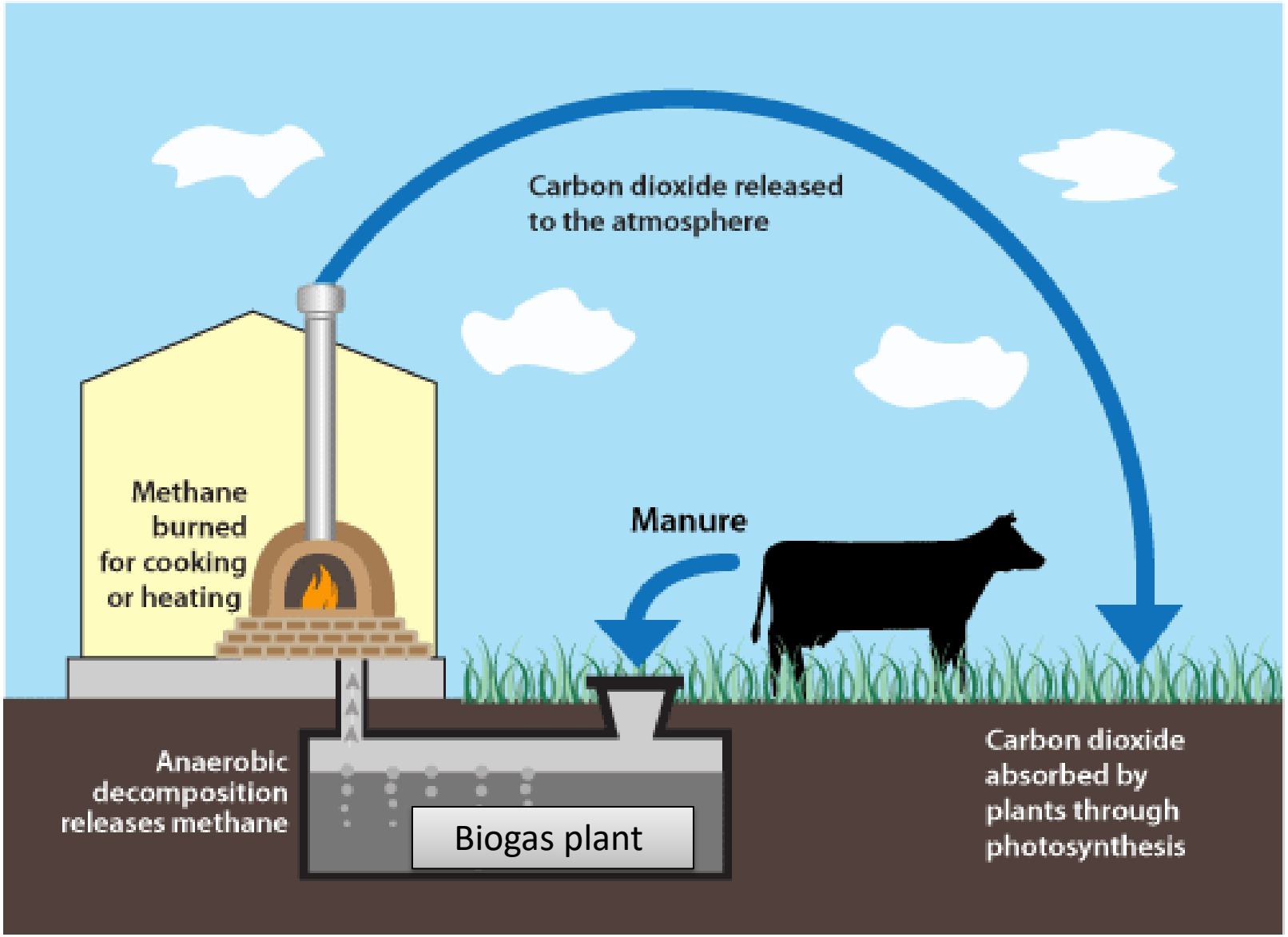
Lecture-3
Familiarization with different types of biogas plants.

- Biogas is a mixture of gases produced by the breakdown of organic matter in the absence of oxygen (an aerobically) and presence of moisture.

- The biogas so obtained is a mixture of methane (CH_4) : 55-65% and Carbon dioxide (CO_2) : 30- 40%. It also contains traces of Nitrogen, Hydrogen, carbon monoxide, oxygen, hydrogen sulphide and water.
- The calorific value of biogas is 4713 kcal/ m^3.
- It can be burnt with thermal efficiency of 60%.

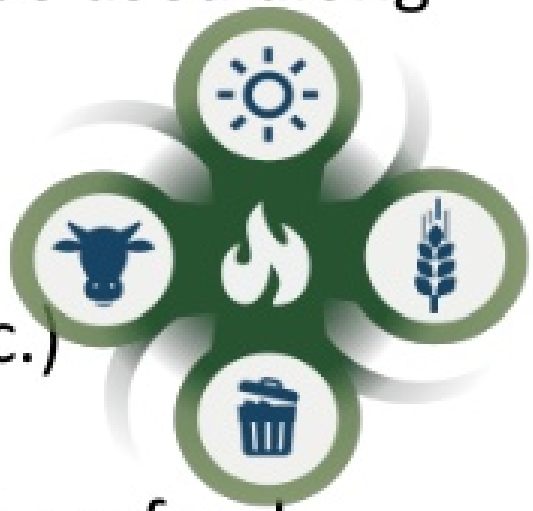
- The calorific value of dung cake is 2093 kcal/kg and the thermal efficiency of burning them in stove is about 11%.
- The calorific value of firewood is 4978 kcal/kg and the thermal efficiency of burning them in stove is about 17.3%.
- So biogas is an efficient fuel for cooking.
- The biogas plant was first installed in 1941 at IARI New Delhi.



