Presence of sulphur is highly undesirable in coal to be used for making coke for iron industry, since it is transferred to the iron metal and badly affects the quality and properties of steel. Moreover, oxides of sulphur (formed as combustion products) *pollute* the atmosphere and leads to *corrosion.*

(4) **Oxygen** *content decreases the calorific value of coal. High oxygen-content coals* are characterized by *high inherent moisture, low calorific value, and low coking power.* Moreover, oxygen is in combined form with hydrogen in coal and thus, hydrogen available for combustion is *lesser* than actual one. An increase in 1% oxygen content decreases the calorific value by about 1.7% and hence, *oxygen is undesirable. Thus, a good quality coal should have low percentage of oxygen.*

BIOMASS

Biomass *is the waste organic matter (mostly from the dead plants and animals) which used either as a source of energy (by burning or biogas production) and/or as a chemical feedstock.* For example, wood, cattle dung, bagasse (remaining part of sugar cane) poultry wastes, vegetable wastes, waste paper, waste cotton clothes, plant wastes (grass, husk leaves,, skins, weeds), human excreta, birds excreta, dead animals, sewage, etc. Biomass consists of carbon compounds which may be used as a source of energy by using either of the following methods :

(1) Biomass such as wood,, cattle dung, bagasse, plant wastes, agricultural wastes, dry vegetable wastes,, etc. is used *directly* in Chulhas for getting energy. However, by doing so a lot of heat energy is wastes and lot of smoke, etc. is liberated, thereby causing blackening of utensils and houses. Moreover, it liberates poisonous gas carbon monoxide and leaves ash as residue.

(2) Biomass is converted into *biogas*, which is used for heating and lighting purposes. By burning biogas much larger amount of heat is liberated. For example, 1 kg of dry cattle dung (or 4.25 kg of fresh dung) liberates only 100 kJ of effective heat on direct burning, but when 1 kg of dry cattle dung is converted into biogas, approximately 160 litres of biogas is produced which can supply about 800 kJ of heat on burning. Moreover, on burning biogas does not produce poisonous gas, CO.

Note : Biomass refers to *"all materials that are produced by photosynthesis and potentially useful as energy sources and for the production of organic chemicals"*. Biomass is plants or their principal components (cellulose, starch, sugars). Some biomass (*e.g.*, wood) may be used directly as a fuel ; while others (*e.g.*, fossil fuels) may be converted into other gaseous (*e.g.*, producer gas), liquid (*e.g.*, gasoline, diesel, kerosene, etc.) or solid (*e.g.*, coke) materials for use as fuels or raw materials for producing chemicals (*e.g.*, sugars to produce-ethanol, ethanoic acid, etc. and wood to methanol).

It may be pointed that *plants are no longer being converted in significant quantities to fossil fuel (coal, petroleum, natural gas) by geologic process, so the total amount of biomass available to us is dwindling day-by-day.*

Advantages of converting biomass into biogas : (*i*) *Biogas production is very economical.* It has been found that 1 kg of dry cattle dung gives about 160 litres of gobar gas, which can supply 800 kJ of heat. On the other hand, 1 kg of dry dung on direct burning gives only 100 kJ of effective heat.

(*ii*) The gas has all advantages of gaseous fuel like *cleanliness absence of smoke, flexibility, etc.*

(*iii*) It *does not contain poisonous gas*, CO, as an ingredient.

(*iv*) It provides simultaneously excellent yield of *good manure.*

BIOGAS

Biogas *is produced by the degradation of biological matter by the bacterial action (of anaerobic bacteria) in the absence of free oxygen.*

