CHAPTER-8

MICROBES IN HUMAN WELFARE

Topic-1 Microbes and their Uses

Concepts Covered • *Microbes in Daily Life, household products, Industrial Products Sewage Treatment and Biogas Production*

Revision Notes

Microbes in Daily Life

- Microbes are the major components of the biological system on the Earth.
- They are very minute organisms that cannot be seen with the naked eyes but are viewed under the microscope.
- Microbes are present everywhere such as in soil, water, air, inside our body and bodies of animals and plants.
- They are also present where no other life-form could exist such as deep inside the geysers (thermal vents) where the temperature may be as high as 100°C, deep in the soil, under the layers of snow, several metres thick and in highly acidic environments.
- Microbes are diverse–protozoa, bacteria, fungi and microscopic plants.
- Viruses, viroids and also prions are not considered as living entities, even though, they are considered as 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.
- Some microbes are harmful to mankind, causing several infectious diseases but some are important in many ways for human welfare.

Microbes in household products.

1. ***Lactobacillus* or Lactic Acid Bacteria (LAB)**
   - It converts milk into curd.
   - It produces lactic acid that coagulates and partially digests the milk protein casein.
   - A small amount of curd containing LAB converts fresh milk into curd.
   - It also increases vitamin B_{12}.
   - In the stomach, it inhibits the growth of pathogens.

2. **Bacterial Fermentation (Anaerobic Respiration)**
   - The dough which is formed by the fermentative activity of bacteria is used to make foods such as *dosa, idli,* etc.
   - The puffed-up appearance of dough is due to the production of CO_2 gas.
   - 'Toddy' is an alcoholic drink, made by fermenting flower sap from palms by bacteria.
   - Microbes are used to ferment fish, soyabean and bamboo-shoots to make foods.
   - Microbes are used to produce cheese, which differ in flavour, taste and texture e.g., Large holes in 'Swiss cheese' are due to the production of a large amount of CO_2 by *Propionibacterium shermanii* (a bacterium).
   - 'Roquefort cheese' is ripened by growing a specific fungus (*Penicillium roqueforti*) on them that gives them a particular flavour.

3. **Baker's Yeast (*Saccharomyces cerevisiae*):**
   - It is used to make bread by fermenting dough.

Microbes in Industrial Products

- The large scale production of beverages, antibiotics etc., on an industrial scale, requires growing microbes in very large vessels called fermentors or bioreactors.

1. **Fermented Beverages**
   - *Saccharomyces cerevisiae* (Brewer's yeast) is used in the production of beverages by fermenting malted cereals and fruit juices to produce ethanol.
   - Wine and beer are produced without distillation.
   - Whisky, Brandy and Rum are produced by distillation of the fermented broth.
2. **Antibiotics**
   - The chemical substances produced by some microbes that can kill or inhibit the growth of other disease-causing microbes.
   - They are used to treat plague, whooping cough, diphtheria, leprosy and many other infectious diseases.

Key Words

Antibiotic: They are the medicines, which prevent the growth and multiplication of bacteria in animal or human body which are harmful to them.

Immunosuppressive agent: It is an agent that decreases the body's immune response.

- **Penicillin**
  - First antibiotic discovered by Alexander Fleming in 1929.
  - He observed that a mould (*Penicillium notatum*) growing in unwashed culture plates around which *Staphylococci* could not grow.
  - He extracted penicillin from it.
  - Ernst Chain and Howard Florey established its full potential as an effective **antibiotic**.
  - Fleming, Chain and Florey were awarded Nobel Prize (1945).

3. **Chemicals, enzymes and other bioactive molecules**
   - **(a) Organic Acids:** e.g.,
     - *Aspergillus niger* (a fungus): Citric acid
     - *Acetobacter aceti* (a bacterium): Acetic acid
     - *Clostridium butylicum* (a bacterium): Butyric acid
     - *Lactobacillus* (a bacterium): Lactic acid
   - **(b) Alcohol:**
     - Yeast (*Saccharomyces cerevisiae)* is used to produce ethanol.
   - **(c) Enzymes:**
     - **Lipases:** Used in detergent formulations. Help to remove oily stains from the laundry.
     - **Pectinases and Proteases:** To clarify bottled juices.
     - **Streptokinase:** Produced by *Streptococcus*. Used as a 'clot buster' to remove clots from the blood vessels of patients who have a myocardial infarction.
   - **(d) Cyclosporin A:**
     - It is produced by *Trichoderma polysporum* (fungus).
     - It is used as an **immunosuppressive agent** in organ-transplant patients.
   - **(e) Statins:**
     - It is produced by *Monascus purpureus* (an yeast).
     - It is used as a blood-cholesterol lowering agent.
     - It inhibits the enzymes responsible for the synthesis of cholesterol.