BIOGAS AND ENVIRONMENT

Raw materials required

- Forms of biomass listed below may be used along with water.
- Animal dung
- Poultry wastes
- Plant wastes (Husk, grass, weeds etc.)
- Human excreta
- Industrial wastes(Saw dust, wastes from food processing industries)
- Domestic wastes (Vegetable peels, waste food materials)



What is important

Ratio of water & Nutrients

- Ratio
  - 1 water :1 solid waste
- Nutrients
  - carbon (C) and nitrogen (N)
    - N= provide nutrients for the growth and multiplication of the anaerobic organisms
    - Experiment with different types of solid waste!

Advantages:

a) The technology is very suitable for rural areas.

b) Biogas is locally generated and can be easily distributed for domestic use.

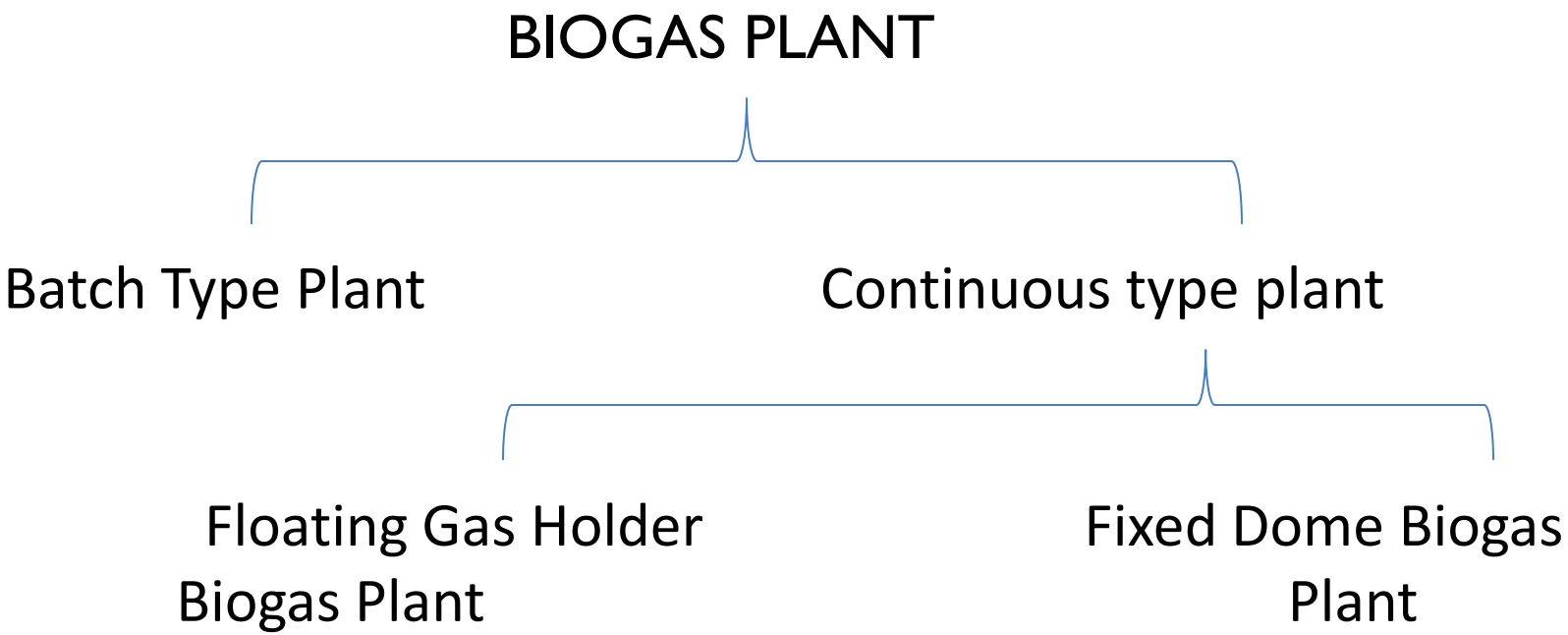
c) Biogas reduces the rural poor from dependence on traditional fuel sources, which lead to deforestation.

d) The use of biogas in village helps in improving the sanitary condition and checks environmental pollution.

e) The by-products like nitrogen rich manure can be used with advantage.

f) Biogas reduces the drudgery of women and lowers incidence of eye and lung diseases.

Classification of biogas plants:



BATCH TYPE BIOGAS PLANT

a) Batch type biogas plants are appropriate where daily supplies of raw waste materials are difficult to be obtained.

b) Batch type plant is charged at 50-60 day intervals.

c) Once charged, it starts supplying the gas after 8-10 days and continuous to do so for about 40-50 days till the process of digestion is completed. Afterwards it is emptied and recharged.

d) Gas production in batch type is uneven.

e) Several digesters occupy more space.

f) This type of plants require large volume of digester, therefore, initial cost becomes high.

g) Such plants are installed in European countries.

h) Does not suit the conditions in Indian rural areas

CONTINOUS TYPE BIOGASS PLANT

- In continuous type biogas plant, the supply of the gas is continuous and the digester is fed with biomass regularly.
- Plant operates continuously and is stopped only for maintenance or for sludge removal.
- The gas produced is stored in the plant or in a separate gas holder.

