

Microbes in human welfare

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- Introduction :→ Microbes are the major components of biological systems on the earth.
 - Microbes are diverse that includes protozoa, bacteria, fungi, viruses, viroids and also prions that are proteinaceous infectious agents.
 - Microbes are present everywhere, that is in soil, water, air, inside the body of plants and animals, inside thermal vents, deep in the soil, under the layers of snow several meters thick and in highly acidic environments.
 - Microbes cause a large number of diseases in human beings, animals and plants, but all microbes are not harmful.
 - Several microbes are useful and play an important role in human welfare and environment.
 - Microbes can be easily grown in laboratories or at industrial scale for research and production of various useful products.
 - This chapter deals with some of the most important contribution of microbes to human welfare.
- * Microbes in household products :→ The following products of microbes are used in our everyday life.
- (i) Curd from milk :→ Microorganisms such as Lactobacillus and other commonly called lactic acid bacteria (LAB) grow in milk and convert it into curd.

These bacteria (LAB) produce lactic acid during their growth, partially digest the milk protein and cause coagulation.

- A small amount of curd is added to milk as starter or inoculum for curd making. The inoculum contains millions of lactic acid bacteria. At suitable temperature they multiply and convert milk into curd.
- During this process the amount of vitamin B₁₂ increases and the nutritional quality of the product also improves.
- The LAB found in our stomach prevents the growth of disease causing microbes and thus protect us from disease.

(ii) Dosa and idli : → The mixed flour of rice and pulses is fermented by water and air-borne bacteria. The puffed appearance of the dough is due to the production of CO₂ during fermentation. This dough is used for preparing dosa and idli.

(iii) Bread : → Baker's yeast (*Saccharomyces cerevisiae*) is added to wheat flour fermentation is brought about under anaerobic conditions by yeast. CO₂ produced during fermentation makes the dough fluffy and the bread becomes spongy and porous due to release of CO₂ during bread making.

(iv) Cheese : → It is one of the oldest food items produced by using microbes. It is formed by partial degradation of milk by different microbes. Different varieties of cheese have

different flavour, taste and texture depending upon the microbes used in formation of cheese. Some common varieties of cheese are as follows -

- (a) Swiss cheese :- In this cheese large holes are formed due to production of large volume of CO_2 by the activity of a bacterium - *propionibacterium sharmanii*.
- (b) Roquefort cheese :- These are ripened by growing a specific fungus - *penicillium roquefort* which gives a specific flavour to the cheese.
- (v) Toddy :- It is a traditional drink of some part of South India. It is made by fermenting the sap from palm tree.

Microbes are also used to ferment fish, soyabean and bamboo shoots to make food.

* Microbes in industrial production :-
presently microbes are used to produce several industrial products useful to human beings. Some of the most important are fermented beverages and antibiotics. for production of these at commercial level, the microbes are grown at large scale in large sized vessels called fermentors.

- (i) fermented Beverages :- These are alcoholic beverages or drinks and are prepared by using various microbes. The most commonly used microbes is the yeast. *Saccharomyces cerevisiae* alcoholic beverages such as wine, whisky, beer, brandy or rum are prepared by fermentation of various substrate as raw material and using different processes (with or without distillation)

→ Brewer's yeast (*Saccharomyces cerevisiae*) is used for fermenting malted Cereals and fruit juices to produce ethanol in the formation of alcoholic beverages.

→ Wine and beer are produced without distillation.

→ Whisky, brandy and rum are produced by distillation of the fermented broth.

(ii) Antibiotics: → Antibiotics are chemical substances produced by some microbes which kill or slow down the growth of some other microbes. These substances are highly useful for human and have greatly contributed towards the welfare of human society.

→ The discovery of first antibiotic penicillin by Alexander Fleming is one of the most significant discovery of 20th Century.

While Alexander Fleming working on staphylococci bacteria, he observed a mould growing in one of his unwashed culture plates around which staphylococci could not grow.

→ He found that a chemical produced by the mould was responsible for preventing the growth of the bacteria. He named this chemical as penicillin after the name of the fungus - penicillium notatum.

→ The capability of penicillin as an effective antibiotic was later established by Ernest Chain and Howard Florey. The penicillin was extensively used to treat American soldiers, who were wounded in 2nd world war. Fleming, Chain and Florey were awarded Nobel prize in 1945 for their contribution.

→ "Anti" is a greek word that means "against" and "bio" means "life". together they means "against life" of disease causing microbes.

→ They are "pro life" and not against of human life.

(iii) Chemicals : → Different microbes are used for commercial and industrial production of certain useful substances for human beings.

These are as follows →

(a) Organic acids : →

Name of chemical	Name of microbe
Citric acid	Aspergillus niger (fungi)
Acetic acid	Acetobacter aceti (Bacteria)
Butyric acid	Clostridium butylicum (Bacteria)
Lactic acid	Lactobacillus (Bacteria)
Oxalic acid	Penicillium oxalicum (Fungi)

(b) Alcohol : → Ethanol is obtained from Saccharomyces cerevisiae (yeast)

(iv) Enzymes : → Microbes are also used for production of enzymes. these are as follows -

(a) Lipases : → These are formed by the fungi - Candida rugosa and Candida antarctica. These are used in detergent making. These enzymes help in removing oily stains from cloths.