- **Microbes in Sewage Treatment**
  - Sewage (municipal waste-water) contains a large amount of human excreta, organic matter and microbes.
  - Sewage is treated in Sewage Treatment Plants (STPs) to make it less polluting. It includes stages namely: primary treatment and secondary treatment.
    - **(a) Primary Treatment**
      - It is a physical treatment.
      - It involves the physical removal of large and small particles from sewage. It includes:
        - Removal of floating debris by sequential filtration.
        - Removal of the grit (soil and pebbles) by sedimentation.
        - All solids that settle form the primary sludge and the supernatant forms the primary effluent.
        - The effluent is taken for secondary treatments.
    - **(b) Secondary treatment (Biological treatment)**
      - Primary effluent is passed into large aeration tanks and constantly agitated.
      - This allows vigorous growth of useful aerobic microbes into flocs (masses of bacteria associated with fungal filaments to form mesh-like structures).
      - These microbes consume the major part of the organic matter in the effluent.
      - This reduces the BOD (Biochemical Oxygen Demand) of the effluent.
      - The effluent is then passed into a settling tank where the bacterial 'flocs' are allowed to sediment. This sediment is called 'activated sludge'.
      - A small part of the activated sludge is pumped back into the aeration tank to serve as the inoculum.
      - The remaining major part of the sludge is pumped into large tanks called anaerobic **sludge digesters.**
      - Here, some anaerobic bacteria digest the bacteria and fungi in the sludge by producing gases like CH_4, H_2S and CO_2. These gases form the biogas.
      - The effluent from the secondary treatment plant is released into natural water bodies like rivers and streams.
      - The Ministry of Environment and Forests has initiated the **Ganga Action Plan** and **Yamuna Action Plan** to save rivers from water pollution.

Biological Oxygen Demand (BOD)

- BOD represents the amount of dissolved oxygen required for the complete oxidation of all the organic matter present in one litre of water by bacteria at 20°C.
- BOD measures the amount of organic matter present in water by measuring the rate of O_2 taken up by microbes.
- Higher BOD indicates that the water is highly polluted by organic matter. A lower value of BOD means the water is less polluted or normal.

Key Words

Inflammable gases: Gases which burns in the presence of oxidant when provided with source of ignition.

Methanogens: Microorganisms that produce methane along with O_2 and H_2 under anaerobic conditions.

Microbes in Production of Biogas

- Biogas is a mixture of **inflammable gases** (mainly CH_4) produced by the microbial activity.
- Biogas is used for cooking and lighting.
- **Methanogens** grow anaerobically on cellulosic material and produce CH_4 gas e.g., *Methanobacterium*.
- *Methanobacterium* is found in the anaerobic sludge and rumen of cattle (for cellulose digestion).
- The dung of cattle (gobar) is rich in these bacteria.
- Dung can be used for the generation of biogas (Gobar gas).

Key Fact

There are more bacteria in a person's mouth than the entire population of the world.

A Biogas plant consists of

(a) A concrete tank
(b) Floating cover
(c) An outlet

- The concrete tank (10-15 feet deep) collects bio-wastes and slurry of dung.
- A floating cover is placed over the slurry, which keeps on rising as the biogas is produced.
- There is an outlet which is connected to a pipe to supply biogas to nearby houses.
- Used slurry is removed through another outlet and can be used as a fertilizer.
- Indian Agricultural Research Institute (IARI), Khadi and Village Industries Commission (KVIC) developed the technology of biogas production in India.

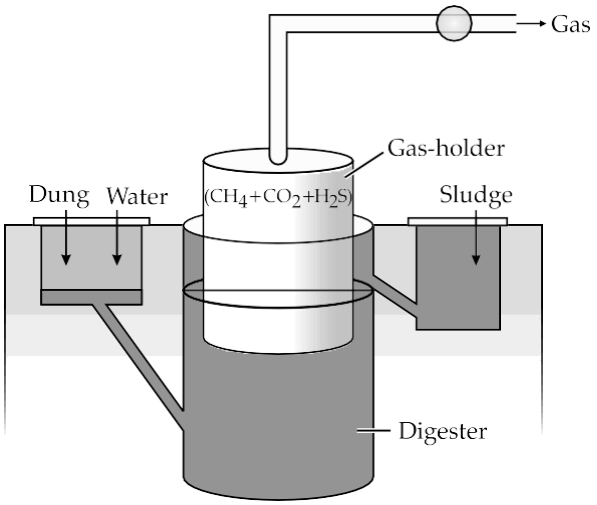

Fig. 8.1 A Biogas plant

Mnemonics

1. Concept: Organic acid bacteria
Mnemonic: **A**ll **A**nswers **C**learly **L**abelled
Interpretations: *Aspergillus niger*, *Acetobacter aceti*, *Clostridium butylicum*, *Lactobacillus*.

