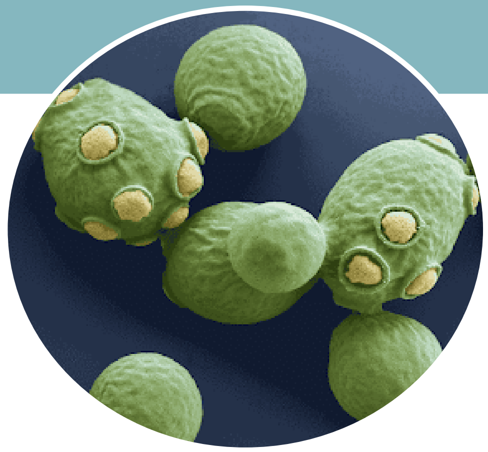
UNIT - III

9

CHAPTER

Microbes in Human Welfare



Saccharomyces cerevisiae, a species of yeast used in baking and brewing industry.

Chapter outline

Learning objectives

- *Differentiates probiotics from pathogens.*
- *Understands the use of microbes in household products.*
- *Learns about antibiotic production and fermented beverages.*
- *Realizes the importance of microbes in sewage treatment and energy generation.*
- *Learns the role of bio-fertilisers in farming.*
- *Realizes the applications of microbes in bio-remediation.*

NR6T4Q

Microbes such as bacteria, fungi, protozoa, certain algae, viruses, viroids and prions are some of the major components of the biological system on Earth. Several microorganisms are beneficial and contribute to human welfare. Microbes are present everywhere – in soil, water, air and within bodies of animals and plants. Microbes like bacteria and fungi can be grown on nutritive media to form colonies which can be visibly seen. Some of the microbes useful to human welfare are discussed here.

9.1 Microbes in household products

In every day life, microbes and their products are used in the preparation of idli, dosa, cheese, curd, yogurt, dough, bread, vinegar, etc., Bacteria like *Lactobacillus acidophilus, L. lactis* and *Streptococcus lactis* commonly called **lactic acid bacteria** (LAB) are probiotics which check the growth of pathogenic microbes in the stomach and other parts of the digestive tract.

The LAB bacteria grows in milk and convert it into curd, thereby digesting the milk protein casein. A small amount of curd added to fresh milk as a starter or inoculum contains millions of *Lactobacilli*, which under suitable temperature (≤40°C) multiply and convert milk into curd. Curd is more nutritious than milk as it contains a number of organic acids and vitamins.

> **DO YOU KNOW?**
>
> **Prebiotics** are compounds in food (fibers) that induce the growth or activity of beneficial microorganisms.
>
> **Probiotics** are live microorganisms intended to provide health benefits when consumed, generally by improving or restoring the gut flora.

Yogurt is produced by bacterial fermentation of milk, and lactic acid is produced as a byproduct. Microorganisms such as *Streptococcus thermophilus* and *Lactobacillus bulgaricus* coagulate the milk protein and convert the lactose in the milk to lactic acid. The flavour in yogurt is due to acetaldehyde.

Cheese is a dairy product produced in a wide range of flavours, textures and is formed by coagulation of the milk protein, casein. During cheese production, milk is usually acidified and the enzyme rennet is added to cause coagulation. The solids are separated and pressed to form cheese. Most cheese are made with a starter bacteria, *Lactococcus*, *Lactobacillus* or *Streptococcus.*

Paneer (cottage cheese) is fresh cheese common in South Asia, especially in India. It is made by curdling milk with lemon juice, vinegar and other edible acids. Large holes in Swiss cheese is due to the production of large amount of carbon-di-oxide by the bacterium *Propionibacterium shermanii.*

The dough used in the preparation of idlis and dosas are fermented by the bacteria *Leuconostoc mesenteroides* whereas the dough used in bread making is fermented by *Saccharomyces cerevisiae* (Baker's Yeast). Fermentation of glucose mainly forms ethyl alcohol and carbon-di-oxide, which is responsible for leavening of dough. When leavened dough is baked, both carbon-di-oxide and ethyl alcohol evaporate making the bread porous and soft.

Single cell protein (SCP)

Single cell protein refers to edible unicellular microorganisms like *Spirulina*. Protein extracts from pure or mixed cultures of algae, yeasts, fungi or bacteria may be used as ingredient or as a substitute for protein rich foods and is suitable for human consumption or as animal feed.

9.2 Microbes in industrial products

Microbes are used to synthesize a number of products valuable to human beings. Products like beverages, antibiotics, organic acids, amino acids, vitamins, biofuels, single cell protein, enzymes, steroids, vaccines, pharmaceutical drugs, etc., are produced in industries. Production on a large scale requires growing microbes in very large vessels called fermentors. A fermentor (bioreactor) is a closed vessel with adequate arrangement for aeration, agitation, temperature, pH control and drain or overflow vent to remove the waste biomass of cultured microorganisms along-with their products.

9.2.1 Antibiotic production

Antibiotics are chemical substances produced by microorganisms which can kill or retard the growth of other disease causing microbes even in low concentration. Antibiotic means "**against life**". Antibiotics are used to treat diseases such as plague, meningitis, diphtheria, syphilis, leprosy, tuberculosis etc., **Selman Waksman** discovered Streptomycin and was the first to use the term "**antibiotic**" in 1943.

While working on *Staphylococci* bacteria, Alexander Fleming observed a green 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 the mould and he named it as penicillin, which was the first antibiotic discovered by Alexander Fleming in 1926 (**Fig. 9.1**). Penicillin is produced by the fungi *Penicillium notatum* and *Penicillium chrysogenum*. It is bactericidal (antibiotics that kill bacteria) in action and inhibits the synthesis of the bacterial cell wall.