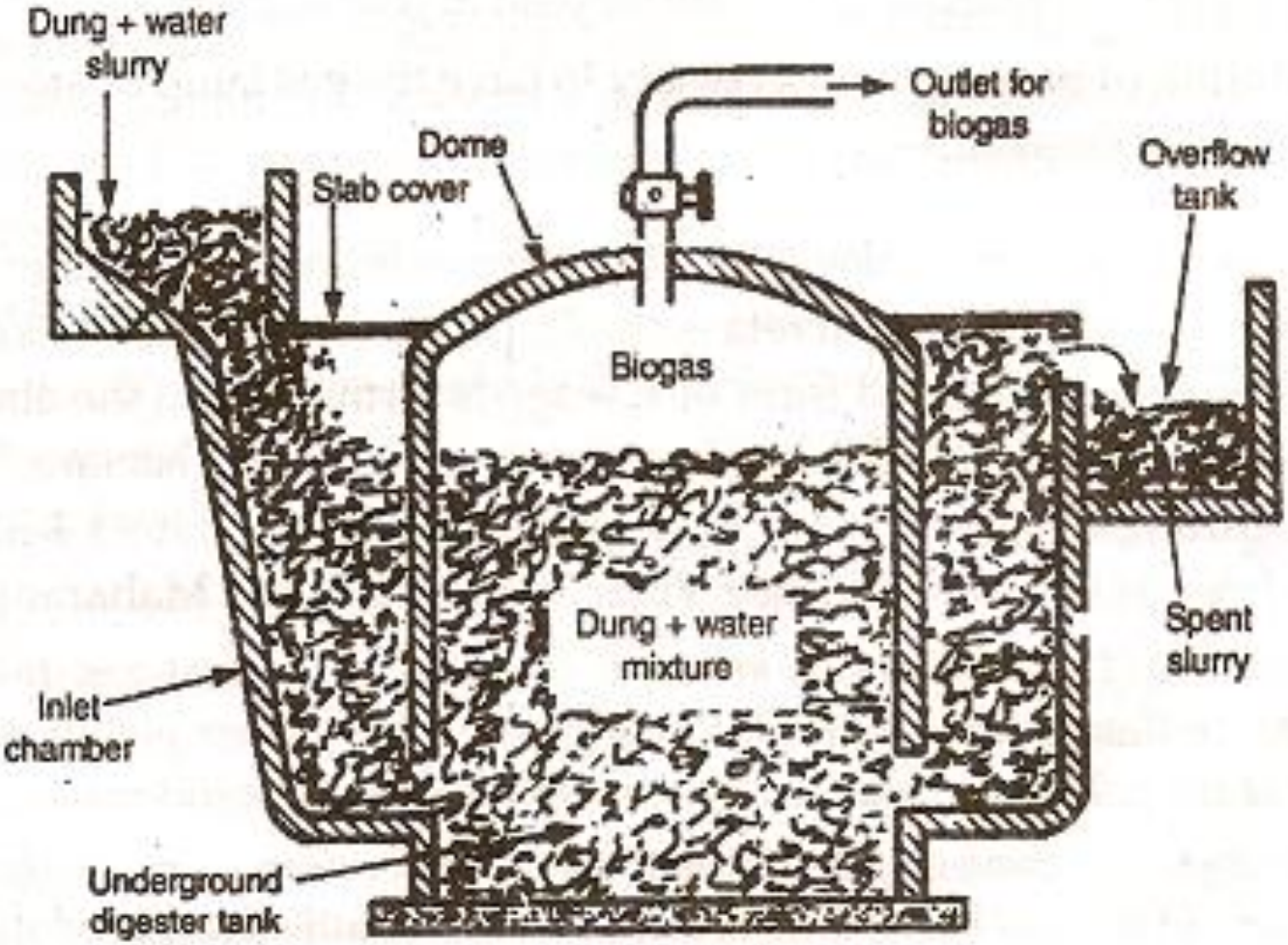
Examples : (*i*) *Natural gas* is a biogas, which results after a long period decay of animal and vegetable matters, buried inside the earth. (*ii*) *Gobar gas* (or dung gas), which is produced by the anaerobic fermentation of cattle dung. (*iii*) *Biogas* can also be produced from the sewage waste, and other organic wastes.

Constituents : The average composition of biogas is : (*i*) CH_4 (methane) – 50-60% (a combustible gas). (*ii*) CO_2 – 30-40% (a non-combustible gas). (*iii*) H_2 – 5-10% (a combustible gas). (*iv*) N_2 – 2-6% (a non-combustible gas). (*v*) H_2S – traces (a combustible gas). Out of these, the constituent *methane* (an extremely good fuel) makes biogas an *excellent fuel*.

Raw materials for biogas : Animal dung, poultry wastes, vegetable wastes, waste paper and cotton clothes, plants wastes (grass, husk, leaves, skins, weeds), human excreta, bird's excreta, etc.

Manufacture of dung (or gobar) gas : It is produced *by the anaerobic degradation of cattle dung*. It is carried out in a ***gobar gas plant*** which consists of a well-shaped underground tank (called *digester*) covered with *dome-shaped roof*, both made of bricks and cement. The dome of the digester is fixed so that it acts as *gas holder* (or gas strong tank) for the biogas produced. At the top the dome, there is a *gas outlet pipe* and a *gas valve*. On the left side of the digester, there is a *sloping inlet chamber* and on the right side, there is a *rectangular outlet chamber*, both made of bricks and cement. Fresh cattle dung + water slurry is introduced from the inlet chamber ; while spent dung slurry gets collected in the outlet chamber. The inlet chamber is connected to the *mixing tank* ; while the outlet chamber is connected to the *overflow tank*.

Working : *Slurry* (made by mixing cattle dung and water in equal proportion in *mixing tank*) is fed into the digester tank via the inlet chamber, till the slurry level becomes nearly equal to the cylindrical top level. In about 50 to 60 days, the biogas plant starts functioning. During this time period, the cattle dung undergoes



Fixed-dome type biogas plant.

fermentation in the presence of *anaerobic bacteria* with gradual evolution of biogas, which starts collecting in dome-shaped space. As the time passes, more and more biogas collects inside the dome, thereby exerting pressure on the slurry in the digester tank and this in-turn forces the *spent slurry* to the overflow tank via outlet chamber. From the overflow tank, the spent slurry is withdrawn periodically and used as a good *manure*.

From time to time, fresh slurry is fed to the digester so as to get regular supply of biogas. The biogas collected in dome is taken out through the outlet pipe by opening the gas valve and then used as fuel gas.

Note : Fixed-dome type biogas plant is also known as *Janta gobar gas plant*.