Example 1

Q. What are methanogens ? How do they help to generate biogas ?

Sol. Methanogens are the bacteria which grow anaerobically on cellulosic material and produce large amount of methane along with CO_2 and H_2S.

(i) Present in cattle (rumen) a part of stomach.

(ii) They help in:

(a) Breaking down of cellulose present in food of cattle.

(b) Nutrition of animal for digestion of cellulose.

The excreta of cattle is rich in these bacteria (methanogens) and therefore can be used for generation of biogas.

Topic-2 Microbes as Biocontrol Agents and Bio-Fertilisers

Concepts Covered • *Microbes as biocontrol agents, biofertilisers.*

Revision Notes

- **Biocontrol**
  - It is the application of biological methods for controlling plant diseases and pests.
- **Chemical Pesticides and Insecticides**
  - These are toxic and harmful to all organisms including human beings and cause pollution.
  - Chemical pesticides kills both useful and harmful life forms.
  - Weedicides used to eliminate weeds cause soil pollution.
- **Microbial biocontrol agents**

  (a) *Bacillus thuringiensis* (Bt):
  - This is to control the butterfly caterpillar. These are available in sachets as dried spores which are mixed with water and sprayed on vulnerable plants such as *Brassica* 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. Scientists have introduced *B. thuringiensis* toxin genes into plants e.g., Bt cotton.

Key Words

Pesticides are the substances which are used to kill harmful pests from the soil.

Insecticides are the substances which are formulated to kill one or more species of insects.

Symbiotic: The relationship involving interaction between two different organisms living in close physical association.

(b) *Trichoderma* sp. (Fungus):
- These are free livings species that are seen in the root ecosystem. They are effective biocontrol agents of several plant pathogens.

(c) *Baculoviruses* (Especially genus *Nucleopolyhedrovirus*):
- It attacks insects and other arthropods. These are suitable for species-specific, narrow spectrum insecticidal applications. This is desirable in the IPM program to conserve beneficial insects.

- **Microbes as Biofertilisers**
  - Biofertilizers are the micro-organisms that enrich the nutrient quality of the soil. e.g., Bacteria, fungi, cyanobacteria etc.
- ***Rhizobium***
  - It is a **symbiotic** bacteria found in root nodules of leguminous plants that fixes atmospheric N_2.
  - Free-living bacteria in the soil such as *Azospirillum* and *Azotobacter* enrich the nitrogen content of the soil.
- ***Mycorrhiza***
  - It is a symbiotic association of fungi (e.g., the genus of *Glomus*) with the roots of higher plants.
  - The fungus gets food for the plant.
  - The fungal symbiont help to absorb phosphorus from soil and passes it to the plant, give resistance to root-borne pathogens, tolerance to salinity and drought and also gives an overall increase in plant growth and development.
- **Cyanobacteria (Blue-green algae):**
  - They are autotrophic microbes that fixes atmospheric nitrogen e.g., *Anabaena, Nostoc, Oscillatoria,* etc.
  - In paddy fields, Cyanobacteria serve as an important biofertilizers.
  - It also adds organic matter to the soil and increases its fertility.

Mnemonics

1. Concept: Microbial Biocontrol agents
Mnemonic: **B**ack **T**o **B**ack
Interpretation: *Bacillus thuringiensis, **T**richoderma sp., Baculoviruses.*

2. Concept: Free living bacteria
Mnemonic: **A**lmond's **A**pple
Interpretation: *Azospirillum, Azotobacter*

Example 2

Q. (i) How do organic farmers control pests ? Give two examples.
(ii) State the difference in their approach from that of conventional pest control methods.

Sol. **(i)** Organic farmers control pests by utilising natural predation instead of introducing or applying chemicals. Microbial biocontrol agents are the species – specific pesticides.
The examples include:
(a) ***Bacillus thuringiensis:*** This is a bacterium which produces a toxin that specifically kills insect larvae of cotton bollworm such as lepidopterans, coleopterans and dipterans leaving aside all other non-targeted organisms.
(b) It is free living fungus and works as *Trichoderma sp*, a bio-control agent against several plants pathogens.

(ii) The difference between the organic farming method and conventional pest control methods are:
(a) Conventional pest control methods use chemicals. They are non-specific, cause harm to non target beneficial organisms and pose problems like environmental pollution and biological magnification, whereas organic farmers control pest by biocontrol agents. They are specific, do not harm non target organism and do not cause pollution.
(b) As compared to conventional pest control methods, organic farmers do not try to completely get rid of pests but keep them at manageable levels. They believe that complete eradication of pests is not beneficial and has certain adverse effects. It leads to death of those beneficial creatures that are dependent on them for food.