Chapter 10

Microbes in Human Welfare

Microbes in Household Products

What are Microbes?

Have you wondered why food spoils if left unrefrigerated for days? Or how you get cheese from milk?
These are all due to the action of living organisms that are not visible to the naked eye, called **microbes or microorganisms.** These microbes also have some very important applications in our lives. Along with plants and animals, microorganisms also form an important part of the biological system on earth.

- Microbes exist everywhere – in soil, air, water and also in the human body and the bodies of plants and other animals!
- They also exist in places where no other life-form exists, such as deep in the geysers where the temperature is extremely high!
- Bacteria, fungi, protozoa, viroids are all microorganisms. Although microscopic, they can grow on nutritive media and form colonies visible to the naked eye. This allows us to study them better.

Types of Microbes

The term "**microbes**" is used to describe several different life forms with different size and characteristics. few of these microbes include:

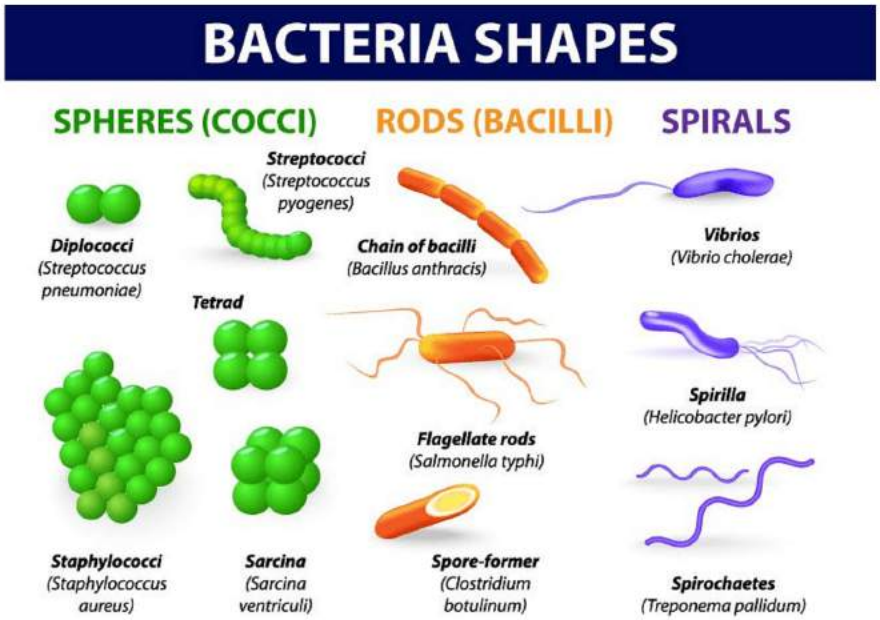
1. Bacteria
2. Fungi
3. Protists
4. Viruses
5. Archaea

Microbes can be useful as well as harmful. Certain microbes cause severe infections and diseases and can also spoil food and other materials. While others play an important role in maintaining environmental balance.

Let us have a detailed look at the different types of microorganisms and their importance.

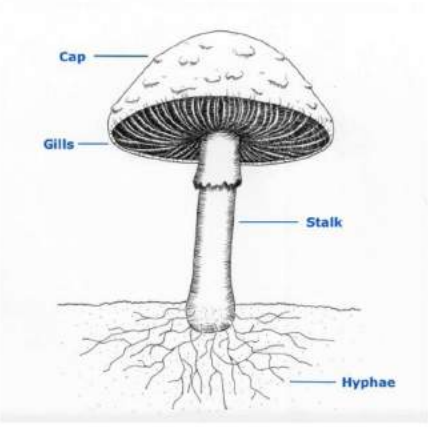
1. Bacteria

- Bacteria are unicellular, microscopic, prokaryotic microbes that contain no true nucleus.
- Their cell wall is made up of peptidoglycan. They have a flagellum that facilitates locomotion.
- Bacteria are of different types depending on their shapes and sizes. For eg., spherical-shaped bacteria are known as cocci; rod-shaped bacteria are known as bacilli; spiral-shaped, spirilla, etc.
- They reproduce through binary fission, transfer of genetic material through transformation, transduction and conjugation, and through sporulation.
- Bacteria play an important role in human survival. They break down nutrients in the digestive system into simpler forms.
- Few bacteria such as Rhizobium are involved in nitrogen fixation.
- They are also used in making antibiotics and can also be used in agriculture as pesticides.