Penicillin is also referred as the **"queen of drugs"** and its full potential as an effective antibiotic was established much later by **Earnest Chain** and **Howard Florey** when they treated the wounded soldiers in World War II with penicillin. **Fleming, Chain** and **Florey** were awarded the **Nobel prize** in 1945 for the discovery of penicillin.

Antibiosis is the property of antibiotics to kill microorganisms.
Broad-spectrum antibiotics act against a wide range of disease-causing bacteria.
Narrow-spectrum antibiotics are active against a selected group of bacterial types.

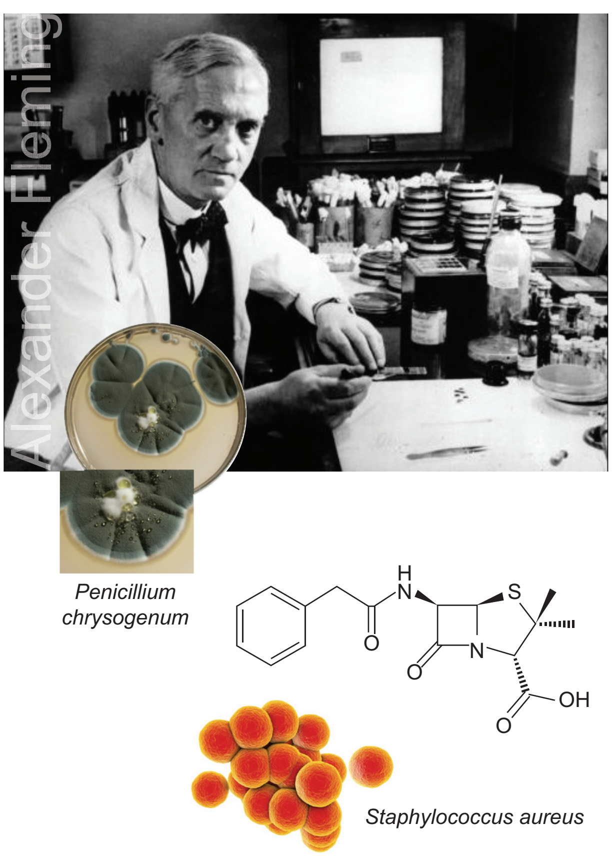


Fig. 9.1 Discovery of penicillin

DO YOU KNOW?

Hypersensitivity reaction is a major problem with the use of penicillin, resulting in nausea, vomiting, wheezing and ultimately cardiovascular collapse. To check the sensitivity reaction, doctors use a needle to prick the forearm of the patients to give a weak dose of penicillin. An itchy red region in the forearm is an indication that the patient is allergic to penicillin. This test is important before administration of penicillin to a patient.

Tetracycline is a broad spectrum bacteriostatic antibiotic (antibiotics that limit the growth of bacteria) that inhibits microbial protein synthesis. **Chlortetracycline** is the first antibiotic of this group, isolated from the cultures of *Streptomyces aureofaciens*. **Streptomycin** is a broad spectrum antibiotic isolated from the actinomycetes, *Streptomyces griseus*. It is bactericidal against both gram positive and gram negative bacteria, especially against *Mycobacterium tuberculosis*. Antibiotics, such as **erythromycin, chloromycetin, griseofulvin, neomycin, kenamycin, bacitracin,** etc., are also isolated as microbial products.

Antibiotic resistance

Antibiotic resistance occurs when bacteria develop the ability to defeat the drug designed to kill or inhibit their growth. It is one of the most acute threat to public health. Antibiotic resistance is accelerated by the misuse and over use of antibiotics, as well as poor infection prevention control. Antibiotics should be used only when prescribed by a certified health professional. When the bacteria become resistant, antibiotics cannot fight against them and the bacteria multiply. Narrow spectrum antibiotics are preferred over broad spectrum antibiotics. They effectively and accurately target specific pathogenic organisms and are less likely to cause resistance. "**Superbug**" is a term used to describe strains of bacteria that are resistant to the majority of antibiotics commonly used today.

9.2.2 Fermented beverages

Microbes especially yeast is being used from time immemorial for the production of beverages like wine, beer, whisky, brandy and rum. Wine is among the oldest alcoholic beverages known and is produced by fermentation of fruit juice by yeast. **Zymology** is an applied science which deals with the biochemical process of fermentation and its practical uses.

Saccharomyces cerevisiae commonly called brewer's yeast is used for fermenting malted cereals and fruit juices to produce various alcoholic beverages. Wine and beer are produced without distillation, whereas whisky, brandy and rum are obtained by fermentation and distillation.

DO YOU KNOW?

The Pasteur effect is the inhibiting effect of oxygen on the fermentation process.

Oenology is the science and study of **wine** and wine making. Wine is made from the fermentation of grape juice. Grape juice is fermented by various strains of *Saccharomyces cerevisiae* into alcohol. Grape wine is of two types, red wine and white wine. For red wine, black grapes are used including skins and sometimes the stems also are used. In contrast white wine is produced only from the juice of either white or red grapes without their skin and stems.

Beer is produced from germinated barley malt grain by *Saccharomyces carlsbergensis* or *Saccharomyces cerevisiae*. Rum is made from fermented sugarcane or molasses or directly from sugarcane juice by *Saccharomyces cerevisiae*. **Whisky** is a type of distilled alcoholic beverage made from fermented grain mash by *Saccharomyces cerevisiae*.

