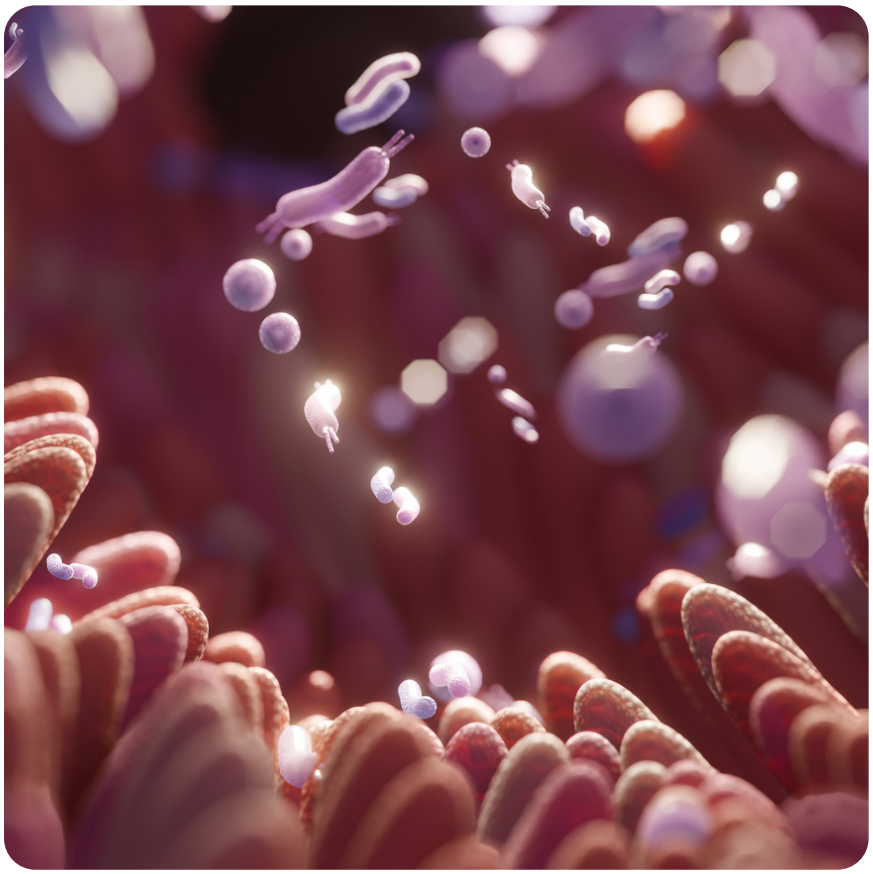
PRE-MEDICAL

ZOOLOGY

ENTHUSIAST | LEADER | ACHIEVER



STUDY MATERIAL

Microbes in human welfare

ENGLISH MEDIUM

Copyright Statement

M.S. SWAMINATHAN (1925)

Born in August 1925 in Kumbakonam in Tamil Nadu, Monkambu Sambasivan Swaminathan did his graduation and post-graduation in Botany from Madras University. He worked in different capacities in large number of institutions in India and abroad and developed his expertise in genetics and plant breeding.

The School of Cytogenetics and Radiation Research established at the Indian Agricultural Research Institute (IARI) enabled Swaminathan and his team to develop short-duration high-yielding varieties of rice including scented Basmati. He is also known for the development of the concept of crop cafeteria, crop scheduling and genetically improving the yield and quality.

Swaminathan initiated collaboration with Norman Borlaug, which culminated in the 'Green Revolution' through introduction of Mexican varieties of wheat in India. This was highly recognised and appreciated. He is also the initiator of 'Lab-to-Land', food security and several other environmental programmes. He has been honoured with Padma Bhushan and several other prestigious awards, medals and fellowships by institutions of excellence.

