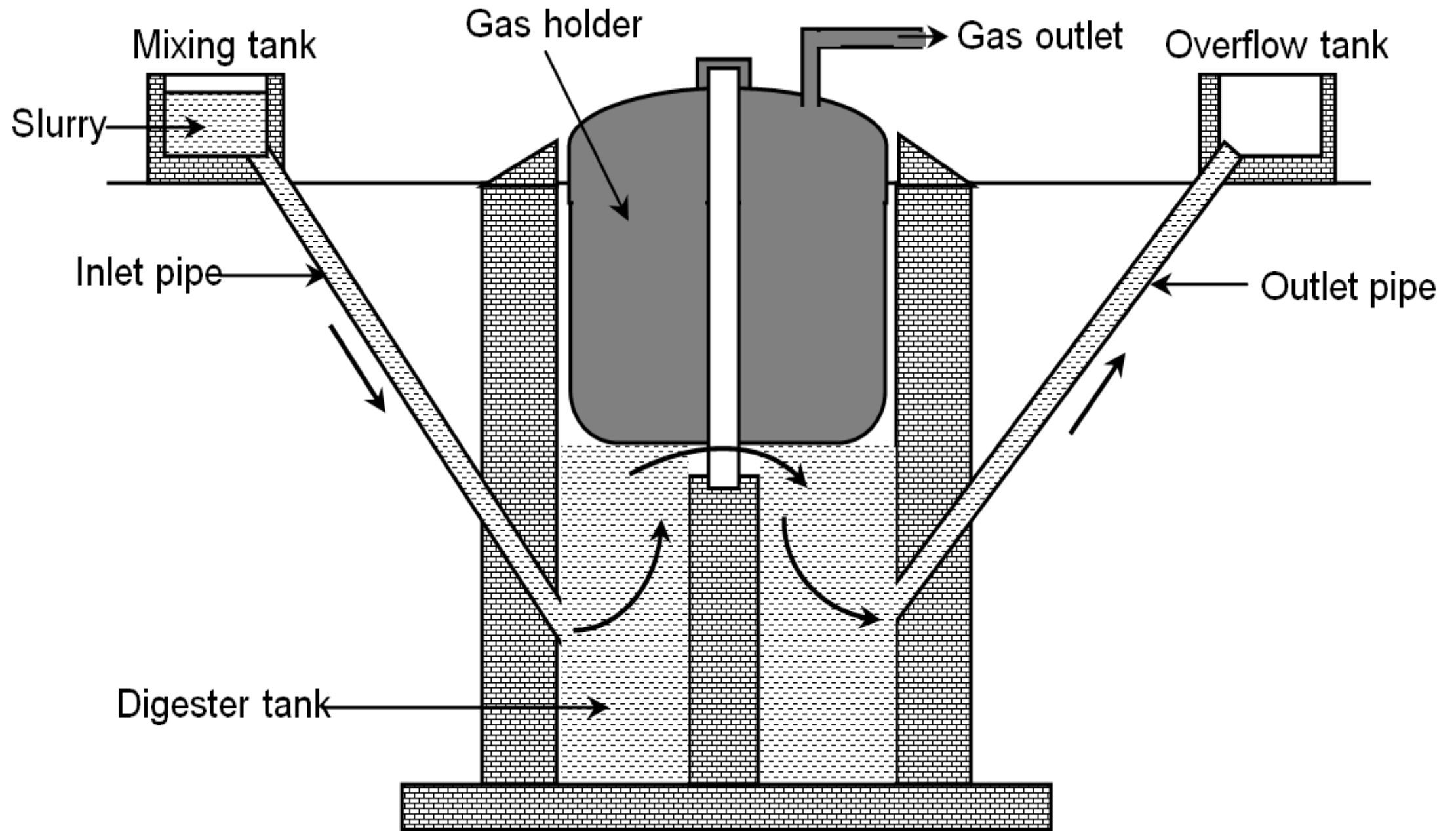
- The **biodigester** is a physical structure, commonly known as the biogas plant.
- Since various chemical and microbiological reactions take place in the bio-digester, it is also known as **bio-reactor** or **anaerobic reactor**.
- The main function of this structure is to provide anaerobic condition within it.
- As a chamber, it should be air and water tight.