Advantages of fixed-dome type biogas plant : (*i*) Such a plant is *quite cheap*, since only bricks and cement are used for its construction. (*ii*) There is *no danger of corrosion* of such a plant.

Uses of biogas : (*i*) For cooking food. (*ii*) As a fuel to run engines. (*iii*) As an illuminant in villages.

Reasons for the use of animal dung in biogas plants : (1) *Biogas* (produced from animal dung) *burns without producing any residue, smoke, etc.* (2) The gas, on burning, liberates a *larger amount of heat* than that obtained by burning animal dung directly. (3) The waste left in the biogas plants can be used as a better manure than animal dung itself. (4) Burning of biogas produces *no harmful gases*.

Reasons for considering biogas an ideal domestic fuel : Biogas is an ideal fuel for domestic use, because : (1) It burns *without smoke*, thereby causing *no pollution*. (2) Its calorific value is *high*. (3) It is the *cheapest* gaseous fuel. (4) It is very *clean*, and *convenient* fuel in use. (5) It involves *no storage problem*, since biogas can be supplied through pipes directly from the biogas plant.

Advantages of biogas : (*i*) *Biogas production is very economical.* It has been found that 1 kg of dry cattle dung gives about 160 litres of gobar gas, which can supply 800 kJ of heat. On the other hand, 1 kg of dry dung on direct burning gives only 100 kJ of effective heat.

(*ii*) The gas has all advantages of gaseous fuel like *cleanliness, absence of smoke, flexibility, etc.*

(*iii*) It *does not contain poisonous gas*, CO, as an ingredient.

(*iv*) It provides simultaneously excellent yield of *good manure*.

Limitation of biogas : It is necessary to have the gas lamp or stove or burner *within 10 metres of the plant.*

Sewage gas plants *employ domestic sewage as biomass.* Domestic sewage includes human faeces (human excreta – stool), urine, etc. In Delhi (Okhla – South Delhi), screened out semi-solid form of sewage is fermented in the absence of air under the action of bacteria. The products are *sewage gas* and *manure*. Sewage gas is supplied through pipes to nearby localities like Okhla, Jamia Millia Islamia University, Friends Colony, Sukhdev Vihar, Ishwer Colony, Maharani Bagh, etc.

Advantages of sewage gas plant : (*i*) It provides useful fuel gas. (*ii*) It provides manure for agriculture purposes. (*iii*) It helps in controlling water pollution, since it removed most of the pollutants from water bodies in which sewage inflows.

Advantages of converting cattle dung into biogas over using cattle dung cakes directly as fuel : (*i*) Bio-gas burns *without smoke;* whereas cattle dung produces smoke on burning. (*ii*) Biogas has *higher calorific value* than the cattle dung from which it is produced.

(*iii*) Biogas is a *very clean fuel*, and convenient in use ; whereas cattle dung on burning produces smoke. (*iv*) Biogas does not cause any *air pollution* ; where as cattle dung causes pollution on burning, since it evolves CO on burning. (*v*) It can be is used *directly* from the gas plant. (*vi*) Biogas can be burnt or put off at *moment's notice* ; whereas it takes time to start or stop burning of cattle dung. (*vii*) The efficiency of burning of biogas is *much higher* than that of cattle dung.

Promoting biogas plants : Because of the multiple advantages of biogas as a fuel, as well as supplying manure, the *Khadi, and village Industries Commission*, and other government. agencies are engaged in promoting the installation of biogas plants in our country on large scale. They are *assisting* the farmers in the following ways :

(*i*) Providing *government loans* to the farmers for the installation of biogas plants. (*ii*) Providing the *necessary materials at the subsidised rates* to the farmers for the construction of biogas plants. (*iii*) Providing *adequate scientific knowledge* regarding the construction of biogas plants. (*iv*) Providing *training free of cost* to the farmers regarding the operations of biogas plants.

Cattle dung versus biogas obtained from it.

Burning cattle dung directly	*Burning biogas obtained from cattle dung*
1. *Lower* amount of heat is liberated. For example, 1 kg of dry dung (or 4.25 kg of fresh dung) liberates only 100 kJ of effective heat on direct burning.	*Higher* amount of heat is liberated by burning biogas obtained from the same mass of cattle dung. 1 kg of dry dung (or 4.25 kg of fresh dung) gives approximately 160 L of gobar gas, which can supply 800 kJ of heat.
2. Cattle dung on burning liberates smoke, dust, dirt, etc., and causes blackening of utensils, and houses.	Gobar gas has all the advantages of gaseous fuels like cleanliness of utensils, flexibility, absence of smoke, dust, dirt, etc.
3. Cattle dung flame can provide temperature only upto 300°C.	Flame of biogas can provide temperature of 540°C.
4. Cattle dung liberates poisonous gas, carbon monoxide, on burning.	Gobar gas does not produce any poisonous gas on burning.
5. Cattle dung on burning leaves *ash* as residue.	Gobar gas on burning leaves *no ash* as residue.
6. Cattle dung on burning *does not leave* any manure.	Gobar gas also gives simultaneously good quantity of *manure*.