MICROBES IN HUMAN WELFARE

01. INTRODUCTION

- **Introduction**
- **Microbes in Household Products**
- **Microbes in Industrial Products**
- **Microbes as Biocontrol Agents**
- **Microbes as Biofertilisers**
- **Microbes in Production of Biogas**

- Microbes are diverse–protozoa, bacteria, fungi and microscopic plants viruses, viroids and also prions that are proteinacious infectious agents.
- Microbes like bacteria and many fungi can be grown on nutritive media to form colonies that can be seen with the naked eyes. Such cultures are useful in studies on micro-organisms.

02. MICROBES IN HOUSEHOLD PRODUCTS

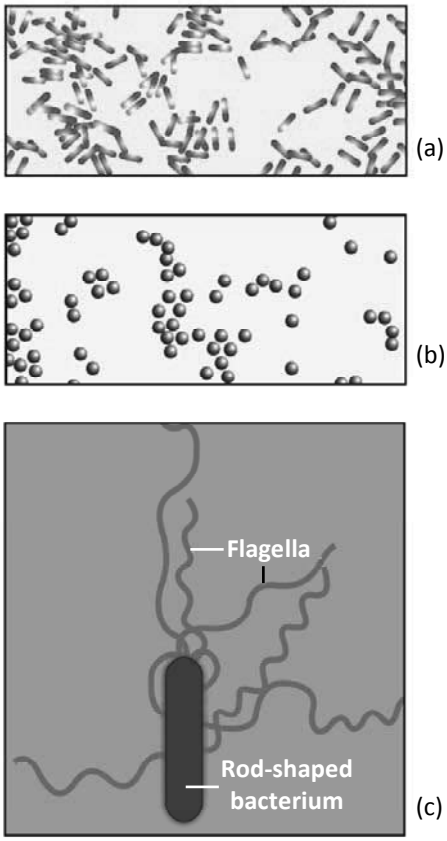
(1) CURD

- Micro-organisms such as Lactobacillus and others commonly called **lactic acid bacteria (LAB)** grow in milk and convert it to curd.
- During growth, the LAB produce acids that coagulate and partially digest the milk proteins.
- A small amount of curd added to the fresh milk as inoculum or starter contain millions of LAB, which at suitable temperatures multiply, thus converting milk to curd, which also improves its nutritional quality by increasing vitamin B_{12}.
- In our stomach too, the LAB play very beneficial role in checking disease causing microbes.

(2) CHEESE

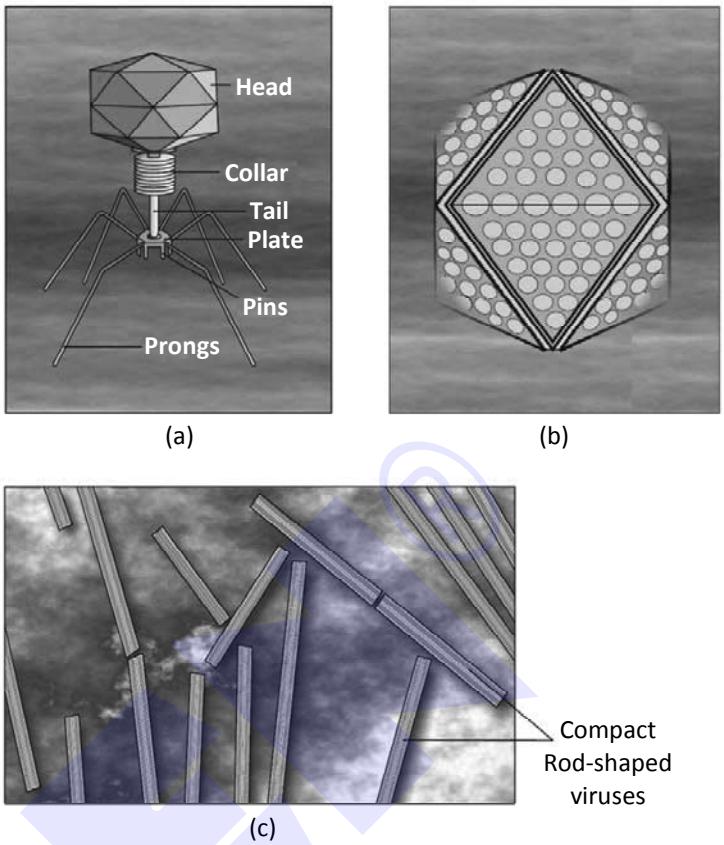
- Cheese, is one of the oldest food items in which microbes were used.
- Different varieties of cheese are known by their characteristic textur flavour and taste, the specificity coming from the microbes used.
- The large holes in 'Swiss cheese' are due to production of a large amount of CO_2 by a bacterium named ***Propionibacterium sharmanii***.
- The Roquefort cheese are ripened by growing a specific fungi on them, which gives them a particular flavour.
- Nearly 400 varieties of cheese available which can be classified into following type –