(b) Proteases and pectinases : → These are produced by several species of Bacillus and pseudomonas. These enzymes are useful in clearing the bottled juices.

(c) Streptokinase : → It is produced by the bacterium Streptococcus and modified by genetic engineering. This enzyme is used as a clot buster for removing blood clots from the blood vessels.

It is used in patients who have undergone myocardial infarction leading to heart attack.

(V) Bioactive molecules :->

	Bioactive molecule	Name of microbes	Uses
(i)	Cyclosporin-A	<i>Trychoderma polysporum</i> (fungi)	It works as immunosuppressive agent in patients undergoing organ transplant
(ii)	Statins	<i>Monoascus purpureus</i> (yeast)	It inhibits the activity of enzyme responsible for synthesis of cholesterol. Thus acts as blood cholesterol lowering agent.

★ Microbes in Sewage treatment :-> The term Sewage is used to represent both liquid and solid wastes generated (Produced) every day in cities and towns. The Sewage contains large amount of wastes including human and animal excreta. The municipal waste-water is also called Sewage.

→ It contains large amount of organic matter and microbes, many of which are pathogenic. Hence this should not be discharged directly into natural water bodies like rivers and streams.

→ Before disposal the Sewage has to be treated in sewage treatment plants (STPs) to make it less polluting. The treatment of waste water is done by heterotrophic microbes naturally

present in the Sewage. This treatment is carried out in two stages →

(i) Primary treatment : → It is also named as physical treatment. In this treatment large and small particles are removed from the Sewage through filtration and Sedimentation.

→ In the beginning the floating objects are removed by passing the waste through sequential filtration. After this the grit (soil and small pebbles) are removed by Sedimentation.

→ These are allowed to settle at the bottom of settling tanks. All the solids which settle at the bottom of settling tank form the primary sludge. The waste water present as Supernatant forms the effluent. The effluent from the primary settling tank is taken for secondary treatment.

(ii) Secondary treatment or biological treatment : → First of all the effluent from the settling tank is passed on to the large aeration tank. Here the effluent is mechanically shaken and air is pumped into it. As a result it becomes aerobic (oxygen rich) and aerobic microbes grow vigorously in the effluent.

→ Vigorous growth of useful microbes in the form of masses of bacteria along with fungal filaments results in to formation of mesh like structure known as ~~flocs~~ flocs.

→ During their growth the microbes consume a major part of the organic matter present in the effluent. As a result BOD (Biochemical oxygen demand) of effluent is significantly reduced.

- BOD is defined as the amount of oxygen which is consumed by the bacteria to decompose (oxidise) all organic matter present in one litre of water. Thus BOD of a sample serves as an indicator of amount of organic matter present in waste water.
- When the BOD is greater of waste water then the amount of organic matter is more present in it and more is its polluting potential.
- When the BOD of the effluent is reduced significantly by the activity of aerobic microbes, then this effluent is passed in the settling tank where the flocs formed by microbes are allowed to settle at the bottom as sediment. This sediment formed after secondary treatment is known as activated sludge.
- A small part of the activated sludge is pumped back into the aeration tank where it serves as inoculum. The remaining major part of the activated sludge is passed into large tanks called anaerobic sludge digesters. In these tanks aerobic bacteria grow and digest the aerobic bacteria and fungi as well as the organic matter present in the activated sludge.
- During this process the anaerobic bacteria produce a mixture of gases such as methane, hydrogen sulphide and carbon dioxide. These gases produced by digestion of the activated sludge by the activity of the anaerobic bacteria such as methanogens form the "Biogas". The Biogas is inflammable and can be used as source of energy for cooking and for illumination.

- The effluent from the secondary treatment plant is generally released into natural water bodies like rivers and streams.
- Two major rivers of India have become polluted due to discharge of untreated sewage and industrial waste in these rivers. The ministry of environment and forest has initiated Ganga action plan and Yamuna action plan to make these two major rivers pollution free.
- These plans have a provision to build a large number of Sewage treatment plants (STPs) at the banks of these rivers. This will ensure that the sewage and other industrial waste are discharged in these rivers only after treatment in STPs.

* Microbes in production of Biogas : →

Microbes produce different types of gaseous products during their growth and their metabolic activities. ~~The~~ The type of gases produced depend upon the microbes and the organic matter used by them.

- Certain bacteria which grow anaerobically on cellulosic material, produce large amount of methane, along with CO_2 and H_2 . These anaerobic bacteria are collectively called methanogens. and one such common bacterium is *Methanobacterium*. Biogas is a mixture of gases containing mainly methane. The methanogens are known to produce large amount of methane (50-70%) along with CO_2 (25-30%) and H_2 (1-5%). These bacteria are commonly found in the anaerobic sludge in the sewage treatment plant.