Alcohol content in various beverages

- Beer contains 3 to 5 percent of alcohol.
- Wine contains 9 to 14 percent alcohol. Wine coolers are made of wine mixed with carbonated water and flavourings. Wine coolers have about 4 to 6 percent alcohol.
- Distilled spirits such as whiskey, gin, scotch and vodka usually contain 35 to 50 percent alcohol.

In some parts of South India, a traditional drink called **pathaneer** is obtained from fermenting sap of palms and coconut trees. A common source is tapping of unopened spadices of coconut. It is a refreshing drink, which on boiling produces jaggery or palm sugar. When pathaneer is left undisturbed for few hours it gets fermented to form **toddy** with the help of naturally occurring yeast, to form a beverage that contains 4 percent alcohol. After 24 hours **toddy** becomes unpalatable and is used for the production of vinegar.

Saccharomyces cerevisiae is the major producer of ethanol (C_2H_5OH). It is used for industrial, laboratory and fuel purposes. So ethanol is referred to as **industrial alcohol**. Bacteria such as *Zymomonas mobilis* and *Sarcina ventriculi* are also involved in ethanol production. The principal substrates for the commercial production of industrial alcohol include molasses or corn, potatoes and wood wastes. The process of ethanol production starts by milling a feed stock followed by the addition of dilute or fungal **amylase (enzyme)** from *Aspergillus* to break down the starch into fermentable sugars. Yeast is then added to convert the sugars to ethanol which is then distilled off to obtain ethanol which is upto 96 percent in concentration. The two most common type of biofuels in use today are ethanol and biodiesel, both of them represent the first generation of biofuel technology. Ethanol is often used as a fuel, mainly as a biofuel additive for gasoline.

Biodiesel is a fuel made from vegetable oils, fats or greases. Biodiesel fuel can be used in diesel engines without altering the engine. Pure biodiesel is non-toxic, biodegradable and produces lower level of air pollutants than petroleum-based diesel fuel. The Government of India approved the National Policy on Biofuels in December 2009 and identified *Jatropha curcas* as the most suitable oilseed for biodiesel production. *Pongamia* species is also a suitable choice for production of biodiesel.

$$\underset{\text{(Glucose)}}{C_6H_{12}O_6} \xrightarrow[\text{Fermentation}]{\text{Yeast}} \underset{\text{(Ethanol)}}{2C_2H_5OH} + 2CO_2\uparrow$$

DO YOU KNOW?

World biofuel day is observed every year on **10th August** to create awareness about the importance of renewable bio-fuels as an alternative to conventional non-renewable fossil fuels. This day also highlights the various efforts taken by the Government in the biofuel sector.

9.2.3 Chemicals, enzymes and other bioactive molecules

Microbes are not only used for commercial and industrial production of alcohol, but also used for production of chemicals like organic acids and enzymes. Examples of organic acid producers are *Aspergillus niger* for **citric acid**, *Acetobacter aceti* for **acetic acid**, *Rhizopus oryzae* for **fumaric acid**, *Clostridium butyricum* for **butyric acid** and *Lactobacillus* for **lactic acid**.

Yeast (*Saccharomyces cerevisiae*) and bacteria are used for commercial production of enzymes. Lipases are used in detergent formulations and are used for removing oily stains from the laundry. Bottled juices are clarified by the use of **pectinase, protease** and **cellulase**. Rennet can also be used to separate milk into solid curds for cheese making. Streptokinase produced by the bacterium *Streptococcus* and genetically engineered *Streptococci* are used as "**clot buster**" for removing clots from the blood vessels of patients who have undergone myocardial infarction.

Cyclosporin A, an immunosuppressant used in organ transplantation is produced from the fungus *Trichoderma polysporum.* It is also used for its anti-inflammatory, anti-fungal and anti-parasitic properties. **Statins** produced by the yeast *Monascus purpureus* have been used to lower blood cholesterol levels. It acts by competitively inhibiting the enzyme responsible for the synthesis of cholesterol. Recombinant **human insulin** has been produced predominantly using *E. coli* and *Saccharomyces cerevisiae* for therapeutic use in human.

9.3 Microbes in sewage treatment and energy generation

Sewage is the waste generated every day in cities and towns containing human excreta. It contains large amounts of organic matter and microbes, which are pathogenic to humans and are bio-degradable pollutants. Domestic waste consists of approximately 99 percent water, suspended solids and other soluble organic and inorganic substances. Sewage should not be discharged directly into natural water bodies like rivers and streams. Before disposal, sewage should be treated in sewage treatment plants to make it less polluting **(Fig. 9.2)**.

9.3.1 Wastewater treatment

The main objective of a wastewater treatment process is to reduce organic and inorganic components in wastewater to a level that it no