	Type of Cheese	Micro Organisms used for ripening
1.	**Soft** Camembert cheese	*Penicillium camemberti*
2.	**Semi-hard** Roquefort cheese	*Penicillium roqueforti*
3.	**Hard** Swiss cheese	*Propionibacterium sharmanii*



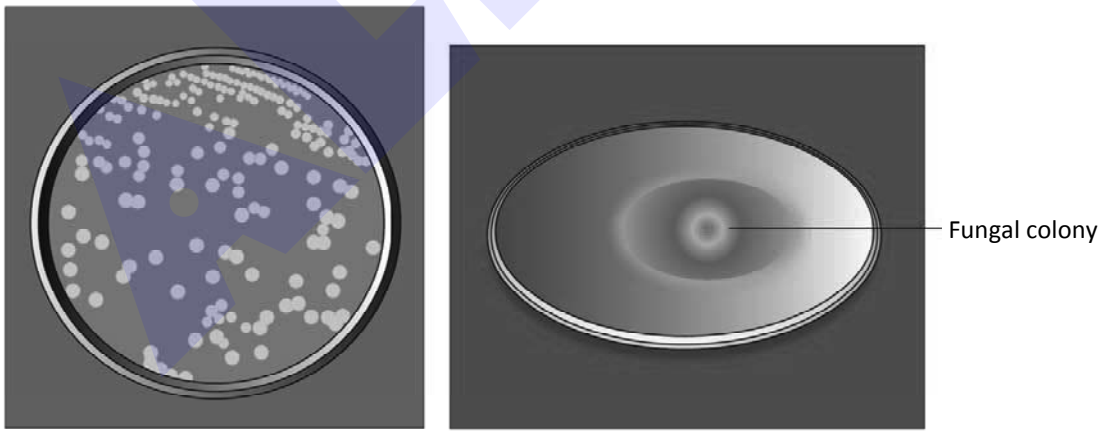
Bacteria: (a) Rod-shaped, magnified 1500X; (b) Spherical shaped, magnified1500X; (c) A rodshaped bacterium showing flagella, magnified 50,000X

Figure No. 10.1



Viruses: (a) A bacteriophage; (b) Adenovirus which causes respiratory infections; (c) Rod-shaped Tobacco Mosaic Virus (TMV). Magnified about 1,00,000–1,50,000X

Figure No. 10.2



(a) Colonies of bacteria growing in a petri dish; (b) Fungal colony growing in a petri dish

Figure No. 10.3

NCERT XII Page No. 180

OTHER PRODUCT :-

- The **dough**, which is used for making foods such as dosa and idli is also fermented by bacteria. The puffed-up appearance of dough is due to the production of CO_2 gas. Similarly the dough, which is used for making bread, is fermented using **baker's yeast (*Saccharomyces cerevisiae*)**.
- A number of traditional drinks (e.g. 'Toddy' prepared from sap of palms) and foods are also made by fermentation by the microbes.
- Microbes are also used to ferment fish, soyabean and bamboo shoots to make foods.

