

MICROBES IN HUMAN WELFARE

Introduction:

- On this earth, microbes are the major components of biological systems. They are present everywhere even under extreme conditions, where no other life-form could exist.
- They are present in diverse forms such as protozoa, bacteria, fungi, viruses, viroids, prions and other microscopic animals.

CELLULAR (LIVING)	
 Parasites (e.g., helminthes) → Tapeworm	 Protozoa (e.g., Plasmodium) → Malaria
 Fungi (e.g., Trichoderma) → Athlete's Foot	 Prokaryote (i.e., bacteria) → Leprosy
ACELLULAR	
 Virus (e.g., HIV) → AIDS	 Prion → CJD

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- They may be pathogenic but also have an important role to play in human and environmental welfare.
- Microbes can be easily grown in laboratories or at industrial scale for research and production of various useful products.

Microbes in Household Products:

- Micro-organisms and their products are used in day-to-day life. These are described as follows-

Formation of curd:

- The bacteria *Lactobacillus* or **Lactic Acid Bacteria (LAB)** produces lactic acid that coagulates and partially digest the milk proteins and thus converting milk into curd.
- LAB also enhances the nutritional quality of curd by increasing vitamin B₁₂ content.
- These bacteria are also present in the stomach and check the growth of pathogens.



Lactobacillus

Dough:

- Bacteria are used for fermenting the dough which leads to the production of CO₂ gas and ultimately the dough shows puffed-up appearance.



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→ For making bread, the dough is fermented using baker's yeast (*Saccharomyces cerevisiae*).

Toddy:

→ It is considered as the traditional drink of some parts of Southern India which is made by fermenting sap from palm trees, coconut, etc.

Cheese:

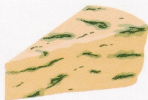
→ Various varieties of cheese are formed by the partial degradation of milk by different microorganisms which provides them characteristic texture, flavour and taste.

→ **Swiss cheese** has large holes due to high production of CO_2 by a bacterium, *Propionibacterium shermanii*.

→ **Roquefort cheese** is ripened by growing a specific fungus, *Penicillium roqueforti* on them, which gives them a particular flavour.



Swiss Cheese



Roquefort Cheese



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Microbes in Industrial Products:

- Valuable products such as beverages and antibiotics are usually synthesised on industrial scale with the help of microbes which are grown or cultured in very large vessels called as **fermentors** or **bioreactors**.

Fermented Beverages:

- *Saccharomyces cerevisiae* (brewer's yeast) is commonly used for the production of fermented beverages. This yeast ferments malted cereals and fruit juices, to produce ethanol.
- Wine and beer are filtered, pasteurized and bottled without distillation whereas whisky, brandy and rum are produced by distillation (increases the alcoholic content) of the fermented broth.
- A non distilled beverages can maximally contain 13% alcohol.

Antibiotics:

- Antibiotics term was given by Waksman. These are the chemical substances which are produced by some microbes and can kill or stop the growth of pathogens which causes deadly diseases like plague, whooping cough, leprosy, diphtheria, etc.
- The first discovered antibiotic was 'Penicillin' obtained from *Penicillium notatum* and it was a chance discovery by Alexander Fleming.



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- While working on *Staphylococci* bacteria, Fleming observed a mould growing in one of his unwashed culture plates around which *Staphylococci* could not grow. He found that it was due to a chemical produced by mould and he named it as **Penicillin**.
- **Ernst Chain** and **Howard Florey** worked on the chemotherapeutic effectiveness of penicillin during 1939-41. Later in 1945, Fleming, Chain and Florey were awarded with Nobel Prize for the discovery of potential use of penicillin as antibiotic.
- Judicious use of antibiotics is mandatory to maximise its therapeutic efficacy and minimizes the development of infection or colonization of resistant microorganisms.

Chemicals, enzymes and other bioactive molecules:

- Commercial and industrial production of various chemicals, organic acids, enzymes are carried out with the use of microbes. Some examples are:

Microor-ganisms	Category	Product	Uses of Product
<i>Aspergillus niger</i>	Fungus	Citric acid (organic acid)	Flavoring and preserving agent
<i>Acetobacter aceti</i>	Bacteri-um	Acetic acid (organic acid)	Preservative
<i>Clostridium butylicum</i>	Bacteri-um	Butyric acid (organic acid)	Provide colon cells with energy



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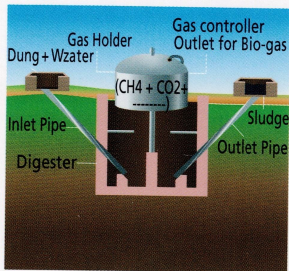
<i>Lactobacillus</i>	Bacterium	Lactic acid (organic acid)	Preservative, Making curd
<i>Bacillus spp.</i>	Bacterium	Lipases (enzyme)	Used in detergent formulations and are helpful in removing oily stains from the laundry.
<i>Aspergillus niger</i>	Fungus	Pectinases and Proteases (enzyme)	Used for the clarification of bottled juices.
<i>Streptococcus</i>	Bacterium	Streptokinase (enzyme)	Used as clot buster for patients who have undergone myocardial infarction leading to heart attack
<i>Trichoderma polysporum</i>	Fungus	Cyclosporin A (bioactive molecule)	Used as an immunosuppressive agent in organ-transplant patients.
<i>Monascus purpureus</i>	Yeast	Statins (bioactive molecule)	Blood-cholesterol lowering agents.