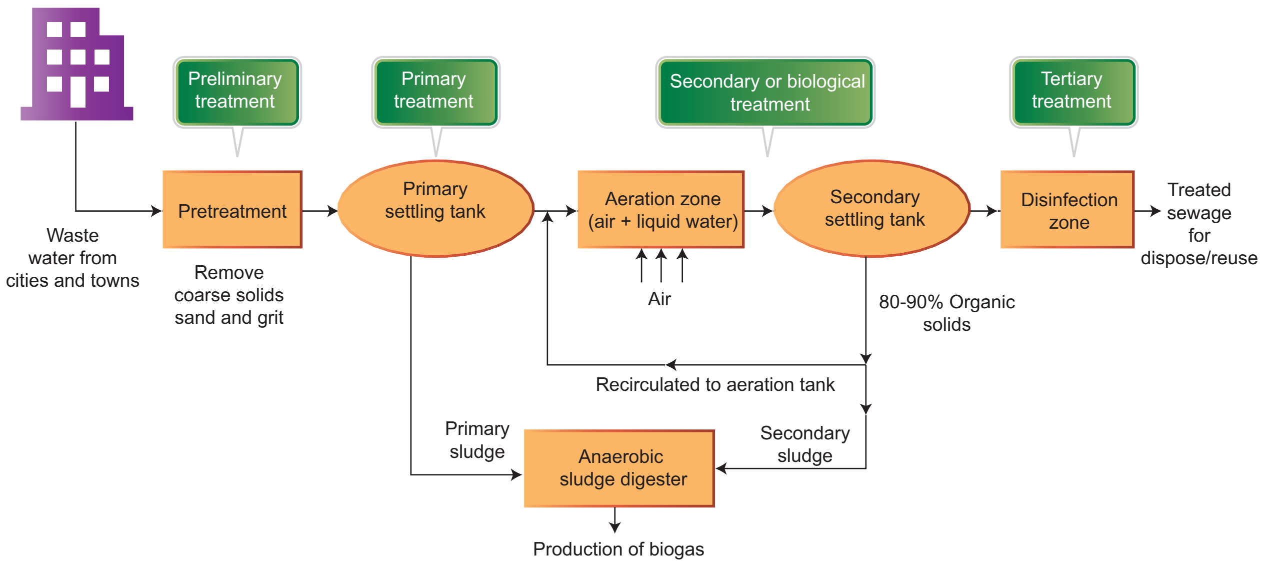


Fig. 9.2 Sewage treatment process

longer supports microbial growth and to eliminate other potentially toxic materials. Microorganisms mainly bacteria and some protozoa play an essential part in the treatment of sewage to make it harmless. Sewage contains pathogenic bacteria. These bacteria must be destroyed in order to prevent the spread of diseases. Sewage treatment is usually performed in the following three stages.

Primary treatment

Primary treatment involves the physical removal of solid and particulate organic and inorganic materials from the sewage through filtration and sedimentation. Floating debris is removed by sequential filtration. Then the grit (soil and small pebbles) are removed by sedimentation. All solids that settle form the primary sludge and the supernatant forms the effluent. The effluent from the primary settling tank is taken for secondary treatment.

Secondary treatment or biological treatment

The primary effluent is passed into large aeration tanks where it is constantly agitated mechanically and air is pumped into it. This allows vigorous growth of useful aerobic microbes into floc (masses of bacteria associated with fungal filaments to form mesh like structures). While growing, these microbes consume the major part of the organic matter in the effluent. This significantly reduces the BOD (Biochemical oxygen demand or Biological oxygen demand). BOD refers to the amount of the oxygen that would be consumed, if all the organic matter in one litre of water were oxidized by bacteria. The sewage water is treated till the BOD is reduced. The greater the BOD of the waste water more is its polluting potential.

Once the BOD of sewage water is reduced significantly, 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 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, the bacteria which grow anaerobically, digest the bacteria and the fungi in the sludge. During this digestion, bacteria produce a mixture of gases such as methane, hydrogen sulphide and CO_2. These gases form biogas and can be used as a source of energy.

Tertiary treatment

Tertiary treatment is the final process that improves the quality of the waste water before it is reused, recycled or released into natural water bodies. This treatment removes the remaining inorganic compounds and substances, such as nitrogen and phosphorus. UV is an ideal disinfectant for wastewater since it does not alter the water quality – except for inactivating microorganisms. UV is a chemical-free process that can completely replace the existing chlorination system and also inactivates chlorine-resistant microorganisms like *Cryptosporidium* and *Giardia*.

Act enforced by Government to conserve water bodies

National river conservation plan (NRCP) was enacted in 1995 to improve the water quality of the rivers, which are the major fresh water resources in our country. This important assignment taken up under the NRCP includes,

- To capture the raw sewage flowing into the river through open drains and divert them for treatment.
- Setting up sewage treatment plants for treating the diverted sewage.
- Construction of low cost sanitation toilets to prevent open defecation on river banks.

The ministry for environment, forest and climate change has initiated the Ganga action plan and the Yamuna action plan to save the major rivers of the country.

The Ganga action plan was launched on 14th January 1986. The main objective of the programme is to improve the water quality of River Ganges by interception, diversion and treatment of domestic sewage and to identify grossly polluting units to prevent pollution.

The Yamuna Action Plan is a bilateral project between the Government of India and Japan. It was formally launched in April 1993. It was proposed to build large number of sewage treatment plants to discharge treated wastewater into the rivers.

9.3.2 Microbial fuel cell(MFC)

A microbial fuel cell is a bio-electrochemical system that drives an electric current by using bacteria and mimicking bacterial interaction found in nature **(Fig. 9.3)**. Microbial fuel cells work by allowing bacteria to oxidize and reduce organic molecules. Bacterial respiration is basically one big redox reaction in which electrons are being moved around. A MFC consists of an anode and a cathode separated by a proton exchange membrane. Microbes at the anode oxidize the organic fuel generating protons which pass through the membrane to the cathode and the electrons pass through the anode to the external circuit to generate current.