03. MICROBES IN INDUSTRIAL PRODUCTS

(1) ALCOHOLIC (Fermanted) BEVERAGE

- Microbes especially yeasts have been used from time immemorial for the production of beverages like wine, beer, whisky, brandy or rum. For this purpose the same yeast *Saccharomyces cerevisiae* used for bread-making and commonly called brewer's yeast, is used for fermenting malted cereals and fruit juices, to produce ethanol.
- Depending on **the type of the raw material used for fermentation** and **the type of processing (with or without distillation)** different types of alcoholic drinks are obtained.
- Wine and beer are produced without distillation whereas whisky, brandy and rum are produced by distillation of the fermented broth.
- **Some other common products of yeast fermentation are –**

  (a) **Beer** – It is produced from ***Hordeum Vulgare*** [Barely] malt and alcohol content is 3-6%

  (b) **Wine** – Produced from **grapes**, alcohol content is 10-20%.

  (c) **Brandy** – Produced by distillation of wine and alcohol content is 60-70%

  (d) **Gin** – Produced from **European Rye-Scale cereal**, alcohol content is 40%.

  (e) **Rum** – Produced from **Molasses** of Sugarcane and alcohol contents is 40%

Figure No. 10.4 (Fermentors)

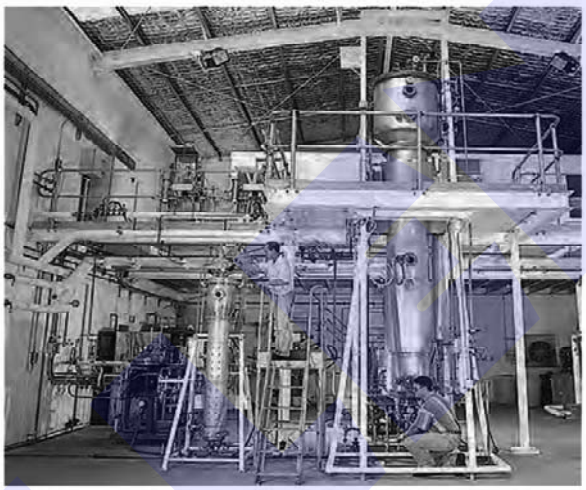


Figure No. 10.5 (Fermentation plant)

NCERT XII Page No. 182

(2) ANTIBIOTICS

- The **term** was **coined by Selman Waksman** (1942).
- Antibiotics produced by microbes are regarded as one of the **most significant discoveries of the twentieth century and have greatly contributed towards the welfare of the human society.**
- **Anti is a Greek word that means 'against', and bio means 'life', together they mean 'against life' (in the context of disease causing organisms); whereas with reference to human beings, they are 'pro life' and not against.**
- Antibiotics are chemical substances, which are produced by some microbes and can kill or retard the growth of other (disease-causing) microbes.
- You are familiar with the commonly used antibiotic Penicillin. Do you know that **Penicillin was the first antibiotic to be discovered** and it was a chance discovery? **Alexander Fleming** while working on Staphylococci bacteria, once observed a mould growing in one of his unwashed culture plates around which *Staphylococci* could not grow. He found out that it was due to a chemical produced by the mould and he named it Penicillin after the mould *Penicillium notatum*.

- However, **its full potential as an effective antibiotic was established much later by Ernest Chain and Howard Florey. This antibiotic was extensively used to treat American soldiers wounded in World War II.**
- **Fleming, Chain and Florey were awarded the Nobel Prize in 1945, for this discovery.**
- After Penicillin, other antibiotics were also purified from other microbes.
- Antibiotics have greatly improved our capacity to treat deadly diseases such as plague, whooping cough (kali khansi), diphtheria (gal ghotu) and leprosy (kusht rog), which used to kill millions all over the globe.
- Today, we cannot imagine a world without antibiotics.

(3) ORGANIC ACIDS

Some organic acids are manufactured by employing fermentation activities of Fungi and others of Bacteria.