Classification of biogas plants

- Based on the nature of feeding, biogas plants would be broadly divided into 3 type:
 - Batch type
 - *Semi-continuous type and*
 - Continous type
- Classification of semi-continuous type biogas plant is explained below:
 - **Floating drum type** – KVIC model
 - **Fixed dome type model** – Deenbandhu model

FLOATING DRUM TYPE (CONSTANT PRESSURE)

- The floating gas holder type bio gas plant consists of a dome shaped gas holder made of steel for collecting bio gas.
- The dome shaped gas holder is not fixed but is moveable and floats over the slurry present in the digester tank.
- Due to this reason, this biogas plant is called floating gas holder type biogas plant.



- Slurry is prepared by mixing water in cattle dung in equal proportion in mixing tank.
- The slurry is then injected into a digester tank with the help of inlet pipe.
- The digester tank is a closed underground tank made up of bricks. Inside the digester tank, the complex carbon compounds present in the cattle dung breaks into simpler substances by the action of anaerobic microorganisms in the presence of water.
- This anaerobic decomposition of complex carbon compounds present in cattle dung produces bio gas and gets completed in about 60 days.
- The bio gas so produced starts to collect in floating gas holder and is supplied to homes through pipes. And the spent slurry is replaced from time to time with fresh slurry to continue the production of bio gas.

