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Chapter-8. Microbes in Human Welfare

Chapter outline

8.1 Microbes in household products
8.2 Microbes in industrial products
8.3 Microbes in sewage treatment and energy generation
8.4 Microbes in the production of biogas
8.5 Microbes as bio-control agents and bio-fertilizers
8.6 Bioremediation

- ✧ 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.

8.1 Microbes in household products

- ❋ In everyday 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. (*E- coli*)
- ❋ 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 ^{o} C)** multiply and convert milk into curd.
- ❋ Curd is more nutritious than milk as it contains a number of organic acids and vitamins.

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Household products

1. Yogurt
2. Cheese
3. Paneer (cottage cheese)

1. Yogurt

- 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.

2. Cheese

- 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*.

3. Paneer

- 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 ***Sacchaomyces cerevisiae*** (Baker's Yeast)

S. No	Household products	Converting microbes (bacteria)
1	Yogurt	*Streptococcus thermophilus and Lactobacillus bulgaricus*
2	Cheese	*Lactococcus, Lactobacillus or Streptococcus.*
3	Paneer	*Propionibacterium shermanii.*
4	Idlis and Dosas	*Leuconostoc mesenteroides*
5	Bread making	*Sacchaomyces cerevisiae (Baker's Yeast).*

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.

8.2 Microbes in industrial products

8.2.1 Antibiotic production (Antibiotic resistance)

8.2.2 Fermented beverages

8.2.2 Fermented beverages

- 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.

Fermentor

Production on a large scale requires growing microbes in **very large vessels** called **fermentors.**

8.2.1 Antibiotic production (Antibiotic resistance)

- 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.

Penicillin

- **Penicillin** was the first antibiotic discovered by **Alexander Fleming** in **1926**.
- 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"**

- Penicillin 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.

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Other antibiotics

- **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**.
- 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.

8.2.2 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.

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- **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.

Fermentation products (Using microbes)

1. **Wine** **(**Wine contains 9 to 14 percent alcohol)

- **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 S*accharomyces cerevisiae* into alcohol.

Grape wine is of two types,

1, Red wine and

2. **White wine**.

- For red wine, black grapes are used including **skin**s 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.

2. **Beer** **(**Beer contains 3 to 5 percent of alcohol)

- Beer is produced from germinated barley malt grain by S*accharomyces* ***carlsbergensis*** **or** ***Saccharomyces cerevisiae*****.**
- Rum is made from fermented sugarcane or molasses or directly from sugarcane juice by ***Saccharomyces cerevisiae*****.**

3. Whisky

(Distilled spirits such as whiskey, gin, scotch and vodka usually contain 35 to 50 percent alcohol)

Whisky is a type of distilled alcoholic beverage made from fermented grain mash by *Saccharomyces cerevisiae*.

4. Pathaneer

- 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.

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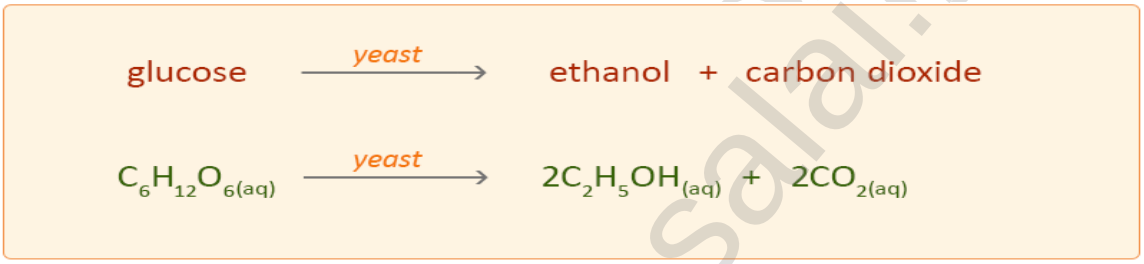
5. Toddy

- ✧ 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.

6. Industrial alcohol

- ✧ *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



8.2.3 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**.