For example :-

S.No.	Organic acid	Source
(1)	Citric acid	Fungus *Aspergillus niger*
(2)	Acetic acid (Vinegar)	Bacterium *Acetobactoer aceti*
(3)	Lactic acid	Bacterium *Lactobacillus bulgaris* and *streptococcus lactis*
(4)	Butyric-acid	Bacterium *Clostridium butylicum*

(4) ENZYMES

- **The bottle juices are clarified by the use of pectinases and protease.**
- **Streptokinase/Tissue Plasminogen Activator [TPA]** – This enzyme utilized in medicinal field. Streptokinase produced by the **bacterium Streptococcus** and modified by genetic engineering is used as a **clot buster for removing clots from the blood vessels** of patients who have undergone myocardial infarction leading to heart attack.

(5) BIOACTIVE MOLECULE

- **Cyclosporin A**, that is used as an **immunosuppressive agent** in organ-transplant patients, is produced by the **fungus *Trichoderma polysporum***.
- **Statins** produced by the **yeast *Monascus purpureus*** have been commercialised as **blood - cholesterol lowering agents.** It acts by competitively inhibiting the enzyme responsible for synthesis of cholesterol.

04. MICROBES AS BIOCONTROL AGENTS

- Biocontrol refers to the use of biological methods for controlling plant diseases and pests. In modern society, these problems have been tackled increasingly by the use of chemicals – by use of insecticides and pesticides.
- These chemicals are toxic and extremely harmful, to human beings and animals alike, and have been polluting our environment (soil, ground water), fruits, vegetables and crop plants.
- Our soil is also polluted through use of weedicides to remove weeds.

(1) BIOLOGICAL CONTROL OF PESTS AND DISEASES

- In agriculture, there is a method of controlling pests that relies on natural predation rather than introduced chemicals.
- A key belief of the organic farmer is that biodiversity furthers health. The more variety a landscape has, the more sustainable it is.
- The organic farmer, therefore, works to create a system where the insects that are sometimes called pests are not eradicated, but instead are kept at manageable levels by a complex system of checks and balances within a living and vibrant ecosystem.
- Contrary to the 'conventional' farming practices which often use chemical methods to kill both useful and harmful life forms indiscriminately, this is a holistic approach that seeks to develop an understanding of the webs of interaction between the myriad of organisms that constitute the field fauna and flora.
- The organic farmer holds the view that the eradication of the creatures that are often described as pests is not only possible, but also undesirable, for without them the beneficial predatory and parasitic insects which depend upon them as food or hosts would not be able to survive. Thus, the use of biocontrol measures will greatly reduce our dependence on toxic chemicals and pesticides.
- An important part of the biological farming approach is to become familiar with the various life forms that inhabit the field, predators as well as pests, and also their life cycles, patterns of feeding and the habitats that they prefer. This will help develop appropriate means of biocontrol.

(2) BIOPESTICIDES

- Biopesticides are those biological agents that are used for control of weeds, insects and pathogens.
- The micro-organisms used as biopesticides include viruses, bacteria, fungi, protozoa and mites.

(A) *Bacillus thuringiensis* :-

- *Bacillus thuringiensis* is the example of soil bacterium. Spores of ths bacterium produce the insecticidal Cry protein. Therefore, spores of this bacterium kill larvae of certain insects.
- **The commercial preparations of *B. thuringiensis* contain a mixture of spores, Cry protein. This bacterium was the first biopesticide to be used on a commercial scale in the world.**
- An example of microbial biocontrol agents that can be introduced in order to control butterfly caterpillars is the bacteria *Bacillus thuringiensis* (often written as Bt). These are available in sachets as dried spores which are mixed with water and sprayed onto vulnerable plants such as brassicas and fruit trees, where these are eaten by the insect larvae. In the gut of the larvae, the toxin is released and the larvae get killed.
- The bacterial disease will kill the caterpillars, but leave other insects unharmed. Because of the development of methods of genetic engineering in the last decade or so, the scientists have introduced *B. thuringiensis* toxin genes into plants. Such plants are resistant to attack by insect pests.

  Bt-cotton is one such example, which is being cultivated in some states of our country.