- This type of plant are very popular in India and China.
- Other features:

I. Retention period is less
II. Less problems as compared to batch type.
III. Small digestion chambers are required.

- Hydraulic Retention Time:

The number of days the feed material is required to remain in the digester for the release of its gas (about 80-90%). It is based on temerature zones of the country .

HRT is 30 days for Average ambient temp. More than 20 degree C.

40 days for 15-20 degree C and 55 days for temp. less than 15 degree C. For Rajasthan 40 days HRT is recommended.

- Scum: The thin dry layer often formed at the top of the slurry is known as scum.

OPERATIONAL PARAMETERS OF A BIOGAS PLANT

Operation of a bio gas plant is affected by a no. of factors:-

A. Temperature

- Methane- forming bacteria works best in temp. ranges 25^{0}-55^{0} C
- Digestion at higher temp. proceeds more rapidly than at lower temp.
- The gas production decreases sharply below 20^{0} C and almost stops at 10^{0} C

B. Pressure

- A minimum pressure of 6-10 cm of water column i.e, 1.2 bar is ideal for proper functioning.
- It should never be allowed to exceed 40-50 cm of water column.
- Excess pressure inhibits leakage in masonry.

C. Solid to moisture ratio in the biomass

- The solid content in the slurry should be maintained between 7.5 to 10 per cent for optimum gas production.
- If water content is too high, the mean slurry temp. and gas production drops.
- If water content is too low, acids accumulate and hinder fermentation process.

D. pH value

- The pH of slurry in the digester should be maintained between 6.8 and 7.2 for optimum gas production and this can be accomplished by maintaining proper feeding rate.
- At higher feeding rate the retention period will be less and undigested slurry may come out.
- So optimum feed rate should be maintained.

F. Carbon to nitrogen ratio

The optimum C/N ratio is 30:1 for maximum microbiological activity.

G. Seeding of biomass with bacteria

- To start and accelerate the fermentation process, a small amount of digested slurry containing a methane forming bacteria is added to the freshly charged plant. This process is known as seeding.
- Seeding helps to accelerate the starting of the digestion process.

H. Mixing or stirring

Mixing

- Maintains uniformity in substrate concentration.
- Minimizes formation of scum.
- Prevents the deposition of solids at the bottom.

I. Retention time

- Retention time should be optimum to obtain 70-80% complete digestion.