- ✧ Bottled juices are clarified by the use of **pectinase, protease** and **cellulase**.

- ✧ 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.

8.3 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.

8.3.1 Wastewater treatment

Sewage treatment is usually performed in the following three stages.

1. Primary treatment

- ❋ Primary treatment involves the physical removal of solid and particulate organic and inorganic materials from the sewage through filtration and sedimentation.

2. Secondary treatment or biological treatment

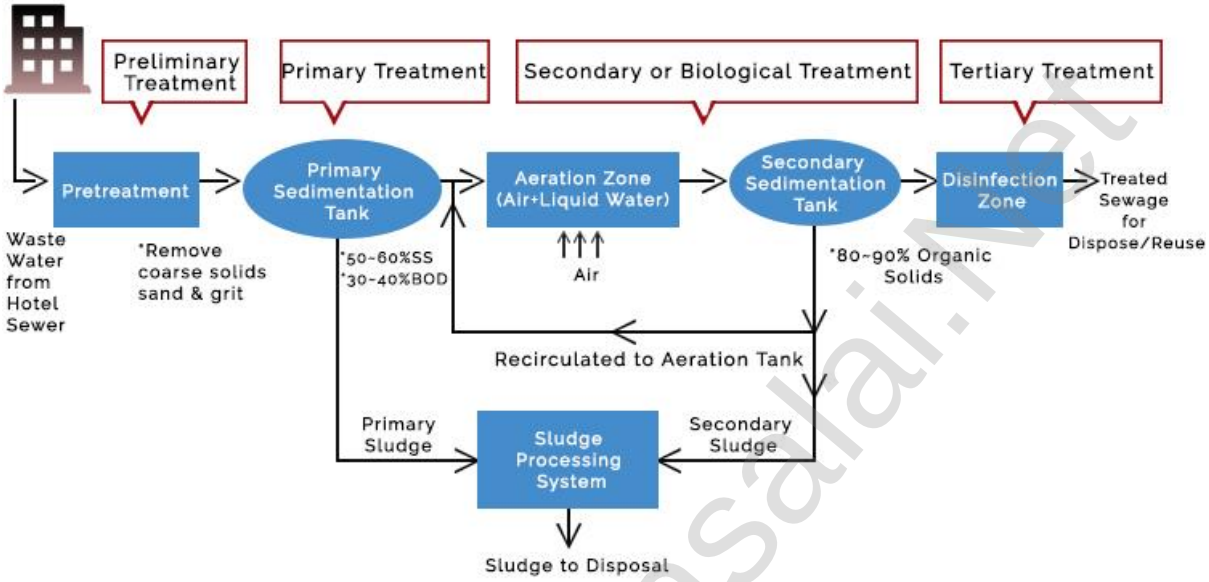
- ❋ Secondary treatment involves allows vigorous growth of useful aerobic microbes into floc (masses of bacteria associated with fungal filaments to form mesh like structures).

- ❋ 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**.

3. 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.

- 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.

1. 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.

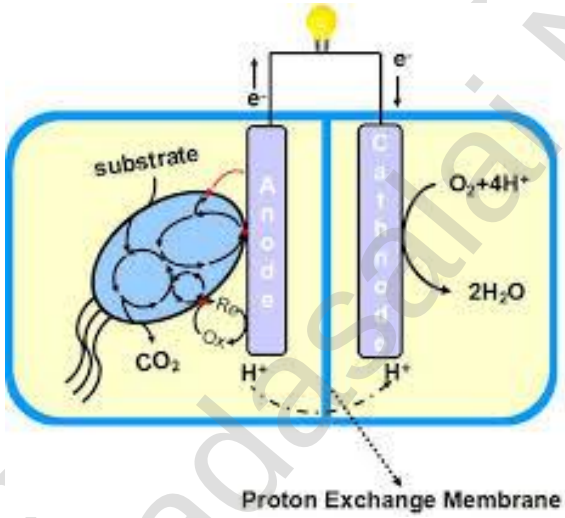
2. The Yamuna Action Plan is a bilateral project between the Government of India and Japan. It was formally launched in April 1993.