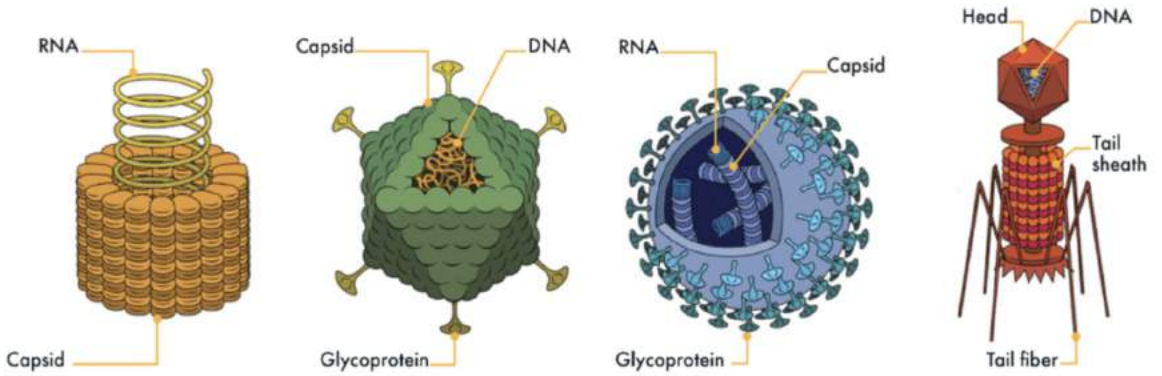
2. Fungi

- These can be unicellular or multicellular with the cell wall made of chitin.
- These are heterotrophic and cannot synthesise their own food.
- They comprise membrane-bound organelles.
- Yeasts, moulds, mushrooms are some of the important fungi.
- They decompose dead plants and animals, extracting nutrients from them.
- Few fungi are harmful and cause fungal infections like ringworm. The others are used in making antibiotics like penicillin.
- Fungi such as yeast are used in all baking industries and also in the beer and wine industries.



3. Viruses

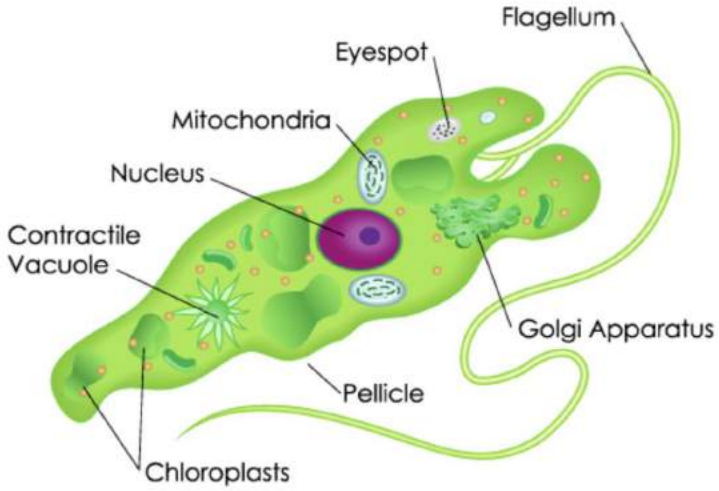
- Viruses are a connecting link between living and non-living.
- They are non-cellular microbes composed of protein, nucleic acids, and lipids.
- They are measured in nanometers with size ranging from 20 nanometers to 250 nanometers and could only be seen with an electron microscope.
- They contain the core of nucleotides surrounded by a protein coat which could invade living cells.
- They are active inside host cells and reproduce inside them by infecting living cells.