Fix dome type biogas plants

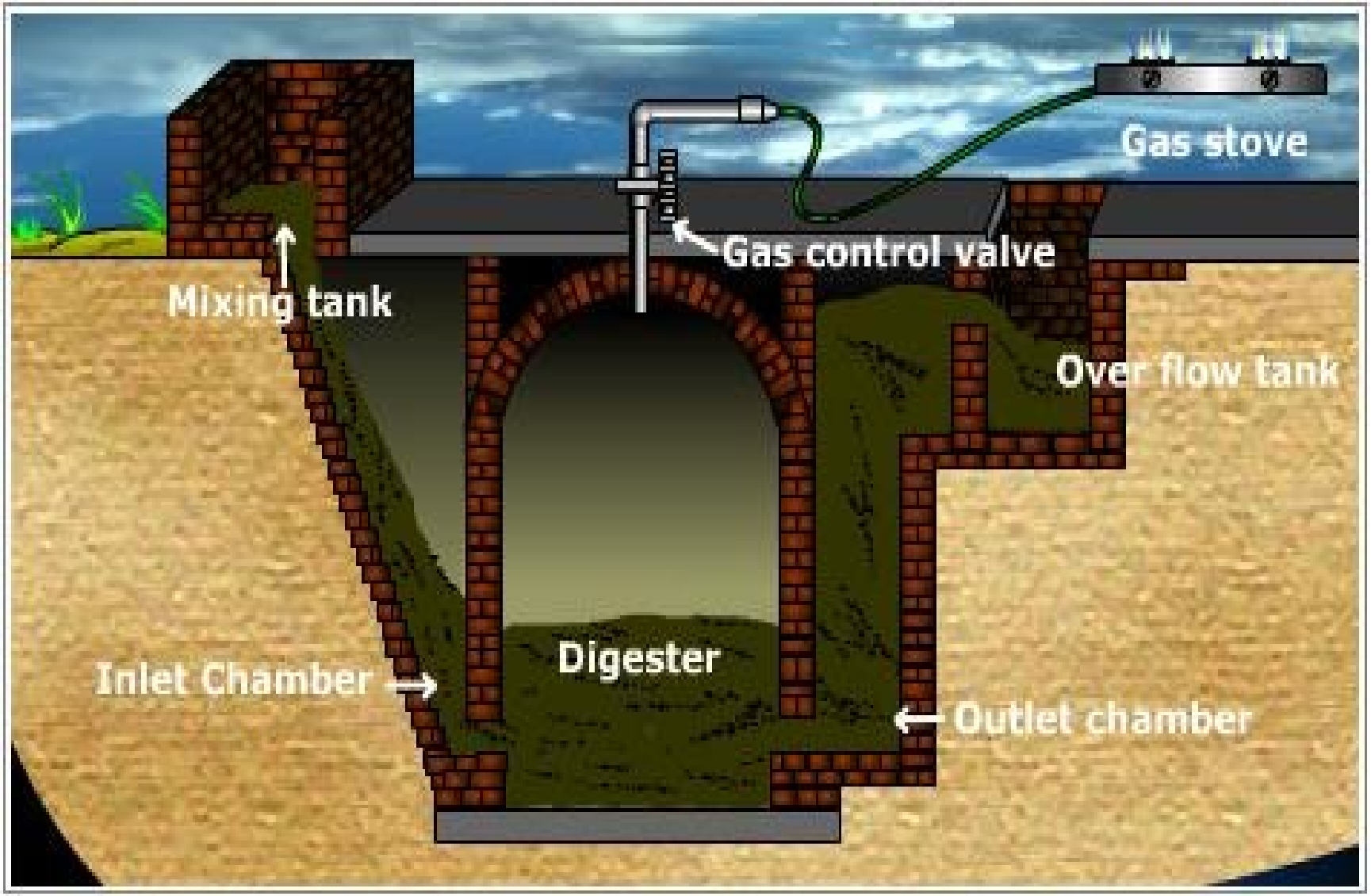
- **Janata Biogas plant:**

It was developed by PRAD (Planning Research and Action Division) in 1978.

- **Deenbandhu biogas plant:**

It is modification and advance version of Janata biogas plant. Action for Food Production (AFPRO) developed it in 1984.

Janta Type Biogas plant



Construction

The Janata biogas plant is a brick and cement structure having the following five sections:

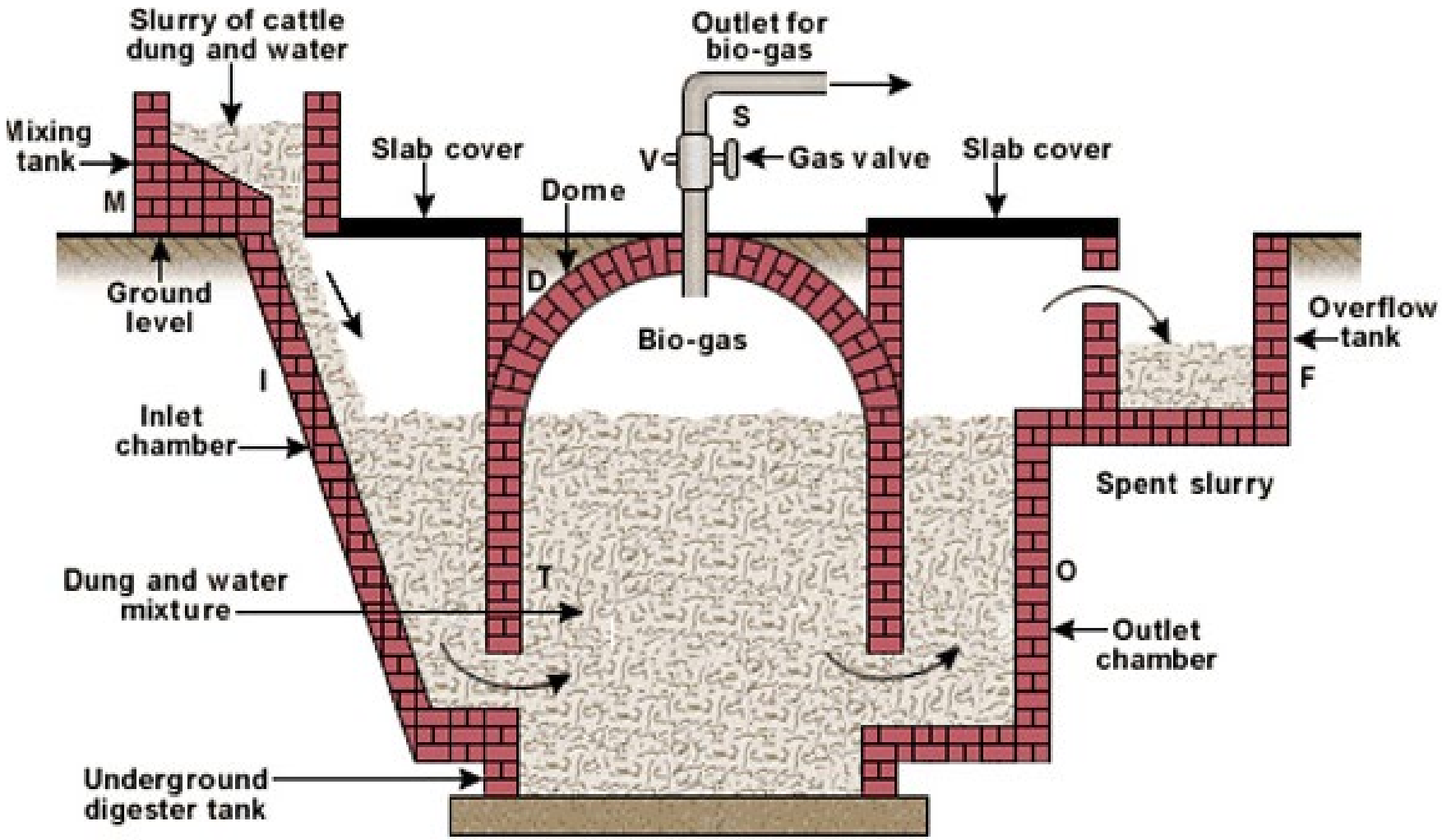
1. Mixing tank: above the ground level.
2. Inlet tank: The mixing tank opens underground into a sloping inlet chamber.
3. Digester: The inlet chamber opens from below into the digester which is a huge tank with a dome like ceiling.
4. Gas outlet: The ceiling of the digester has an outlet with a valve for the supply of biogas.
5. Outlet tank: The digester opens from below into an outlet chamber. The outlet chamber opens from the top into a small over flow tank.