It was proposed to build large number of sewage treatment plants to discharge treated wastewater into the rivers.

8.3.2 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.

- 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.

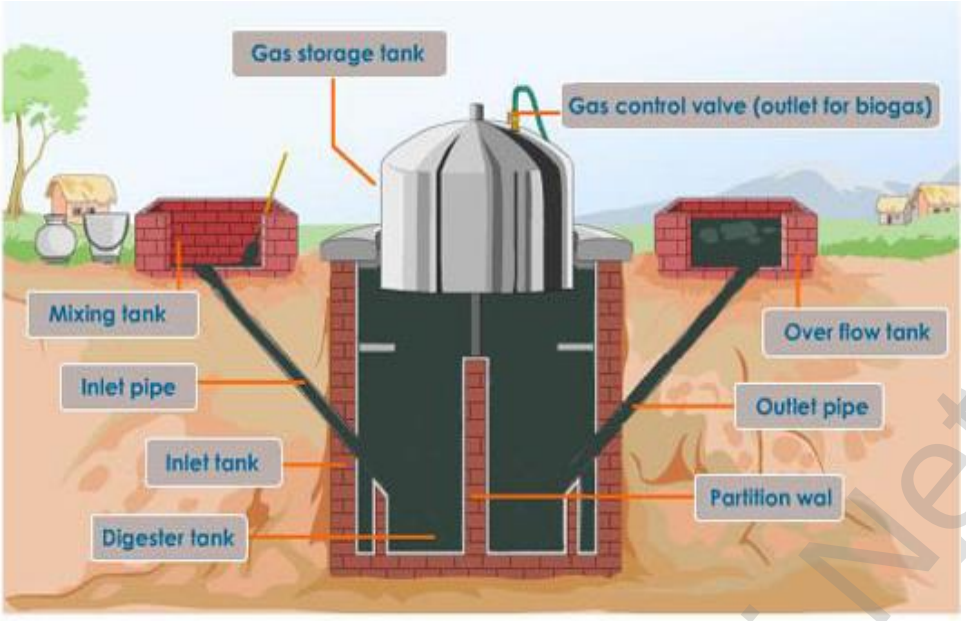


8.4 Microbes in the production of biogas (Gobar gas)

- 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 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).



- Biogas primarily consists of methane (63 percent), along with CO2 and hydrogen. Methane producing bacteria are called **methanogens** and one such common bacterium is *Methanobacterium*.

- In rumen, these bacteria help in the breakdown of cellulose. The excreta of cattle called dung is commonly called "**Gobar**".

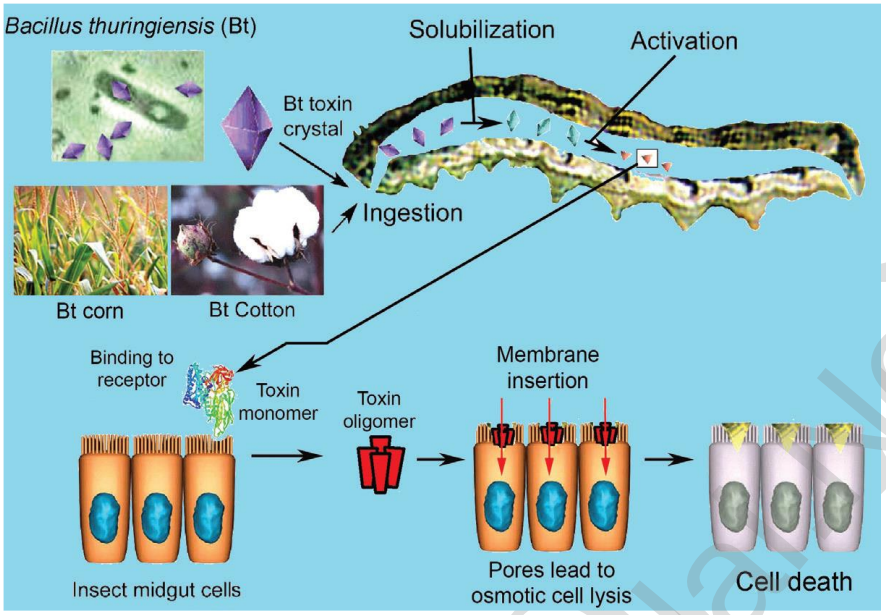
- Gobar gas is generated by the anaerobic decomposition of cattle dung. It consists of methane, CO2 with some hydrogen, nitrogen and other gases in trace amounts.