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Microbes in the Production of Biogas:

- Biogas is a mixture of gases, i.e., CH_4 (50-70%), CO_2 (30-40%) and H_2 which is produced by anaerobic microbial activity. It is used as fuel for cooking and lighting.
- Methanogens, e.g., *Methanobacterium* grow anaerobically on cellulosic material and are responsible for producing large amount of biogas.
- **Methanogens** generally found in the anaerobic sludge for sewage treatment and in the **rumen** of cattle for the breakdown or digestion of cellulose, thus the excreta of cattle (**gobar**) is rich in these bacteria and used for generation of biogas (**gobar gas**).



A typical biogas plant

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- Biogas plant consists of a concrete tank (10-15 feet deep) in which bio-wastes and slurry of dung is collected.
- The slurry is covered with a floating cover, which keeps on rising when the gas is produced in the tank. This biogas is supply to the nearby houses with the help of the pipe which is connected to an outlet in biogas plant.
- There is another outlet through which spent slurry is removed and used as a fertiliser.
- **Indian Agricultural Research Institute (IARI)** and **Khadi and Village Industries Commission (KVIC)** led to the development of the technology of biogas production in India.





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Unit - VIII: Biology in Human Welfare

Microbes in Sewage Treatment:

- **Sewage** is the municipal waste water which contains large amounts of organic matter and microbes. Thus, before the disposal, it is treated in **Sewage Treatment Plants (STPs)** to make it less polluting (BOD of Sewage is reduced).
- Sewage treatment is carried out in two stages, i.e., Primary and Secondary treatment.
- Primary treatment is the **physical** process in which floating debris is removed by sequential filtration. Whereas, grit (soil and small pebbles) are removed by sedimentation.
- The settled solids form the **Primary sludge** and the supernatant forms the primary **effluent**.
- Secondary treatment is the **biological** process. In this, primary effluent passes to large aeration tank which helps in the growth of aerobic microbes into **flocs** (masses of bacteria associated with fungal filaments to form mesh).

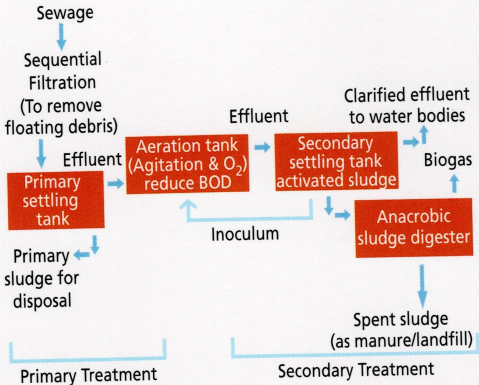




MEMORISE

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like structures) which consumes the organic matter and decreases the BOD (**Biochemical Oxygen Demand**) of the effluent.



- BOD is the amount of oxygen that would be consumed if all the organic matter in one litre of water were oxidised by bacteria. It measures the amount of organic matter present in the water. Greater the BOD of water more it is polluted.





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- Once the BOD of sewage water is reduced, the effluent is passed into a **settling tank** where the bacterial 'flocs' are sediment (**activated sludge**).

$$\text{BOD} \propto \text{Polluting Potential}$$

- Sludge is passed into **anaerobic sludge digester**, where **anaerobic bacteria** digest the organic mass as well as aerobic bacteria and fungi in the sludge and produce mixture of gases such as methane, hydrogen sulphide and carbon dioxide. These collectively form **biogas**.
- The effluents from the secondary treatment plant are released into water bodies.
- To save the major rivers from pollution, Ministry of Environment and Forests initiated Ganga Action Plan, Yamuna Action Plan, Gomti Action Plan, etc.

Microbes as Biocontrol Agents:

- Biocontrol** is the use of biological methods for controlling plant diseases pathogens and pests. This method greatly reduces our dependence on toxic chemicals and pesticides.
- In biological or organic farming, pests are controlled by natural predation. The organic farmer creates an environment in which the insects (pests) are not eradicated, but instead are kept at manageable levels.





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- The main examples of biocontrol agents are:

Ladybird and Dragonflies:

- Ladybirds are used to get rid of aphids and Dragonflies are used to control mosquitoes.



Bacillus thuringiensis (Bt):

- It is used as dried spores which are mixed with water and sprayed onto vulnerable plants such as brassicas and fruit trees to get rid of butterfly caterpillars.
- When these Spores/bacteria are eaten by the insect larvae, the toxin is released in the gut of the larvae and the larvae get killed.
- With the help of genetic engineering, the *Bt* toxin genes have been introduced into several plants and these become resistant to attack by insect pests. Example: Bt-cotton, Bt-Brinjal, etc.