Working of Fixed Dome type Biogas Plant

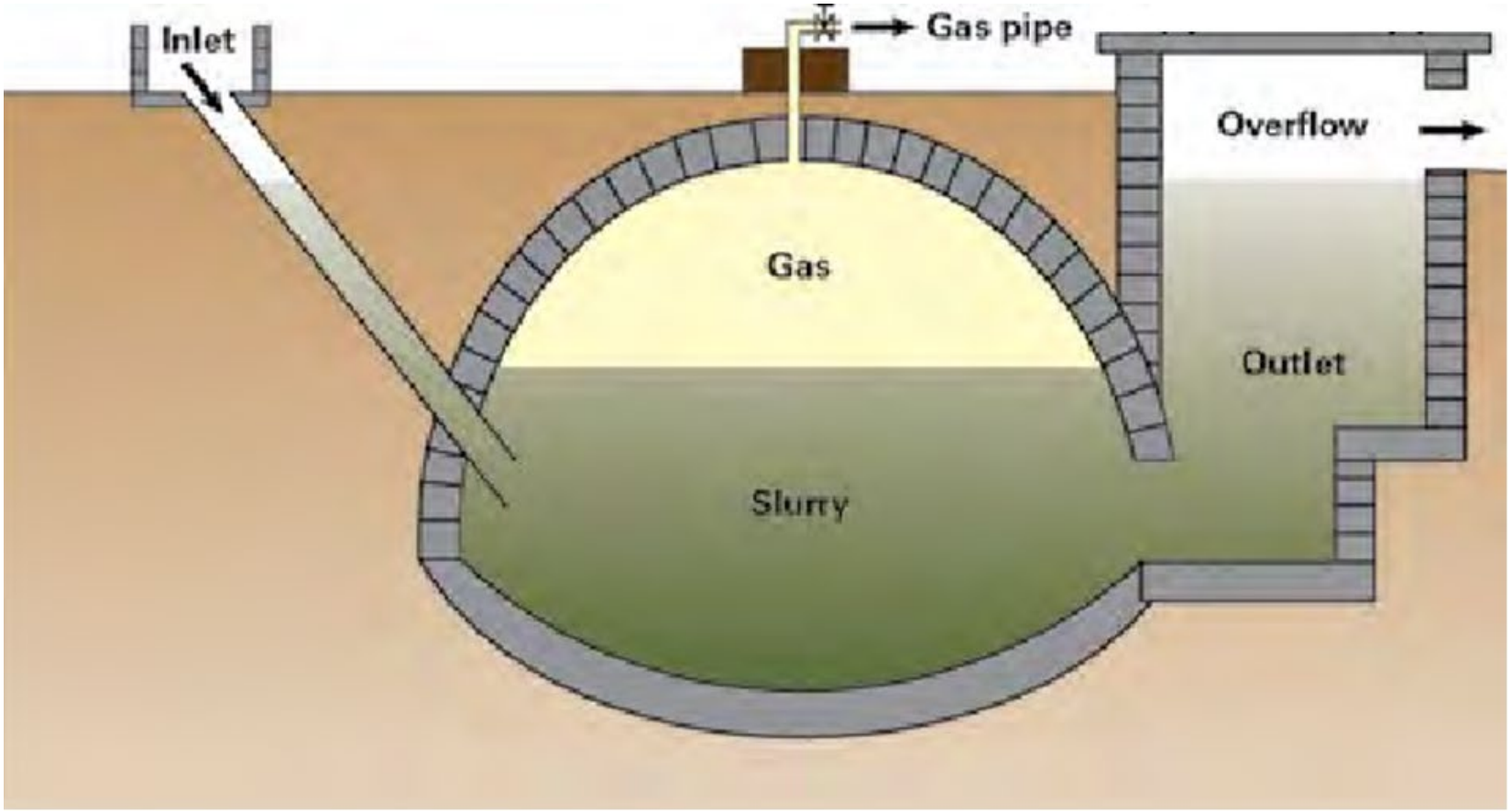
- The various forms of biomass are mixed with an equal quantity of water in the mixing tank. This forms the slurry.
- The slurry is fed into the digester through the inlet chamber.
- Initially the digester is filled with the slurry, the further introduction of slurry is stopped and the plant is left unused for some days.
- During these days, anaerobic bacteria present in the slurry decomposes or ferments the biomass in the presence of water.
- As a result of anaerobic fermentation, biogas is formed, which starts collecting in the dome of the digester.

- As more and more biogas starts collecting, the pressure exerted by the biogas forces the spent slurry into the outlet chamber.
- From the outlet chamber, the spent slurry overflows into the overflow tank.
- The spent slurry is manually removed from the overflow tank and used as manure for plants.
- The gas valve connected to a system of pipelines is opened when a supply of biogas is required.
- To obtain a continuous supply of biogas, a functioning plant can be fed continuously with the prepared slurry.