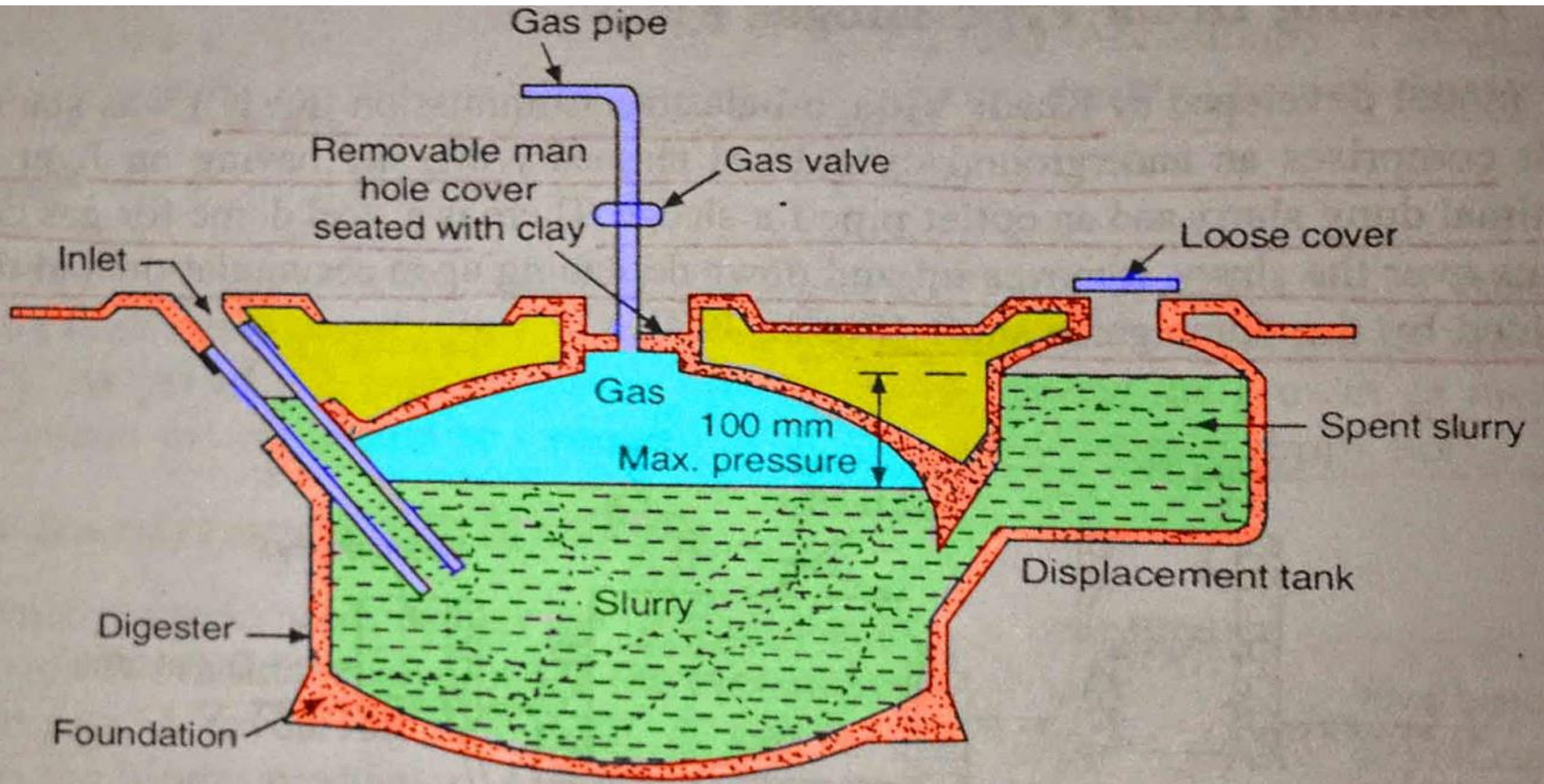
Advantages of floating drum plant-

- It has less scum troubles because solids are constantly submerged.
- No separate pressure-equalizing device needed when fresh waste is added to the tank or digested slurry is withdrawn.
- In it, the danger of mixing oxygen with the gas to form an explosive mixture is minimized.
- Higher gas production per cu m of the digester volume is achieved.
- Floating dome has welded braces, which help in breaking the scum by rotation of the floating drum about a vertical axis.
- No problem of gas leakage.
- Constant gas pressure.
- **Disadvantages-**
- i) It has higher cost due to use of steel and cement.
- ii) Heat is lost through the metal gasholder; hence it troubles in winter and in colder regions.
- iii) Gas holder requires painting once or twice a year
- iv) Flexible pipes joining the gasholder need maintenance.



Fixed Dome Type (CONSTANT VOLUME)

- This type of **biogas plant** is very economical in design. It works with the constant volume principle.
- The main structure is made up of **brick** and **cement masonry**. This type of plant doesn't have any moving parts so it is safe from wear and tear.
- The operating pressure varies from **0 to 100 cm** of water column.
- It is also known as **Janata model**.



Fixed dome biogas plant (Janata model).

➤ Advantages

- It has low cost compare to floating drum type, as it uses only cement and no steel.
- It has non-corrosion trouble.
- It this type heat insulation is better as construction is beneath the ground.
- Temperature will be constant.
- Cattle and human excreta and long fibrous stalks can be fed.
- No maintenance.

➤ Disadvantages:

- This type of plant needs the services of skilled masons, who are rather scarce in rural areas.
- Gas production per cum of the digester volume is also less.
- Scum formation is a problem as no stirring arrangement
- It has variable gas pressure