These bacteria are also present in the rumen 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.

Biogas is commercially produced in biogas plant. The excreta (dung) of cattle is commonly called "Gobar." It is rich in methanogen and is used in biogas plants for generation of biogas. Gobar is used in generation of biogas, so this gas is also called gobar gas.

Biogas plant: → The biogas plant consists of the following four parts —

- i) Slurry tank (ii) Digester (iii) Gas holder (iv) Sludge tank

i) Slurry tank: — In this tank gobar and water are mixed and slurry is prepared. The slurry is carried to main digester tank through a pipe.

ii) Digester tank: — It is made up of Cement Concrete and 10-15 feet deep. Slurry is fed into this tank. Anaerobic bacteria bring about decomposition of cattle excreta (gobar).

i) Gas holder: → It is a metallic gas holder. It is like a floating cover placed on slurry. This gas holder keeps on rising as the gas is produced in the tank due to microbes microbial activity. The gas holder has an exit pipe or an outlet pipe through which bio-gas is supplied to nearby houses.

(iv) Sludge tank : → Through another outlet, the spent slurry/used gobar is collected into a sludge tank. It is used as fertilizer.

→ The biogas 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).

* Microbes as biocontrol agent : → In order to obtain higher yield of the crop and to protect crop plants from pathogen and pests, farmers use insecticides and pesticides. These chemicals are harmful and toxic for human beings and animals. Besides this increased use of chemical fertilizers and pesticides have resulted into pollution of soil, ground water, and the environment. So,

→ Biocontrol or biological control refers to the use of biological methods for controlling plant disease and pests.

* Biological Control of pests and diseases : → Some examples used in biological control are as follows -

① A beetle having black and red markings and commonly known as the lady bird and Dragon flies help in destroying the aphids and mosquitoes.

② The butterfly caterpillars are controlled by the use of *Bacillus thuringiensis* (Bt bacteria). The dried spores of this bacterium are

mixed with water and sprayed on susceptible plants of Cruciferae family and some fruit trees. These spores are eaten by the larvae of Caterpillars. In the gut of the larvae, the toxin is released and the larvae get killed. But other insects are not harmed.

→ Now, the gene which produces the toxin has been isolated from *Bacillus thuringiensis*. By using technique of genetic engineering, this gene has been introduced in other plants. Such plants show resistance to attacks by insect pests on account of presence of Bt gene. The most common example is Bt Cotton which is now cultivated in many states of our Country.

(iii) 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 soil ecosystems. They are effective biocontrol agents of several plant pathogens.

(iv) Baculoviruses are pathogens that attack insects and other arthropods. The majority of baculoviruses used as biological control agents belong to the genus *Nucleopolyhedrovirus*. These viruses are narrow spectrum in their action, so, they attack only some specific species of arthropods. They do not show negative impact on plants, mammals, birds, fish and even on non target insects and arthropods. Hence in integrated pest

management (IPM) programme. These viruses are excellent biocontrol agents because they help in conserving the useful insects and kill the harmful insects only.

★ Microbes as biofertilizers : → Biofertilizers are micro-organisms which enrich the nutrient content of soil and help to increase the output of agricultural products. The use of chemical fertilizers to meet the ever increasing demand of agricultural products has resulted into pollution of environment. Thus there is a pressure to adopt organic farming.

→ Some microbes used as biofertilizers are as follows →

① Rhizobium bacteria : → Rhizobium bacterium is a symbiotic bacterium and lives in the root nodules of leguminous plants. These bacteria fix atmospheric free nitrogen (N_2) into nitrogen compounds which are absorbed by the plants.

Azotobacter and Azospirillum are free living bacteria and can fix free nitrogen (N_2) into nitrogen compounds. These N_2 fixing bacteria enrich the soil with nitrogen contents which are used as biofertiliser by the plants.

② Mycorrhiza : → Some fungi are able to form symbiotic association with the roots of higher plants, specially the gymnosperm. Such type association of fungi with plants is called mycorrhiza.

Many members of the genus "Glomus" are known to form mycorrhizal association with roots of several plants.

- The fungal symbiont in these association absorbs phosphorus from soil and passes it to the plant. plants having such associations show other benefits also, such as resistance to root-borne pathogens, tolerance to salinity and drought, and an overall increase in plant growth and development.

(iii) Cyanobacteria (Blue green algae) → These are autotrophic photosynthetic microbes. These are found in aquatic and wet terrestrial environments. Many of them fix atmospheric nitrogen and serve as important fertilizers.

- Example - Nostoc, Anabaena, Oscillatoria etc. In paddy fields cyanobacteria grow vigorously and serve as an important fertilizer. Hence, these are added into paddy fields.
- These microbes also add organic matter to the soil and increase soil fertility.
- The biofertilizers do not pollute any component of environment. These are relatively cheap as compared to chemical fertilizers.
- The farmers use these in the field to enrich the soil with nutrients and dependence on chemical fertilizers is reduced.



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