(B) Beetle :

- **The very familiar beetle with red and black markings-the Ladybird are useful to get rid of aphids.**

(C) Dragonflies :

- **Dragonflies are useful to get rid of mosquitoes.**

(D) Trichoderma :

- **Fungal pathogens** are attractive biocontrol agents for weed control in view of their host specificity and ease in production and inoculation in the field.
- A biological control being developed for use in the treatment of plant disease is the fungus **Trichoderma**.
- Trichoderma species are **free-living fungi** that are **very common in the root ecosystems.**
- They are effective biocontrol agents of several plant pathogens.

(E) Baculoviruses :

- **Baculoviruses** are pathogens that attack insects and other arthropods.
- **The majority of baculoviruses used as biological control agents are in the genus Nucleopolyhedrovirus.**
- These viruses are excellent candidates for species-specific, narrow spectrum insecticidal application.

- They have been shown to have no negative impacts on plants, mammals, birds, fish or even on non-target insects.
- This is especially desirable when beneficial insects are being conserved to aid in an overall **integrated pest management (IPM) programme**, or when an ecologically sensitive area is being treated.

05. MICROBES AS BIOFERTILISERS

- Biofertilisers are organisms that enrich the nutrient quality (N,P) of the soil. The main sources of biofertilisers are bacteria, fungi and cyanobacteria.

(A) Bacteria :

- ***Rhizobium*** (symbiotic bacteria) fix atmospheric nitrogen into organic forms in the roots of leguminous, which is used by the plant as nutrient.
- Other bacteria like ***Azospirillum*** and ***Azotobacter*** can fix atmospheric nitrogen while free-living in the soil thus enriching the nitrogen content of the soil.

(B) Fungi :

- **Fungi** are also known to form symbiotic associations with plants (mycorrhiza). Many members of the genus **Glomus** form mycorrhiza.
- Fungal symbiont in these associations **absorbs phosphorus from soil** and passes it to the plant. **Also provide resistance to root-borne pathogens, tolerance to salinity and drought and cause an overall increase in plant growth and development.**

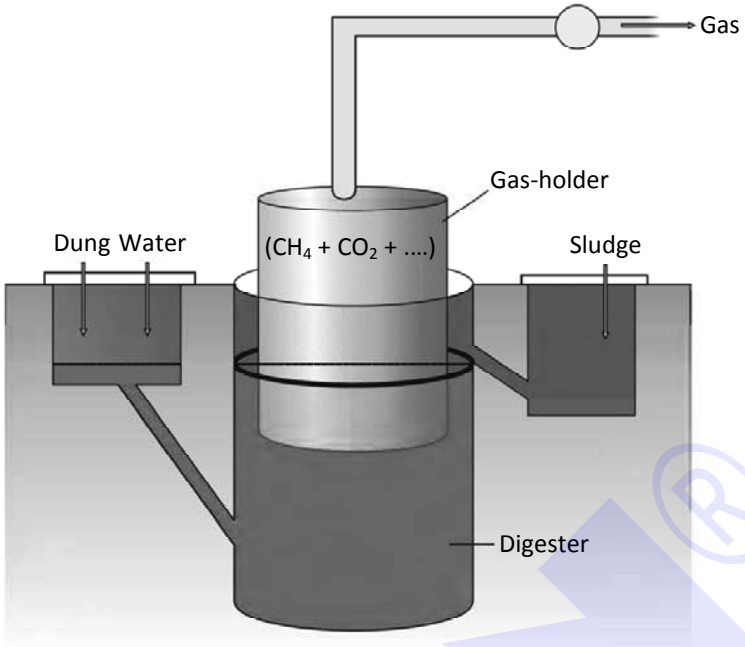
(C) BGA (Blue Green Algae) / Cyanobacteria :

- **Cyanobacteria** are autotropic microbes widely distributed in aquatic and terrestrial environments many of which can fix atmospheric nitrogen. (e.g. ***Anabaena, Nostoc, Oscillatoria,*** etc.)
- In paddy fields, cyanobacteria serve as an important biofertiliser. Blue green algae also add organic matter to the soil and increase its fertility.