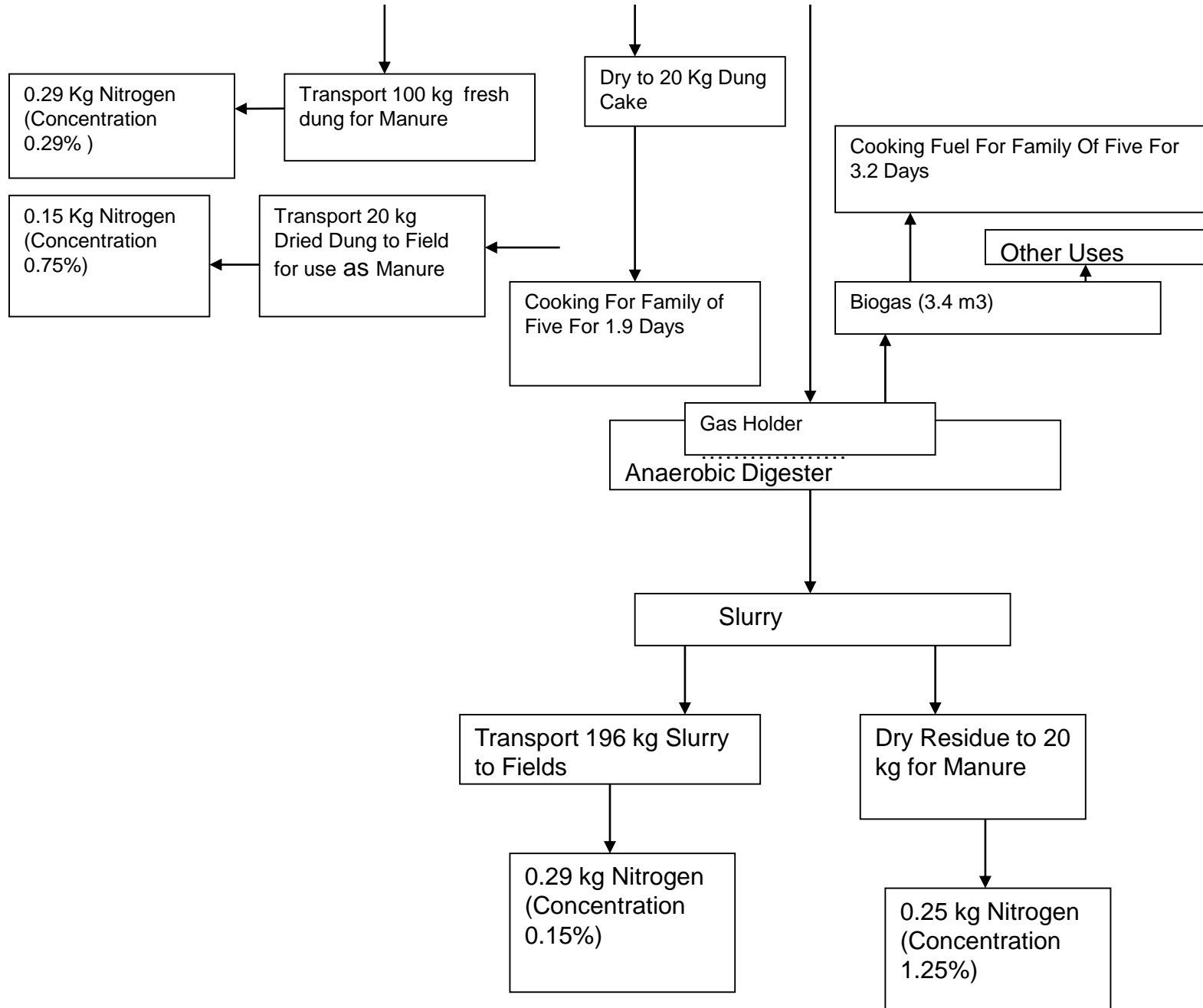
Properties of Biogas

- Biogas is about 20 percent lighter than air (density is 1.15kg/m^3)
- Ignition temperature in the range of 650° to 750° C
- It is an odourless and colourless gas that burns with clear blue flame similar to that of LPG gas
- Its calorific value is 20 Mega Joules (MJ) per m^3 and burns with 60 percent efficiency in a conventional biogas stove
- Explosion limit is 5 to 14% in air
- Air to Methane ratio for complete combustion 10:1 by volume
- 1 m^3 of biogas = 1.613 lt of kerosene = 2.309 kg of LPG = 0.213 khz of electricity
- Pressure and temperature to liquefy: Biogas need 34.47 bars at -83°C where LPG needs 11.03 bars at ambient temperature.

Potential Gas Production from Different Feed Stocks

S. No	Type of feed stock	Gas yield per kg. (Cu.m)	Normal feed availability per animal per day kg (wet weight)	Gas yield per day (Cu.m)
1	Cow dung	0.036	10.0	0.36
2	Buffalo dung	0.036	15.0	0.54
3	Camel dung	0.056	6.0	0.336
4	Horse dung	0.045	10.0	0.45
5	Sheep dug	0.042	1.0	0.042
6	Pig (Approx. 50 kg)	0.08	2.25	0.18
7	Chicken (Approx 2 kg)	0.062	0.18	0.011
8	Human excreta	0.07	0.40	0.28

100 Kilograms Fresh Cattle Dung



Number of Cattle Required for Different Capacity of Plants and Family sizes

S. No.	Size of plant (m3)	Amount of wet dung required daily (kg)	Approximate no. of cattle required	Approximate family size
1	1	25	2-4	1-4
2	2	50	4-5	5-8
3	3	75	6-8	9-12
4	4	100	9-10	13-16
5	6	150	11-15	17-22
6	8	200	13-16	23-26
7	10	250	17-20	27-32

QUANTITY OF BIOGAS REQUIRED FOR A SPECIFIC APPLICATION

USE	SPECIFICATION	QUANTITY OF GAS(M ³ /HR)
Cooking	2" burner	0.33
	Per person per day	0.34-0.42
Gas lighting	Per lamp of 100 candle power	0.13
Engine	Converted to biogas ,per hp	0.45-0.51
Refrigerator	Per ft ³ capacity	0.028
Gasoline	1 lit	1.33 to 1.87
Diesel	1lt	1.5 to 2.07
Boiling water	1lt	0.11