MICROBES IN HUMAN WELFARE

- Those organisms which are not visible with naked eyes and viewed under the microscope are called **microorganisms** or **microbes**.
- These include bacteria, protozoans, yeasts, viruses etc.
- The viruses, viroids and prions are proteinacious infectious agents.
- The microbes are almost omnipresent (*i.e.*, found every where). They are found in snow, inside thermal vents (or inside geysers, high acidic habitats etc.) Some remain viable when cooled upto - 190°C.
- Some microbes are deadly parasites of plants, animals and human beings. Most of the microbes (fungi and bacteria) can be grown on nutritive media where they form colonies.
- Microbes are causal agents of most of the infectious diseases. They also spoil our food and other edible items.
- They are also useful to humans and nature in many important processes. They are more friendly and useful to man than they are harmful.

MICROBES IN HOIJSEHOLD PRODUCTS

- Fermentation is the oldest microbiological process.
- Some of the household products obtained from microbial activity are-dairy products, bread, dosa, upma, idli, SCP, toddy and other foods.
- Lactic acid bacteria (LAB) like *Lactobacillus* convert lactose sugar of milk into lactic acid.
- Lactic acid causes coagulation of milk protein casein. Milk is changed into curd, yoghurt and cheese. The starter or inoculum used in preparation of milk products actually contains millions of LAB.
- Curd is prepared by inoculating cream and skimmed milk with Lactobacillus acidophilus at temperature of about \$\le 40°C.
- Cheese is the partially degraded concentrate of milk fat and casein manufactured by microorganisms.
- Swiss cheese is characterized by the characteristic flavour and large holes. The large holes are formed due to amount of CO₂ released by a thermophilic bacteria (*Propionibacterium sharmanii*).
- **Roquefort cheese** is characterized by greenish blue mottling. It is ripened by *Penicillium roquefortii*. It is probably the best known cheese made from sheep's milk.
- **Camembert cheese** employs *Penicillium camemberti* for ripening.
- **Dosa, upma and idli** are prepared by fermentation process of dough.
- Dough is allowed to ferment overnight for 10-12 hours. Bacteria (microbes) causing fermentation come from surrounding. These are Streptococcus faecalis, Leuconostoc mesenteroides etc.
- Bread is made when dough is mixed with Baker's yeast (Saccharomyces cerevisieae) and allowed to stand

for several hours. The sugar present in dough is rapidly fermented by the yeast. It produces CO_2 and alcohol and swells up which is known as "leaving".

- Toddy is made by fermenting latex obtained from toddy palm and coconut water. It undergoes fermentation with the help of naturally occurring yeast. It is refreshing drink which can be heated to produce palm sugar (Jaggery).
- Other foods like Tempeh (Indonesia), Tofu (Japanese) and Sufu (Chinese) are fermented foods obtained from soyabean.
- Soy sauce is brown flavoured salty sause fermented from soyabean and wheat.
- Tender bamboo shoots are used as vegetable directly or in fermented form.

MICROBES IN INDUSTRIAL PRODUCTS

- A number of powerful industries have been set up based on beneficial activities of microbes.
- A variety of products in enormous amounts are produced as – beverages (alcoholic and non alcoholic), antibiotics, organic acids, enzymes, vitamins, hormones, amino acids, vaccines and steroids.
- The container where fermentation is carried out is called **hioreactor** or fermenter.

Alcoholic fermentation

- Yeast species used in alcoholic <u>fermentation</u> are Saccharomyces cerevisiae, S. ellipsoidens, S. sake, etc.
- Fermented nutrient medium differs based on products.
- The yeasts which are used in the brewing industry for the preparation of alcoholic drinks are collectively called brewer's yeast.
- Different types of alcoholic beverages are produced by using different brewer's yeast.

Products (Source)	Method	Brewer's yeast
Beer (Grain)	Non distillation	Saccharomyces cerevisiae and
		S. carisbergensis
Wine (Fruit juice)	Non distillation	S. ellipsoidens

- Whisky, rum, gin, brandy, vodka and fenny are distilled beverages, so called hard liquors (Higher % of alcohol).
- By products of alcoholic fermentation are CO₂ and ethanol.

Antibiotics

Antibiotics is an organic compound produced by a microorganism that in low concentration inhibits the growth or kills the pathogenic organism without harming the host. The term "antibiotic" (means against life) was coined by Waksman (1942).