Trichoderma:

- These are free-living fungi which commonly found in the root ecosystems and control several plant pathogens.





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Baculoviruses (especially genus *Nucleopolyhedrovirus*):

- These are the pathogens that attack insects and other arthropods. These viruses are excellent for **species-specific, narrow spectrum** insecticidal applications.
- They are desirable in Integrated Pest Management (IPM) to conserve beneficial insects.

Microbes as Biofertilizers:

- Biofertilisers are organisms which improves the nutrient quality of the soil by enhancing the availability of nutrients to the crops. The main sources of biofertilisers are:

Bacteria:

- A symbiotic bacterium, *Rhizobium* form root nodules in leguminous plants and fix atmospheric nitrogen into organic forms, which is used by the plant as nutrient.
- Free living bacteria like *Azospirillum* and *Azotobacter* fix atmospheric nitrogen and increases nitrogen content of the soil.
- *Frankia* form root nodule with non-leguminous plants and fix nitrogen.





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Fungi:

- Many members of the genus *Glomus* form **mycorrhiza** (symbiotic association of fungi with roots of the plants). In such associations, the fungal symbiont absorbs phosphorus from soil and transfers it to the plant.
- Plants having mycorrhizal association show resistance to root-borne pathogens, tolerance to salinity and drought, and an overall increase in plant growth and development.

Cyanobacteria (Blue-green algae):

- These are the autotrophic microbes which can fix atmospheric nitrogen, **Example:** *Anabaena*, *Nostoc*, *Oscillatoria*, etc.
- These also serve as an important biofertiliser in paddy (rice) fields which adds organic matter to the soil and thereby increases its fertility.



TEST

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Unit - VIII: Biology in Human Welfare

1. Large holes in 'Swiss cheese' are due to:
 - (a) *Propionibacterium shermanii*
 - (b) *Saccharomyces cerevisiae*
 - (c) *Penicillium notatum*
 - (d) *Acetobacter aceti*
2. *Monascus purpureus* is a yeast used commercially in the production of:
 - (a) Citric acid
 - (b) Ethanol
 - (c) Blood cholesterol lowering statins
 - (d) None of the above
3. High value of BOD indicates that:
 - (a) Water is less polluted
 - (b) Water is pure
 - (c) Water is highly polluted
 - (d) Consumption of organic matter in water is higher
4. A common biocontrol agent for the control of plant disease is:
 - (a) *Trichoderma*
 - (b) *Glomus*
 - (c) *Bacillus thuringiensis*
 - (d) *Baculovirus*



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Solutions:

1. Option (a) is correct.

Large holes in 'Swiss cheese' are formed due to the production of high amount of CO_2 by a bacterium named *Propionibacterium shermanii*.

2. Option (c) is correct.

Monascus purpureus (yeast) helps in the production of statins. This product commercialized as blood-cholesterol lowering agent, as it acts by competitively inhibiting the enzyme responsible for synthesis of cholesterol.

3. Option (c) is correct.

BOD (Biochemical Oxygen Demand) is the measurement of the rate of uptake of oxygen by micro-organisms during the decomposition of organic matter present in the water. Hence it can be said that, greater the value of organic matter in the water, more is its BOD and polluting potential.

4. Option (a) is correct.

A common biocontrol agent for the control of plant disease is *Trichoderma*. These are free-living fungi which commonly found in the root ecosystems.



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5. Secondary sewage treatment is mainly a:
 - (a) Chemical process
 - (b) Biological process
 - (c) Physical process
 - (d) Mechanical process
6. Which one of the following helps in absorption of phosphorus from soil by plants?
 - (a) *Glomus*
 - (b) *Frankia*
 - (c) *Rhizobium*
 - (d) *Anabaena*
7. Which of the following is correctly matched with the product produced by them?
 - (a) *Acetobacter aceti* : Antibiotics
 - (b) *Methanobacterium* : Lactic acid
 - (c) *Penicillium notatum* : Acetic acid
 - (d) *Saccharomyces cerevisiae* : Ethanol
8. The guts of cow and buffalo possess:
 - (a) *Methanogens*
 - (b) *Cyanobacteria*
 - (c) *Fucus species*
 - (d) *Chlorella species*



TEST

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Solutions:

5. Option (b) is correct.

The secondary treatment is mainly a Biological process, as it involves the use of microbes for sewage treatment. On the other hand, primary sewage treatment is known as Physical process.

6. Option (a) is correct.

Glomus is a genus of fungi whose several members forms symbiotic association with roots of the plants (**mycorrhiza**). In such associations, the fungal symbiont absorbs phosphorus from soil and transfers to the plant.

7. Option (d) is correct.

Saccharomyces cerevisiae (brewer's yeast) ferments malted cereals and fruit juices, to produce ethanol. Whereas, *Acetobacter aceti* produces acetic acid, *Methanobacterium* produces biogas and *Penicillium notatum* produces antibiotic penicillin.

8. Option (a) is correct.

Cows and buffaloes are the ruminants. These animals possess *Methanogens* in their gut, where these bacteria help in the breakdown or digestion of cellulose and thus play an important role in the nutrition of cattle.