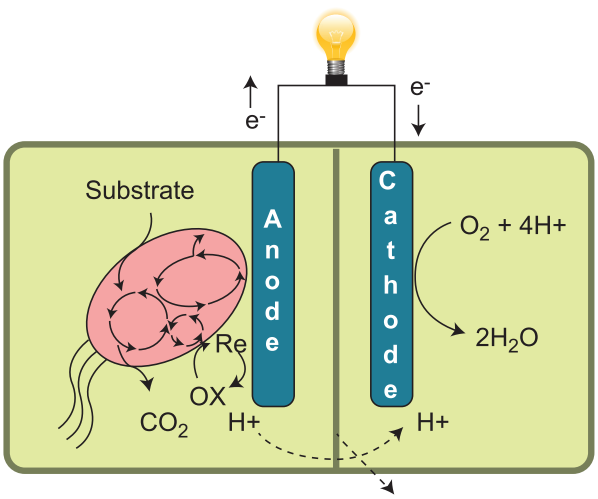


Fig. 9.3 Microbial fuel cell

9.4 Microbes in the production of biogas (Gobar gas)

Biogas is a mixture of different gases produced by the breakdown of organic matter in the absence of oxygen. Biogas can be produced from raw materials such as agricultural wastes, manure, municipal wastes, plant material, sewage, food waste, etc., Biogas is produced under anaerobic condition, when the organic materials are converted through microbiological reactions into gas and organic fertilizer. Biogas primarily consists of methane (63 percent), along with CO_2 and hydrogen. Methane producing bacteria are called **methanogens** and one such common bacterium is *Methanobacterium*. Biogas is devoid of smell and burns with a blue flame without smoke. The *Methanogens* are also present in anaerobic sludge and rumen of cattle.

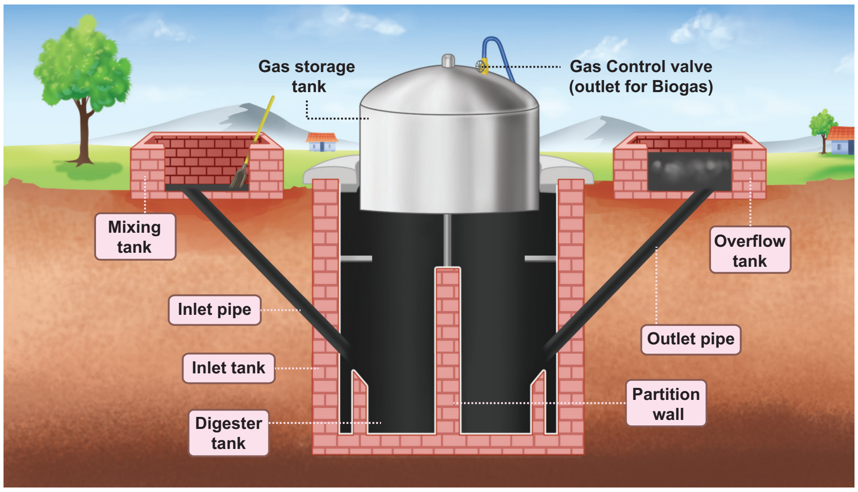


Fig. 9.4 Biogas unit

In rumen, these bacteria help in the breakdown of cellulose. The excreta of cattle called dung is commonly called "**Gobar**". Gobar gas is generated by the anaerobic decomposition of cattle dung. It consists of methane, CO_2 with some hydrogen, nitrogen and other gases in trace amounts.

In a biogas plant, anaerobic digestion is carried out in an air tight cylindrical tank known as digester **(Fig. 9.4)**. It is made up of concrete bricks and cement or steel. Bio-wastes are collected and slurry of dung is fed into this digester. It has a side opening into which organic materials for digestion are incorporated for microbial activity. Anaerobic digestion is accomplished in three stages: solubilisation, acidogenesis and methanogenisis. The outlet is connected to a pipe to supply biogas. The slurry is drained through another outlet and is used as fertilizer. 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).

9.5 Microbes as bio control agents and biofertilisers

Large scale application of chemical insecticides and pesticides have a deleterious effect on the health of human beings and pollute our environment. Biocontrol is a method of controlling pest by use of microbes such as fungi, bacteria, viruses or by naturally occurring substances derived from plants and animals. The use of a microbes or other biological agents to control a specific pest is called a biopesticide. Biopesticides are used to control insect pests. The **lady bird beetle** and **dragonflies** are useful to control aphids and mosquito larvae respectively.

Bacillus thuringiensis is a soil dwelling bacterium which is commonly used as a biopesticide and contains a toxin called ***cry* toxin (Fig. 9.5)**. Scientists have introduced this toxin producing genes into plants and have raised genetically engineered insect resistant plants. E.g. Bt-cotton.

During sporulation *Bacillus thuringiensis* produces crystal proteins called **Delta-endotoxin** which is encoded by ***cry* genes**. Delta-endotoxins have specific activities against the insects of the orders **Lepidoptera**, **Diptera, Coleoptera** and **Hymenoptera**. When the insects ingest the toxin crystals their alkaline digestive tract denatures the insoluble crystals making them soluble. The *cry* toxin then gets inserted into the gut cell membrance and paralyzes the digestive tract. The insect then stops eating and starves to death.

Weedicides are substances, which destroy weeds without harming the useful plants. Bioweedicides are compounds and secondary metabolites derived from microbes such as fungi, bacteria or protozoa. The first bioherbicide developed in 1981 was a **Mycoheribicide** derived from the fungus *Phytophthora palmivora*. It controls the growth of strangler vine in citrus crops.