- Alexander Fleming (1928) discovered first antibiotic penicillin from *Penicillium notatum* in 1928.
- It was commercially extracted by efforts of Chain and Florey.
- The chemical was extensively used in treating wounded American soldiers in world war II.
- Fleming, Chain and Florey were awarded with Nobel prize in 1945.
- Over 7000 antibiotics are known. Streptomyces griseus produces more than 41 antibiotics while Bacillus subtilis can give about 60 antibiotics.
- Antibiotics are obtained from lichens, eubacteria, fungi and actinomycetes.

Antibiotics	Source	Action
Chloramphenicol	S. venezuelae	Typhoid, whooping cough (Kali Khansi)
Erythromycin	S. erythreus	Diphtheria (gal ghotu)
Chloromycetin	S. lavendulae	Pneumonia
Streptomycin	S., griseus	Meningitis, Pneumonia, TB
Bacitracin	Bacillus licheniformis	Syphilis

 Antibiotics are medicines used for treatment of a number of pathogenic or infectious diseases.

CHEMICALS, ENZYMES AND OTHER BIOACTIVE MOLECULES

- A number of **organic acids** are manufactured with the help of microbes acetic acid, citric acid, lactic acid, gluconic acid, cyclosporin A, statins.
- Acetic acid is produced from fermented alcohol with the help of bacteria, *Acetobacter aceti*.
- Citric acid is obtained through the fermentation carried out by *Aspergillus niger* and *Mucor* species on sugary syrup.
- **Gluconic acid** is prepared by the activity of *Aspergillus niger* and *Penicillium* species.
- Cyclosporin A is an important bioactive chemical produced by the fungus *Trichoderma polysporum*. It is used as an immuno suppressive agent in organ transplantation.
- Statins are produced by yeast *Monascus purpureus*. It acts as competitive inhibitor of enzyme for cholesterol

synthesis. So, it is used as blood cholesterol lowering agent.

- **Enzymes** are proteinaceous substances of biological origin which are capable of catalysing biochemical reactions without themselves undergoing any change.
- **Pectinases** are enzymes obtained commercially from *Byssochalmys fulvo*. Alongwith proteases they are used in clearing of fruit juices and also in retting fibres and preparation of green coffee.
- Lipases are lipid dissolving enzymes that are obtained from *Candida lipolytica* and *Geotrichum candidum*. Lipases are added in detergents for removing oily stains from laundry and also used in flavouring cheese.
- Streptokinase (Tissue Plasminogen Activator or TPA) is an enzyme obtained from the cultures of some haemolytic *Streptococci*. It has **fibrinolytic effect**, therefore it helps in clearing blood clots inside the blood vessels.
- Yeast (Saccharomyces cerevisiae) is used for commercial production of ethanol.

MICROORGANISMS IN SEWAGE TREATMENT

- Sewage or municipal waste contains human excreta and other organic wastes. It also contains a number of pathogenic microbes, so should not be passed into rivers, streams and other water bodies. It is made less polluting by passing it through sewage treatment plants (STPs).
- In sewage, heterotrophic microbes naturally present carry out the process of **decomposition**.
- There are two stages of this treatment :
- Primary treatment (Physical)
- Secondary treatment (Biological).
- Primary treatments remove floating and suspended solids from sewage through filtration and sedimentation. All the sewage materials are first diluted with water and passed through sequential filtration to remove large floating objects.
- Now filtered sewage is passed into the grit chamber where coarse solid materials (sand, small pebbles etc.) settle down by gravity. After this, the sewage is allowed to pass into a sedimentation tank. Here most of the suspended materials get concentrated and settles down. The sedimentation is called the primary sludge and supernatant is called effluent.
- The primary sludge traps a lot of microbes and debris, so it is subjected to composting land. The effluent is then taken for secondary treatment.



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Fig .: Activated sludge method of sewage treatment.

- Secondary treatment is purely a biological treatment involving microbial activity.
- In activated sludge system, the primary effluent is taken to aeration tanks. Liquid is constantly agitated mechanically and air is allowed to pass through agitating mixture. This helps several aerobic microbes to grow and oxidise the organic matter present in sewage.
- All microbes form flocs which are masses of bacteria held together by slime and fungal filaments to form mesh like structures. The microbes digest a lot of organic matter, converting it into microbial biomass and releasing a lot of minerals. Due to this BOD of waste matter is reduced to 10-15% of raw sewage.
- Biochemical Oxygen Demand (BOD)
 Biochemical oxygen demand (BOD) represents the amount of dissolved O₂ that would be consumed if all the organic matter in one litre of water were oxidized by microorganisms (at 20°C).
- Whenever untreated sewage are disposed into water bodies, the dissolved O₂ in water, gets quickly utilized (by microorganisms) and oxygen demand (OD) increases. Thus high value of BOD means water is highly polluted and low value means either normal or less polluted.
- Now the effluent is passed through a sedimentation tank where microbial flocs are allowed to settle down. The settled material is called activated sludge.
- The effluent or supernatant is generally passed into natural water (rivers, streams etc) or treated with chemical for further purification. A part of activated sludge is used as inoculum in aeration tank. The remaining is passed into a large tank called anaerobic sludge digester.
- Here aerobic microbes (if present in the sludge) get killed. Anaerobic microbes digest the organic matter as well as aerobic microbes into soluble and gaseous products (CH₄, CO₂, H₂S, etc.).
- They are of two types : nonmethanogenic and methanogenic. Methanogenic bacteria produce a mixture of gases containing CH₄, CO₂, H₂S, etc. This mixture is known as biogas.
- It is highly inflammable and is a source of energy.
- The spent sludge can be used as manure or part of compost.