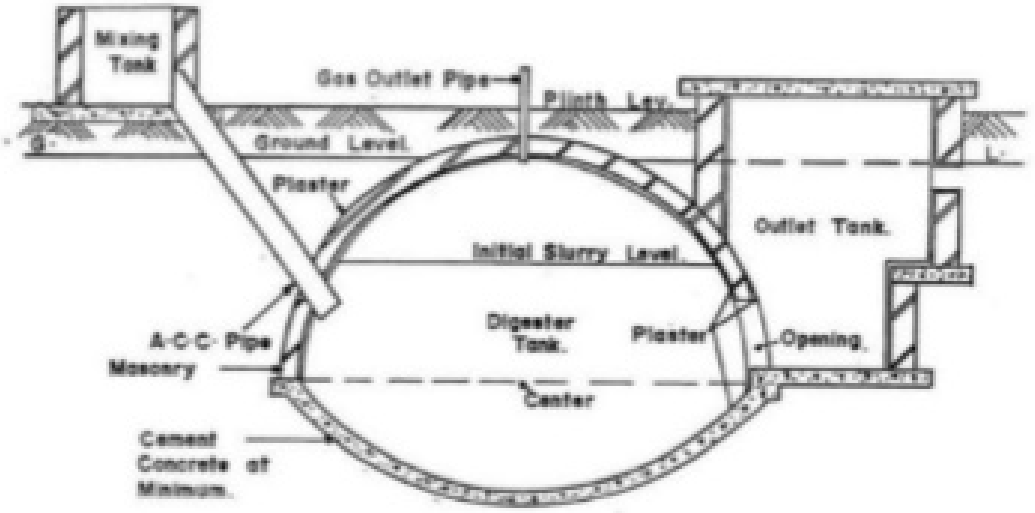
JANATA MODEL



Deenbandhu Biogas Plant



❑ Deenbandhu



- The biogas plant has a hemispherical fixed dome type biogas plant.
- The plant like two saucers kept on each other face to face.
- Working principle is same as janta model
- Low cost biogas plant

Components of biogas plant:

1. Foundation: The foundation of the plant is bowl shaped with a collar around the circumference. The construction of the digester dome is done on this collar.
2. Dome Digester: The dome of the digester is divided in 2 parts.

The bottom part is called digester. The mixture of dung and water decomposes in this part and produces gas due to bacterial activity. Gas storage : The upper part of the digester dome is called gas storage. The gas produced by the bacterial activity is stored in this place.

3.Mixing tank: Slurry after proper mixing is allowed from this tank to inlet pipe.

4..Gas outlet pipe: A nipple is fitted on the top of the dome, which is connected to a GI pipe.

5.. Inlet pipe: The pipe through which fresh dung and water enters the plant is called Inlet pipe. This pipe is connected to a small tank for mixing dung and water. gas reaches the kitchen through this pipe.

6.Outlet tank:The portion of the plant where the slurry accumulates after coming out of the digester is called outlet tank. It is in two parts. The first bottom part is small and rectangular, which is connected to the dome opening, the other part of outlet tank is also rectangular but of big size having a overflow outlet.