Biofertilisers are a low-cost input and they do not pollute the environment. They are **used to replenish soil nutrients**. They also **reduce the dependence on chemical fertilisers** and also help to use **organic farming**.

06. MICROBES IN PRODUCTION OF BIO-GAS

- In rural areas of developing countries, it is a common practice to use animal dung for making dung cakes which are used for fuel. Thus a potential fertiliser of the agricultural fields is wasted in burning.
- The dung can be put to a better use if it is used to generate Bio gas (Gobar Gas) and side by side a stabilised residue to serve as the fertiliser.
- The energy yield of Biogas is lower than that of dung cakes but the efficiency of Biogas burners is very high. Thus over all result indicates that production of biogas is more cost effective.
- Biogas is a mixture of gases (containing predominantly methane) produced by the microbial activity and which may be used as fuel. You have learnt that microbes produce different types of gaseous end-products during growth and metabolism. The type of the gas produced depends upon the microbes and the organic substrates they utilise.
- In the examples cited in relation to fermentation of dough, cheese making and production of beverages, the main gas produced was CO_2. However, certain bacteria, which grow anaerobically on cellulosic material, produce large amount of methane along with CO_2 and H_2.
- These bacteria are collectively called **methanogens**, and one such common bacterium is *Methanobacterium*.
- These bacteria are commonly found in the anaerobic sludge during sewage treatment. These bacteria are also present in the rumen (a part of stomach) of cattle. A lot of cellulosic material present in the food of cattle is also present in the rumen.
- In rumen, these bacteria help in the breakdown of cellulose and play an important role in the nutrition of cattle.
- Thus, the excreta (dung) of cattle, commonly called *gobar*, is rich in these bacteria. Dung can be used for generation of biogas, commonly called *gobar gas*.
- The biogas plant consists of a concrete tank (10-15 feet deep) in which bio-wastes are collected and a slurry of dung is fed.
- A floating cover is placed over the slurry, which keeps on rising as the gas is produced in the tank due to the microbial activity.
- The biogas plan has an outlet, which is connected to a pipe to supply biogas to nearby houses.
- The spent slurry is removed through another outlet and may be used as fertiliser.
- Cattle dung is available in large quantities in rural areas where cattle are used for a variety of purposes.
- So biogas plants are more after build in rural areas.
- The biogas thus produced is used for cooking and lighting. **The technology of biogas production was developed in India mainly due to the efforts of Indian Agricultural Research Institute (IARI) and Khadi and Village Industries Commission (KVIC)**



A typical biogas plant

NCERT XII Page No. 186, Figure No. 10.8

Composition of Biogas :

(1) CH_4 (main gas) (50 – 70%)

(2) CO_2 (30 – 40%)

(3) H_2S

(4) H_2 } Trace amount

(5) N_2

Anaerobic fermentation of waste biomass can be visualised in three stages :-

(a) First stage :

- The **facultative anaerobic microbes** degrade the **complex polymers to simple monomers** by enzymatic action.
- The Polymers like cellulose, hemicellulose, proteins and lipids get degraded into monomers but **lignins** and inorganic salts are left as residue because they do not degraded.

(b) Second stage :

- **Monomers are converted into organic acids** by microbial action under partially aerobic conditions which are finally converted to **acetic acid**.

(c) Third stage :

- **Acetic acid is oxidised into methane** by the activity of anaerobic methanogenic bacteria.
- In this whole process **digestion of cellulose takes place at very slow rate so that it is the "rate limiting factor in biogas production**".