BIOGAS OR GOBAR GAS (MICROBES IN ENERGY GENERATION)

- Biogas is a methane rich fuel gas produced by anaerobic break down or digestion of biomass with the help of methanogenic bacteria.
- It is an ideal gas made up of 50 70% methane (CH₄), 30 - 40% CO₂, 1 - 5% H₂, traces of O₂ and N₂ and H₂S.
- The most important microbes involved in production of biogas are-Archaebacteria (Methanogenic) and Bacillus, etc. The energy released from biogas depends upon the proportion of methane present in it.
- Biogas is commercially produced inside the biogas plants. Each biogas plant consists of a deep (10 - 15 ft) concrete

tank covered by floating lid. It is fed with a mixture of dung (commonly called gobar) and water (1: 1).

- Cattle dung is a rich source of cellulosic material from
- plants. After filling the slurry of the dung, the biogas tank is covered by a floating lid which keeps on raising as the gas is produced from the slurry. The microbial activity on the slurry of dung results in the release of biogas.
- Biogas is allowed to pass through an outlet pipe which is connected with the supply line. The leftover slurry is removed through another outlet, that can be used as fertilizer.
- Biogas is used as fuel for heating, cooking and lighting. It is considered ecofriendly and pollution free source of energy.



Fig.: A typical biogas plant

MICROBES AS BIOCONTROL AGENTS

- Biocontrol refers to the use of biological methods for controlling plant disease and pests.
- Biopesticides are certain pesticides derived from natural or biological agents like animals, plants, bacteria, viruses, fungi etc. to destroy or control weeds, insects and pathogens.
- For example, Lady bird beetle (beetle with red and black markings) feeds on aphids while dragonflies prey upon mosquitoes. Free living fungus *Trichoderma* exerts biocontrol over several plant pathogens.
- According to nature of organism biopesticides are of different types as microbial pesticides, plant pesticides and biochemical pesticides.
- Microbial pesticides consist of a micro-organism (e.g., a bacterium, fungus, virus, or protozoan) as the active ingredient. The most widely used microbial pesticides are subspecies and strains of *Bacillus thuringiensis* (Bt).
- **Biochemical pesticides** are naturally occurring substances that control pests by nontoxic mechanisms.
- **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 applications. 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.

MICROBES AS BIOFERTILIZERS

- **Biofertilizers** are organisms which bring about nutrient enrichment of the soil by enhancing the availability of nutrients like nitrogen and phosphorous to the crops.
- Biofertilizers are of three types nitrogen fixing bacteria, nitrogen fixing cyanobacteria and mycorrhiza.
- Free living nitrogen fixing bacteria live freely in the soil and perform nitrogen fixation. Some of them are saprotrophic, living on organic dead remains e.g., Azotobacter, Bacillus, Clostridum, Beigerinckia etc.
- The most important of the symbiotic nitrogen fixing bacteria is *Rhizobium*. It forms **nodules** on the roots of **legume plants**. There are about a dozen species of *Rhizobium* which form association with different legume roots, *e.g.*, *R. leguminosarum*, *R. lupini*, *R. trifolii*, *R. meliloti*, *R. phaseoli*
- Mycorrhiza is a mutually beneficial or symbiotic association of a fungus with the root of a higher plant. Many members of genus *Glomus* form mycorrhiza. The fungal symbiotic absorbs phosphorus for the plant.
- Nitrogen fixing cyanobacteria (blue-green algae) form symbiotic association with several plants, *e.g.*, *Anabaena*, *Nostoc*, *Oscillatoria*.
- Azolla-A nabaena association is of great importance to agriculture. Azolla pinnata is a free floating fresh water form which multiplies rapidly, doubling every 5-7 days. The fem can coexist with rice plants because it does not interfere with their growth. In some South-East Asian countries, especially China, the rice fields are regularly provided with Azolla.