Trichoderma species are free living fungi that are very common in the root ecosystem. They are effective biocontrol agents for several plant pathogens. **Buculoviruses** are pathogens that

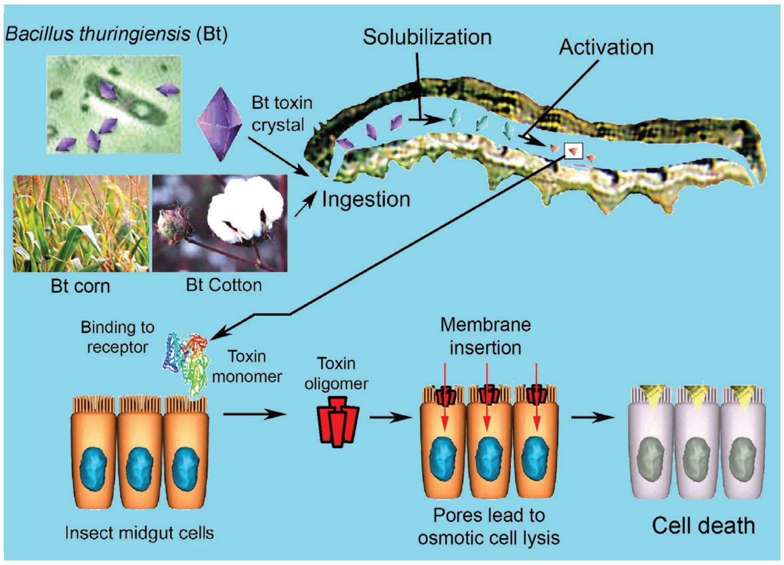


Fig. 9.5 Actions of *cry* toxin

attack insects and other arthropods. The genus **Nucleopolyhedrovirus** is used as a biocontrol agent. These viruses are species specific and have narrow spectrum insecticidal applications.

9.5.1 Biofertilisers

Biofertilisers are formulation of living microorganisms that enrich the nutrient quality of the soil. They increase physico – chemical properties of soils such as soil structure, texture, water holding capacity, cation exchange capacity and pH by providing several nutrients and sufficient organic matter. The main sources of biofertilisers are bacteria, fungi and cyanobacteria. *Rhizobium* is a classical example for symbiotic nitrogen fixing bacteria. This bacterium infects the root nodules of leguminous plants and fixes atmospheric nitrogen into organic forms. *Azospirillum* and *Azotobacter* are free living bacteria that fix atmospheric nitrogen and enrich the nitrogen content of soil.

A symbiotic association between a fungus and the roots of the plants is called **mycorrhiza**. The fungal symbiont in these associations absorbs the phosphorus from soil and transfers to the plant. Plants having such association show other benefits such as resistance to root-borne pathogens, tolerance to salinity, drought, enhances plant growth and developments. For example, many members of the genus *Glomus* form mycorrhiza. **Cyanobacteria** (or) blue green algae (BGA) are prokaryotic free-living organisms which can fix nitrogen. *Oscillatoria, Nostoc, Anabaena, Tolypothrix* are well known nitrogen fixing cyanobacteria. Their importance is realized in the water logged paddy fields where **Cyanobacteria** multiply and fix molecular nitrogen. Cyanobacteria secrete growth promoting substances like indole-3-acetic acid, indole-3-butyric acid, naphthalene acetic acid, amino acids, proteins, vitamins which promotes plant growth and production.

Biofertilisers are commonly used in organic farming methods. Organic farming is a technique, which involves cultivation of plants and rearing of animals in natural ways. This process involves the use of biological materials, avoiding synthetic substances to maintain soil fertility and ecological balance thereby minimizing pollution and wastage.

Key features of organic farming

- Protecting soil quality using organic materials and encouraging biological activity.
- Indirect provision of crop nutrients using soil microorganisms.
- Nitrogen fixation in soils using legumes.
- Weed and pest control based on methods like crop rotation, biological diversity, natural predators, organic manures and suitable chemical, thermal and biological interventions.

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9.6 Bioremediation

The use of naturally occurring or genetically engineered microorganisms to reduce or degrade pollutants is called bioremediation. Bioremediation is less expensive and more sustainable than other remediations available. It is grouped into ***in situ*** bioremediation

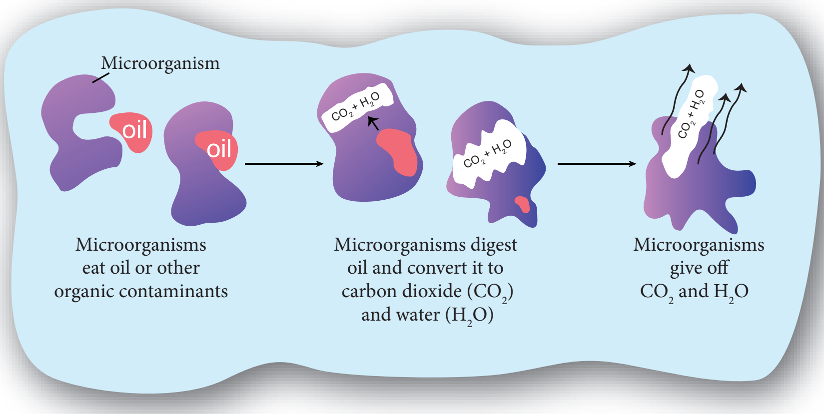

Fig. 9.6 The process of bioremediation

(treatment of contaminated soil or water in the site) and ***ex situ*** bioremediation (treatment of contaminated soil or water that is removed from the site and treated) .

9.6.1 Microorganisms involved in bioremediation

Aerobic microbes degrade the pollutants in the presence of oxygen. They mainly degrade pesticides and hydrocarbons. *Pseudomonas putida* is a genetically engineered microorganism (GEM). Ananda Mohan Chakrabarty obtained patent for this recombinant bacterial strain. It is multi-plasmid hydrocarbon-degrading bacterium which can digest the hydrocarbons in the oil spills **(Fig. 9.6)**.