Helical viruses, | Polyhedral viruses, | Spherical viruses, | Complex viruses,

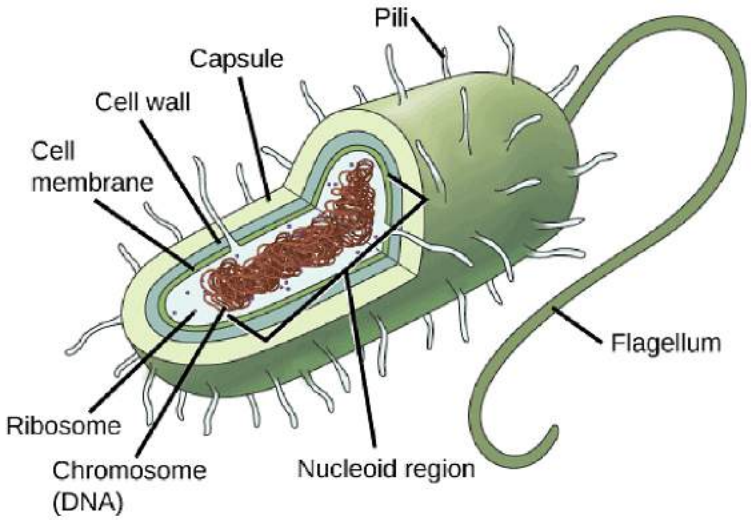
4. Protists

- These are unicellular, microscopic organisms that are neither plants nor animals.
- They may be autotrophic or heterotrophic.
- They reproduce mainly through binary fission or budding.
- This group includes plant-like protists such as algae, animal-like protists such as amoeba, and fungus-like such as slime moulds.
- Protists supply us with oxygen and recycle crucial nutrients to make it available to other life forms.



5. Archaea

- These are unicellular organisms and have a structure similar to bacteria.
- Their cell wall is different from bacteria and contains unique lipids that enable them to survive in extreme conditions.
- They are also found in human gut and skin.



So far, we have learnt that microorganisms cause diseases in humans, plants and animals. However, they can also be useful to man in several ways.

Microbes in Household Products

Household foods are produced by family members for their own consumption. Some of the microorganisms like bacteria and fungi play a variety of roles in the formation of household food. For example,

- Lactobacillus, the bacteria involved in the formation of curd from the milk and yoghurt is produced by the bacteria, Lactobacillus bulgaricus.
- Saccharomyces cerevisiae is a type of yeast used for making bread in the household as well as food processing industry.
- Microorganisms are also used to prepare some traditional drinks like Toddy.
- In addition to these, most common food like dosa and idly are prepared from fermented rice by some bacteria.

Contributions of microbes to human welfare

1. **Production of curd**
   A common example is the production of curd from milk. Micro-organisms such as Lactobacillus and others commonly called lactic acid bacteria (LAB) grow in milk and convert it to curd.

Fig: Microbes in Household products

1. During growth, the LAB produces acids that coagulate and partially digest the milk proteins. A small amount of curd added to the fresh milk as inoculum or starter contains millions of LAB, which at suitable temperatures multiply, thus converting milk to curd, which also improves its nutritional quality by increasing vitamin B_{12}. In our stomach too, the LAB plays a very beneficial role in checking disease-causing microbes.

2. **Fermentation**
   The dough, which is used for making foods such as dosa and idli is also fermented by bacteria. The puffed-up appearance of dough is due to the production of CO_2 gas.

Similarly, the dough, which is used for making bread, is fermented using baker's yeast (Saccharomyces cerevisiae).
A number of traditional drinks and foods are also made by fermentation by microbes. 'Toddy', a traditional drink of some parts of southern India is made by fermenting sap from palms.

Fig: Toddy

1. **Production of cheese**
   Cheese is one of the oldest food items in which microbes were used. Different varieties of cheese are known by their characteristic texture, flavour and taste, the specificity coming from the microbes used.
   Example: The large holes in 'Swiss cheese' are due to the production of a large amount of CO_2 by a bacterium named Propionibacterium sharmanii. The 'Roquefort cheese' are ripened by growing specific fungi on them, which gives them a particular flavour.

Microbes in Industrial Products

Introduction

Even in industry, microbes are used to synthesize a number of products valuable to human beings. Beverages and antibiotics are some examples. Production on an

industrial scale, requires growing microbes in very large vessels called fermentors (Figure).

Fermentors

In large-scale industrial processes, microbes are widely used to synthesize a number of products valuable to human beings. There are numerous industrial products that are derived from microbes such as:

- Food additives.
- Alcoholic and non-alcoholic beverages.
- Biofuels, metabolites, and biofertilizers.
- Few Chemicals, Enzymes and other Bioactive Molecules.
- Vaccines and other Antibiotics to kill or retard the growth of disease-causing microbes.

Microbes in Industrial Products

These microbes play a crucial role in the fermentation process to obtain a number of products. The two common products obtained by fermentation process through industrial processes are fermented beverages, malted cereals, broths, fruit juices, antibiotics, etc.