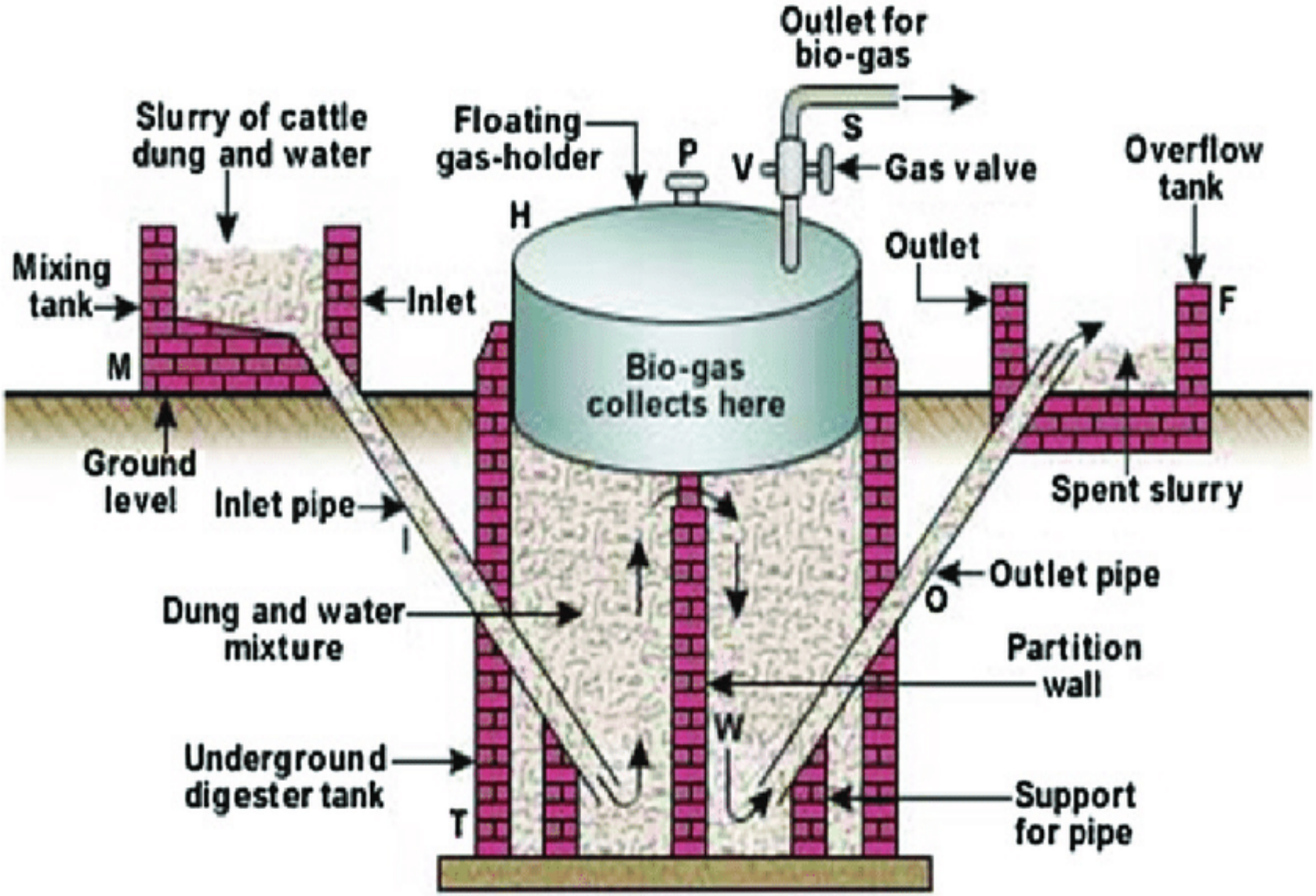
Dome construction

Floating gas holder type biogas plant

a. KVIC
b. Pragati
c. Ganesh

- In 1961 Khadi and Village Industries Commission (KVIC) patented this design.

KVIC MODEL


Outlet for bio-gas
Slurry of cattle dung and water
Floating gas-holder
P
V
S
Gas valve
Overflow tank
H
Outlet
Mixing tank
Inlet
F
M
Bio-gas collects here
Ground level
Inlet pipe
I
Spent slurry
Outlet pipe
O
Dung and water mixture
Partition wall
W
Underground digester tank
Support for pipe
T

Construction:

The floating gas holder type of biogas plant has the following chambers/ sections:

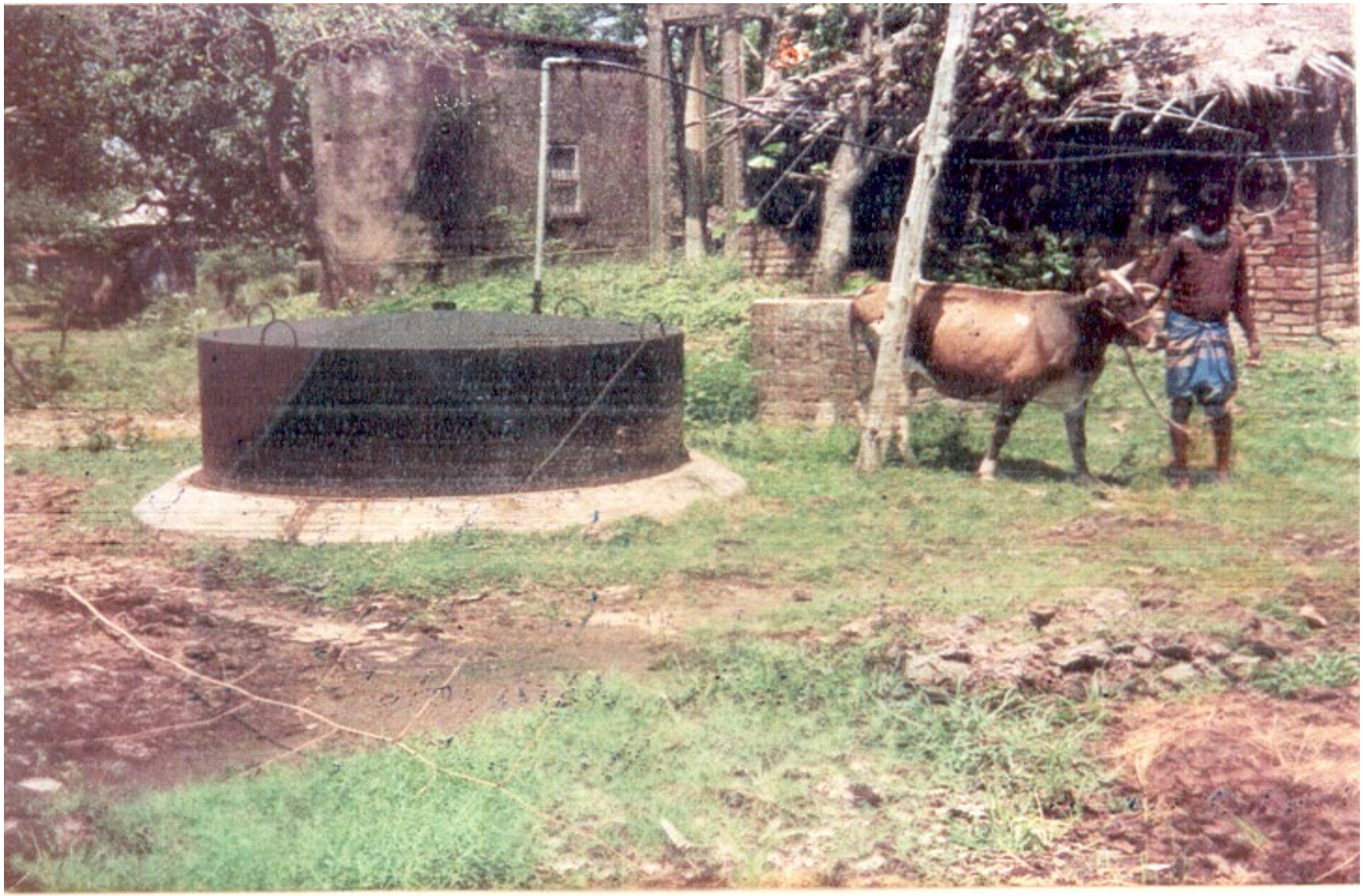
- Mixing Tank - present above the ground level.
- Digester tank - Deep underground well-like structure. It is divided into two chambers by a partition wall in between.
- It has two long cement pipes i) Inlet pipe opening into the inlet chamber for introduction of slurry. ii) Outlet pipe opening into the overflow tank for removal of spent slurry.