Nitrosomonas europaea is also capable of degrading benzene and a variety of halogenated organic compounds including trichloroethylene and vinyl chloride. *Ideonella sakaiensis* is currently tried for recycling of PET plastics **(Fig. 9.7)**. These bacteria use PETase and MHETase enzymes to breakdown PET plastic into terephthalic acid and ethylene glycol.

Anaerobic microbes degrade the pollutants in the absence of oxygen. *Dechloromonas aromatica* has the ability to degrade benzene anaerobically and to oxidize toluene and xylene. *Phanerochaete chrysosporium* an anaerobic fungus exhibits strong potential for bioremediation of pesticides, polyaromatic hydrocarbons, dyes, trinitrotoluene, cyanides, carbon tetrachloride, etc., *Dehalococcoides* species are responsible for anaerobic bioremediation of toxic trichloroethene to non-toxic ethane. *Pestalotiopsis microspora* is a species of endophytic fungus capable of breaking down and digesting polyurethane. This makes the fungus a potential candidate for bioremediation projects involving large quantities of plastics.

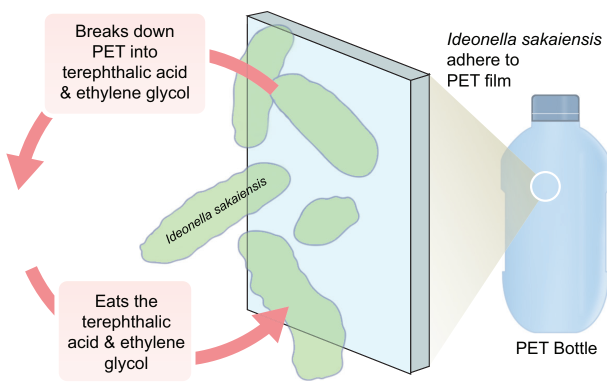

Fig. 9.7 Actions of *Ideonella sakaiensis*

Summary

All microbes are not pathogenic, many of them are beneficial to human beings. We use microbes and their derived products almost every day. Lactic acid bacteria convert milk into curd. *Saccharomyces cerevisiae* (yeast) is used in bread making. Idly and dosa are made from dough fermented by microbes. Bacteria and fungi are used in cheese making. Industrial products like lactic acid, acetic acid and alcohol are produced by microbes. Antibiotics are produced from useful microbes to kill the disease causing harmful microbes. For more than a hundred years, microbes are being used to treat sewage by the process of activated sludge formation. Bio-gas produced by microbes is used as a source of energy in rural areas. Microbes are also used as bio-control agents to avoid the use of toxic pesticides. Now a days chemical fertilisers are gradually replaced by bio-fertilisers. In bio-remediation naturally occurring or genetically engineered microorganisms are used to reduce or degrade pollutants.

Evaluation

1. Which of the following microorganism is used for production of citric acid in industries?

   a) *Lactobacillus bulgaris*
   b) *Penicillium citrinum*
   c) Aspergillus niger d) *Rhizopus nigricans*

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2. Which of the following pair is correctly matched for the product produced by them?

   a) *Acetobacter aceti* - Antibiotics
   b) *Methanobacterium* - Lactic acid
   c) *Penicilium notatum* - Acetic acid
   ***d) Saccharomyces cerevisiae* - Ethanol**

3. The most common substrate used in distilleries for the production of ethanol is__________

   a) Soyameal b) Groundgram
   c) Molasses d) Corn meal

4. Cry toxins obtained from *Bacillus thuringiensis* are effective against for_______

   a) Mosquitoes b) Flies
   c) Nematodes **d) Bollworms**

5. Cyclosporin – A is an immunosuppressive drug produced from ________

   a) *Aspergillus niger*
   b) *Manascus purpureus*
   c) *Penicillium notatum*
   d) Trichoderma polysporum

6. Which of the following bacteria is used extensively as a bio-pesticide?

   a) Bacillus thurigiensis
   b) *Bacillus subtilis*
   c) *Lactobacillus acidophilus*
   d) *Streptococcus lactis*

7. Which of the following is not involved in nitrogen fixation?

   a) Pseudomonas b) *Azotobacter*
   c) *Anabaena* d) *Nostac*

8. CO_2 is not released during

   a) Alcoholic fermentation
   b) Lactate fermentation
   c) Aerobic respiration in animals
   d) Aerobic respiration in plants

9. The purpose of biological treatment of waste water is to ________

   a) Reduce BOD b) Increase BOD
   c) Reduce sedimentation
   d) Increase sedimentation