1. **Beverages:** Yeasts are the widely used microorganism for the production of beverages like beer, brandy, rum, wine, whiskey, etc. Yeasts are single-celled, eukaryotic, microorganisms of the Kingdom Fungi. In these industrial process the species of yeasts, Saccharomyces cerevisiae, generally called as the Brewer's Yeasts are used for fermenting fruit juices and malted cereals to produce ethanol. Once after the fermentation, these beverages are distilled to produce both Alcoholic and non-alcoholic beverages including whiskey, brandy, rum, etc.

2. **Organic acids:** Microbes are also used for the industrial production of certain organic acids. Citric acid was the first discovered organic acids from microbial fermentation of lemon – a citrus fruits. Organic acids are also produced directly from glucose. Aspergillus Niger, Acetobacter acute and Lactobacillus are few examples of microbes used for the industrial production of organic acids.
3. **Enzymes:** Enzymes are naturally occurring, biological catalysts that are mainly used to control certain biochemical reactions in the living system. Enzymes have a wide range of applications in the production of both medical and non-medical field. Apart from the plants and animals, enzymes are also obtained from certain microbes and are referred to as the microbial enzymes. Microorganisms are majorly used for the production of industrial enzymes through the safe gene transfer methods. The first industrially produced microbial enzymes were obtained from the fungal amylase in the year 1896 and were used to cure indigestion and several other digestive disorders.
4. **Antibiotic:** Antibiotics are chemical substances produced by certain microbes which functions either by killing or retarding the growth of harmful microbes without affecting the host cells. Penicillin was the first antibiotic to be discovered by Alexander Fleming in the year 1928 from the fungus Penicilliumnotatum. There are many other antibiotics produced by microorganisms, including Streptomycin, and other antibiotics used to treat a number of bacterial infections.
5. **Vitamins:** Vitamins are organic compounds which are capable of performing many life-sustaining functions inside our body. They are essential micronutrients which are required in small quantities for the body's metabolism. As our body cannot be synthesized these vitamins, they need to be supplied through the diet. Apart from plants and animals sources, microbes are also capable of synthesizing the vitamins. There are few groups of microbes living in the digestive tracts of both humans and other animals which are collectively called as the gut microbiota. These microbes are involved in synthesizing vitamin K. Other examples of microbial vitamins include ascorbic acid, beta-carotene, biotin, ergosterol, folic acid, vitamin b12, thiamine, pantothenic acid, riboflavin, and pyridoxine.
   These were a few information related to the role of microbes in industrial products. Apart from these products, microbes are also used in the production of biofuel, vaccines, protein and other hormonal supplements to treat malnutrition and other deficiency diseases in both humans and animals.

Microbes in Sewage Treatment & in Production of Biogas

Microbes In Sewage Treatment

Municipal waste-water which contains large amounts of organic matter is called sewage.
Before disposal, hence, sewage is treated in sewage treatment plants (STPs) by the heterotrophic microbes to make it less polluting.
Sewage treatment is carried out in two stages.

Primary treatment

- These treatment steps basically involve physical removal of large and small particles.
- Initially, floating debris is removed by sequential filtration and then the grit 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 which allows vigorous growth of useful aerobic microbes into flocs.
- Flocs are the masses of bacteria associated with fungal filaments to form mesh like structures.
- While growing, the microbes significantly reduces the **BOD (biochemical oxygen demand)** which is the amount of oxygen required to oxidize total organic matter in the effluent.
- The BOD test measures the rate of uptake of oxygen by micro-organisms, the greater the BOD of waste water, more is its polluting potential.
- The effluent is then passed into a settling tank where the bacterial 'flocs' are allowed to sediment and the sediment is called **activated sludge**.
- A small part of the 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** where other kinds of bacteria grow anaerobically which digest the bacteria and the fungi in the sludge.
- During digestion, bacteria produce a mixture of gases such as methane, hydrogen sulphide and carbon dioxide which form biogas.
- The effluent from the secondary treatment plant is generally released into natural water bodies like rivers and streams.

sewage plant

Microbes In The Production of Biogas

Biogas is the mixture of gases produced by the microorganisms. It is a renewable source of energy. Methane is the predominant gas present in the biogas mixture. Certain bacteria grow under anaerobic conditions and produce a large amount of methane along with carbon dioxide and hydrogen. The bacteria which produce the gaseous mixture are collectively known as methanogens. Methanobacterium is one such methanogen.