8.5 Microbes as bio control agents and bio fertilisers

- 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.** 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**.



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

8.5.1 Biofertilisers

- Biofertilisers are formulation of living microorganisms that enrich the nutrient quality of the soil.
- 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.
- **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.
- 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.

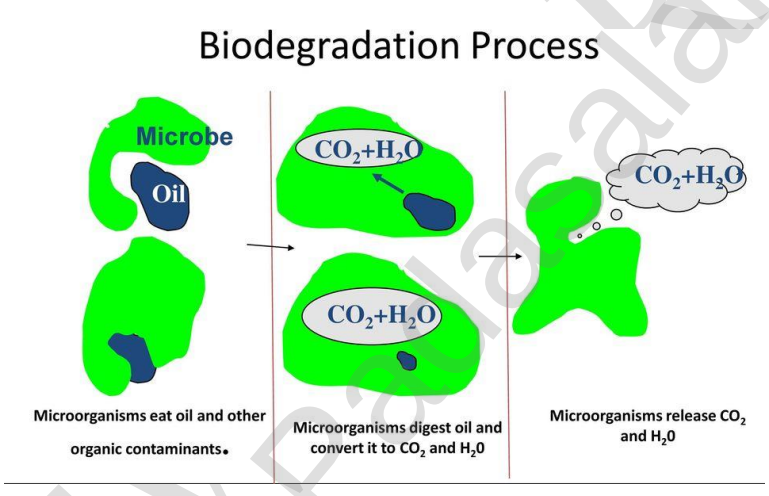
- Biofertilisers are commonly used in organic farming methods. Organic farming is a technique, which involves cultivation of plants and rearing of animals in natural ways.

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.

8.6 Bioremediation

- The use of naturally occurring or genetically engineered microorganisms to reduce or degrade pollutants is called bioremediation.



- It is grouped into ***in situ*** 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)

8.6.1 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)
- ★ *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.
- ★ These bacteria use PETase and MHETase enzymes to breakdown PET plastic into terephthalic acid and ethylene glycol.

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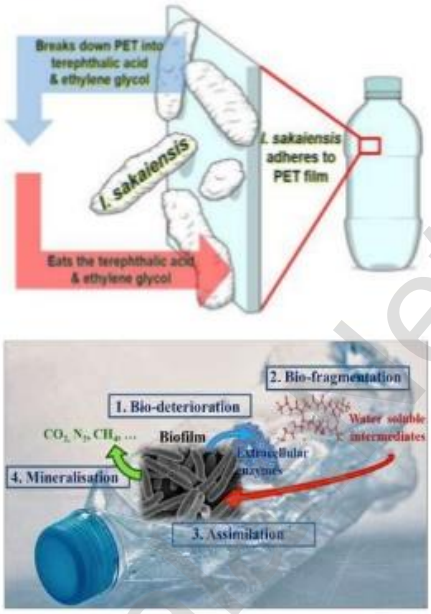
Ideonella sakaiensis 201-F6

How does it degrades PET?

- ***Ideonella sakaiensis* 201-F6**, a newly discovered bacterium that feed on PET.
- Bacteria that break down the plastic using two enzymes- **PETase** and **MHETase**-could break down both **PET** and another compound **MHET mono (2-hydroxyethyl) terephthalic acid**-which forms during breakdown process.



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★ *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.

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ALL THE BEST

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