10. The gases produced in anaerobic sludge digesters are

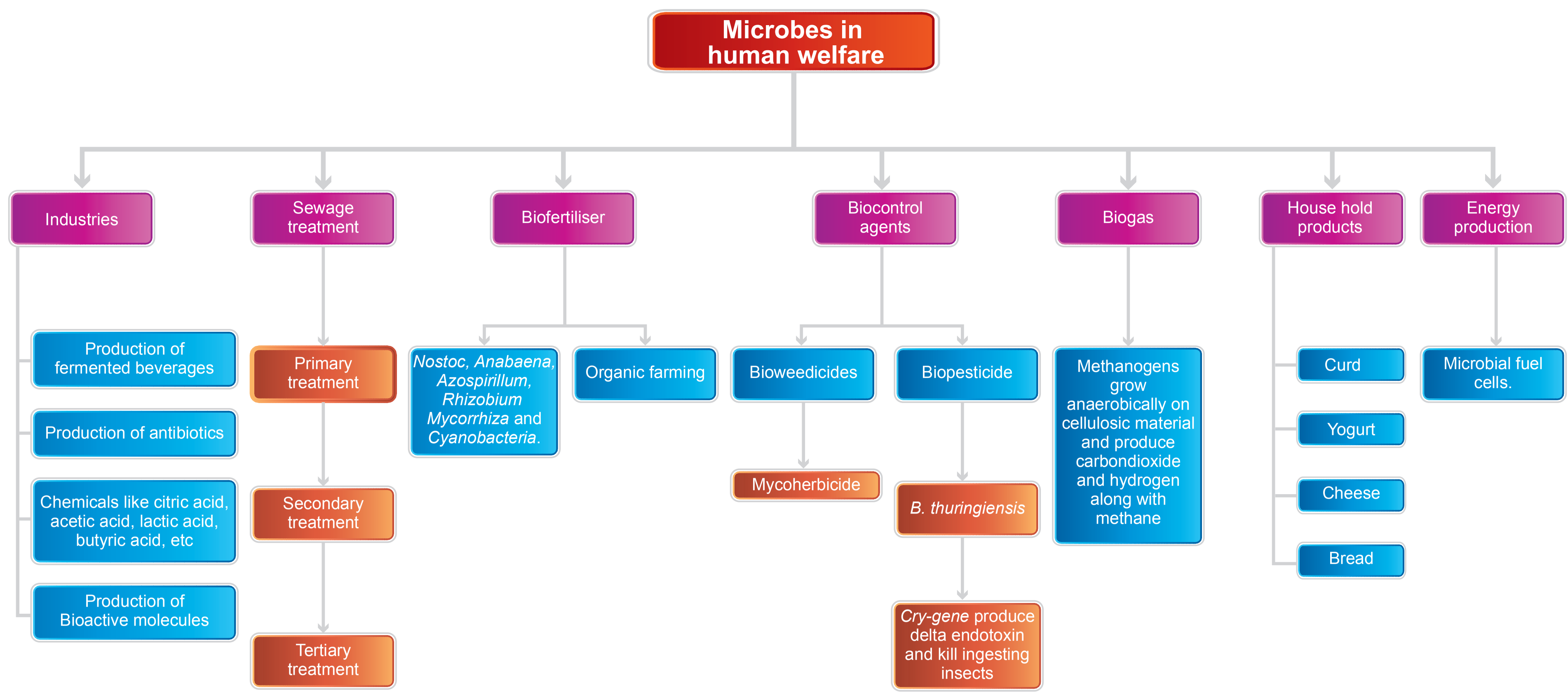
    a) Methane, oxygen and hydrogen sulphide.
    b) Hydrogen sulphide, methane and sulphur dioxide.
    c) Hydrogen sulphide, nitrogen and methane.
    d) Methane, hydrogen sulphide and CO_2.

11. How is milk converted into curd? Explain the process of curd formation.
12. Give any two bioactive molecules produced by microbes and state their uses.
13. What is biological oxygen demand?
14. Explain the role of cry-genes in genetically modified crops.
15. Write the key features of organic farming.
16. Justify the role of microbes as a bio-fertilizer.
17. Write short notes on the following.

    a) Brewer's yeast b) *Ideonella sakaiensis*
    c) Microbial fuel cells

18. List the advantages of biogas plants in rural areas.
19. When does antibiotic resistance develop?
20. What is the key difference between primary and secondary sewage treatment?

Concept Map


Microbes in human welfare
Industries
Production of fermented beverages
Production of antibiotics
Chemicals like citric acid, acetic acid, lactic acid, butyric acid, etc
Production of Bioactive molecules
Sewage treatment
Primary treatment
Secondary treatment
Tertiary treatment
Biofertiliser
Nostoc, Anabaena, Azospirillum, Rhizobium Mycorrhiza and *Cyanobacteria*.
Organic farming
Biocontrol agents
Bioweedicides
Mycoherbicide
Biopesticide
B. thuringiensis
Cry-gene produce delta endotoxin and kill ingesting insects
Biogas
Methanogens grow anaerobically on cellulosic material and produce carbondioxide and hydrogen along with methane
House hold products
Curd
Yogurt
Cheese
Bread
Energy production
Microbial fuel cells.

ICT CORNER

MICROBES IN HUMAN WELFARE

How the fermentation takes place?
Lets us experiment it virtually

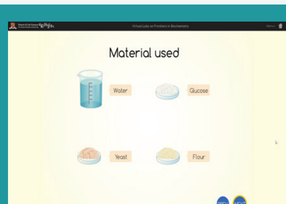
Procedure :

Step -1: Type the **URL** or scan the **QR** code to open the activity page and click **"START"** to begin the fermentation experiment.

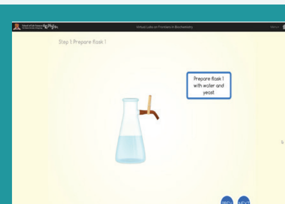
Step -2: Click **"next"** for all the flasks combination.

Step -3: When the **"Matching Game"** starts to know the result, **"Drag and place"** the combination perfectly to their respective flasks.

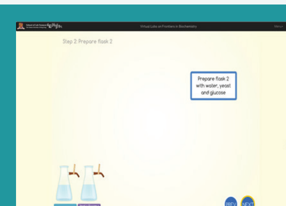
Step – 4 : Go on through the other tests, explanations and the principle involved in the fermentation process.



Step 1



Step 2



Step 3

Step 4

MICROBES IN HUMAN WELFARE URL:

http://www.bch.cuhk.edu.hk/vlab2/animation/fermentation/

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*Pictures are indicative only
*Allow flash player