SPECIAL POINTS

(1) SINGLE CELL PROTEIN (SCP) :-

- It is microbial biomass. This biomass is obtained from both mono and multi cellular microorganism. Single cell protein can be produced using algae, fungi, yeast and bacteria.
- Conventional agricultural production of cereals, pulses, vegetables, fruits, etc., may not be able to meet the demand of food at the rate at which human and animal population is increasing.
- The shift from grain to meat diets also creates more demand for cereals as it takes 3-10 Kg of grain to produce 1 Kg of meat by animal farming.
- More than 25 per cent of human population is suffering from hunger and malnutrition. One of the alternate sources of proteins for animal and human nutrition is **Single Cell Protein (SCP).**
- Microbes are being grown on an industrial scale as source of good protein.
- Microbes like ***Spirulina*** can be grown easily on materials like waste water from potato processing plants (containing starch), straw, molasses, animal manure and even sewage, to produce large quantities and can serve as food rich in protein, minerals, fats, carbohydrate and vitamins. Incidentally such utilisation also reduces environmental pollution.
- It has been calculated that a 250 Kg cow produces 200 g of protein per day. In the same period, 250g of a micro-organism like ***Methylophilus methylotrophus***, because of its high rate of biomass production and growth, can be expected to produce 25 tonnes of protein.
- The fact that mushrooms are eaten by many people and large scale mushroom culture is a growing industry makes it believable that microbes too would become acceptable as food.

(2) PLANTS AS SOURCES OF HYDROCARBONS FOR PRODUCING PETROLEUM

- **Melvin Calvin** has identified certain plants which produce hydrocarbons. The plants of **Euphorbiaceae**, **Asclepiadaceae** and **Apocyanaceae** produce **latex** a milky secretion which contains hydrocarbons.

  e.g. **Jatropha**

(3) ALCOHOL AS FUEL (BIOETHANOL) :-

- Ethanol (C_2H_5OH) can be partly or wholly substituted for petrol in automobiles after suitable modifications in Engines.
- Alcohol has been successfully used as motor fuel in **Brazil** and it is the first leading country in the world.
- Recntly Govt. of India has allowed mixing of alcohol (5%) in petrol.

Microbes in Human Welfare

- **House hold produts**
  - **Curd** : Lactic Acid Bacteria (LAB)
    - Vitamin B12 (nutritional quality)
    - Checking disease causing microbes
  - **Bread** : (Baker's yeast)
    Saccharomyces cerevisiae
  - **Cheese**
    - Swiss cheese – *Propionibacterium Sharmanii*
    - Roque Fort cheese – Specific fungi
- **Industrial products**
  - **Fermented Beverages**
    Brewer's yeast – *Saccharomyces cerevisiae*
    With distillation – Whisky, brandy and rum
    Without distillation – Wine and Beer
  - **Antibiotics**
    Penicillin
    - *Penicillium notatum*
    - Discovered by Alexander Fleming
    - Established by Ernest chain and Howard Florey
  - **Chemicals**
    - Organic acids
    - Citric acid *(Aspergillus niger)*
    - Acetic acid *(Acetobacter acetic)*
    - Butyric acid *(Clostridium butylicum)*
    - Lactic acid *(Lactobacillus)*
  - **Alcohol** → Ethanol *(S. Cerevisiae)*
  - **Enzymes**
    - Lipases (detergent)
    - Pectinase and protease (Clarified juices)
    - Streptokinase (clot buster)
  - **Bio active molecules**
    - Cyclosporine A *(Trichoderma polysporum)*
    - Statins *(Monoscus purpureus)*
- **Biogas production**
  - **Methanogens** : *Methanobacterium* grow
    In aerobically on cellulosic material produce methane, CO_2 and H_2
  - **Gobar gas** – dung
  - **IARI and KVIC** (Developed biogas technology in India)
- **Biocontrol agent**
  - *Bacillus thuringiensis* – Caterpilars (Larva)
  - Lady bird – aphids
  - Dragonflies – Mosquitoes
  - Trichoderma – Plant pathogens
  - Nucleopoly hedrovirus – Inescts species specific e.g. Baculovirus
- **Biofertiliser**
  - Symbiotic – *Rhizobium* (Plant-bacteria)
  - Free living – *Azospirillum, Azotobacter*
  - Glomus – Mycorrhiza (Plant – Fungi)
  - Cyanobacteria – *Anabaena, Nostoc, Oscillatoria*