- Gas holder - an inverted steel drum resting above the digester. The drum can move up and down i.e., float over the digester.
- The gas holder has an outlet at the top which could be connected to gas stoves.
- Over flow tank - Present above the ground level.

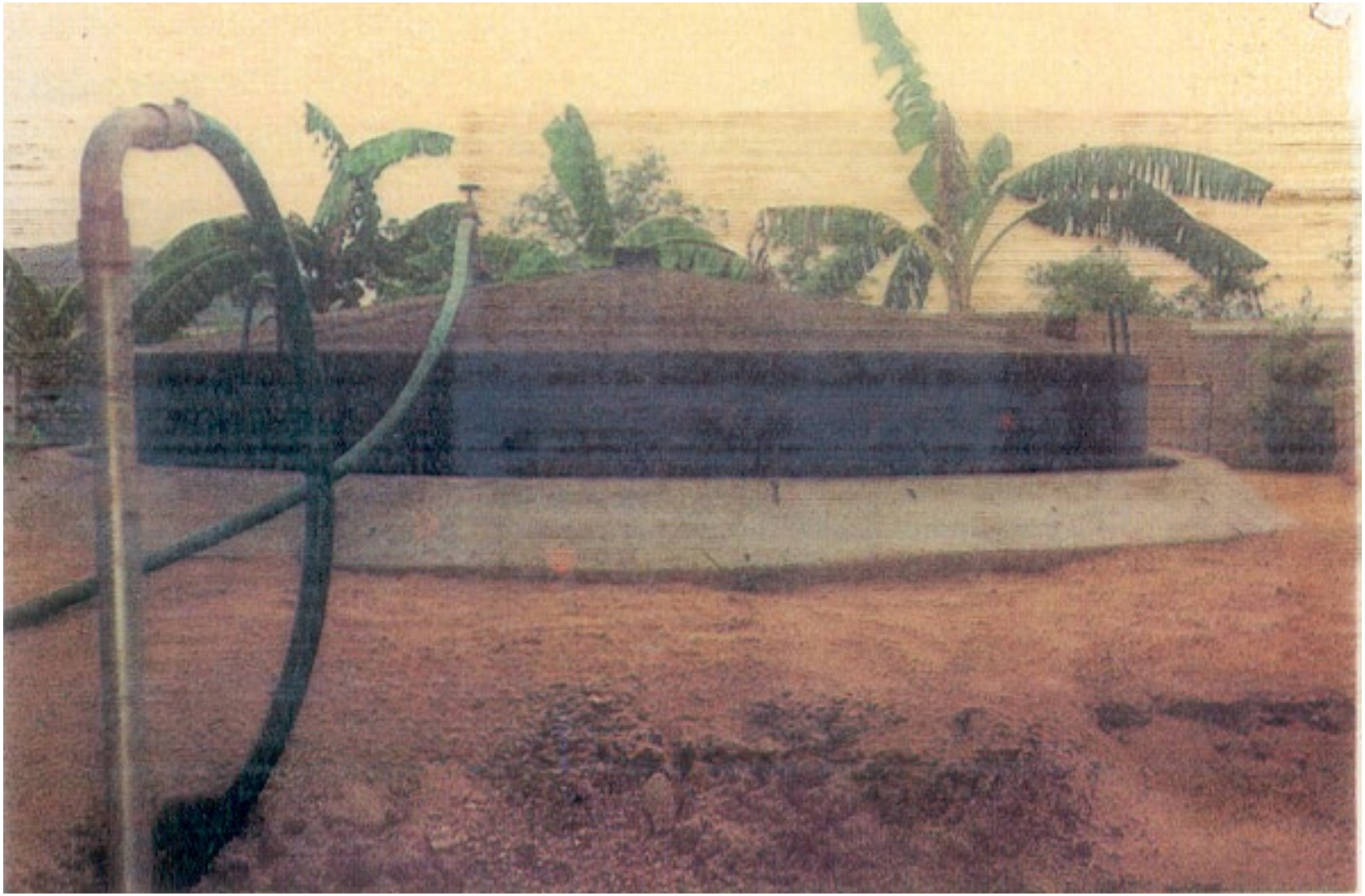
What is important

- Stirring
  - Prevents scum growth
- Retention Time
  - Effected by temperature, dilution, loading rate, etc.
  - A normal period for the digestion of dung would be 2 to 4 weeks
  - At high temperature bio-digestion occurs faster
    - Between 20° and 30°

• The gas holder cannot rise up beyond a certain level.
• As more and more gas starts collecting, more pressure begins to be exerted on the slurry.
• The spent slurry is now forced into the outlet chamber.
• When the outlet chamber gets filled with the spent slurry, the excess is forced out through the outlet pipe into the overflow tank. This is later used as manure for plants.
• The gas valve of the gas outlet is opened to get a supply of biogas.
• Once the production of biogas begins, a continuous supply of gas can be ensured by regular removal of spent slurry and introduction of fresh slurry.



FAMILY SIZE BIOGAS PLANT



IBP/CBP PLANT

PRAGATI MODEL