Methanobacterium is present inside the rumen of the cattle and the sludge produced during sewage treatment. The Methanobacterium present in the food of the cattle digests the cellulose present. The dung then produced by the cattle contains these methanogens which can be used for the production of biogas also known as the gobar gas.

Cattle dung is available in the rural area in very large quantities. Therefore, we can find biogas plants more often in rural areas. The biogas produced can be used for lighting and cooking purposes.

The conversion of waste into energy takes place in a biogas plant, by the activity of certain microbes.

Biogas Plant

- The biogas plant consists of a source to supply the feedstock, a digestion tank for biogas production, a biogas recovery unit to isolate the produced biogas, and heat exchanger to maintain the temperature of the digester.
- The biowaste and the slurry of dung are fed into an anaerobic digester.
- The slurry is covered with a floating cover. The gas produced due to microbial activity makes the cover rise upwards.
- The produced biogas is supplied to the respective places through connected pipes and can be used for cooking and lighting.
- The used slurry is removed through an outlet and can be used as fertilizer later.

Biogas Production in Landfill

Apart from the biogas plant, the biogas is also produced in the landfills.

- The organic matter naturally decomposes inside the landfill, i.e. inside a pit in the land, and biogas is produced by the activity of the microbes.
- The Methanobacteria present in the organic waste decompose the waste and produce the mixture of gases known as the biogas.
- There is a network of interconnected pipes in the landfill to collect the gas produced.
- The composition of the gas varies after a certain time interval. After a year, the composition of methane and carbon dioxide is 60% and 40% respectively.
- This method is gaining acceptance due to the fact that it prevents the explosion caused by the collection of methane inside the landfill, and also prevents the loss of methane in the atmosphere.
- The biogas thus produced is used to create electricity.

Substrates Required in Biogas Production

Animal Wastes	Dung and urine of cattle, buffalo, goat, sheep, slaughter houses
By-products	Tobacco waste, bagasse, bran
Aquatic plants	Algae, water hyacinth
Crop Residues	Straw, fodder, weed, crop stubble, sticks of cotton and jute
Forest Residues	Branches, leaves, twigs, bark
Urban solid waste	Paper, domestic waste
Human waste	Night soil

Advantages of Biogas

1. Biogas is a safe, cheap, renewable source of energy.
2. Biogas can be burnt in stoves to provide heat.
3. It is used for domestic and street lighting, and cooking.
4. It is eco-friendly and does not cause any pollution.
5. It is also used for driving engines.
6. It is easy to generate, transport and store.
7. It improves the sanitation of the surroundings.

The use of biogas is environment-friendly. It implies the conversion of animal and plant waste into useful energy, thereby, reducing the production of methane.

This is because of the biogas combustion which results in a net decrease in the emission of greenhouse gases.

Microbes as Biocontrol Agents & as Biofertilizers

Microbes or microorganisms are tiny single-celled creatures. They are small enough not to be seen by our naked eyes. Some microbes are useful in human welfare while others are harmful and toxic and make us ill. Let's take a glance at the role of microbes as biocontrol agents.

What is Biocontrol?

The natural method of eliminating and controlling the insects, pests and other disease-causing agents using their natural, biological enemies is called biocontrol or biological control.
The agents which are employed for this are called biocontrol agents. Microbes are one of them. Biocontrol works on the principle of predation and parasitism. It is much reliable and healthier than killing insects and pest using insecticides and pesticides. Thus, this prevents soil pollution and health issues related to insecticide poisoning, etc.

Biocontrol Agents

Biocontrol agents are an integral part of organic farming. In organic farming, farmers believe in mutualism. In other words, organic farmers keep a balance of useful and harmful agents within the system. The chemicals used for eradicating pest and parasite might not be always successful and also harm useful agents too. Instead, farmers used biocontrol agents which predate the insects and pests that cause diseases to crops. This approach of pest management needs vivid knowledge about the life cycle and feeding habits of different life forms.

Microbial Biocontrol Agents

Ladybird and dragonflies are two common insects which are employed to eradicate aphids and mosquitoes respectively. Other than insects, microbes are also used as biocontrol agents. These microbes include bacteria, fungi, viruses, and protozoans. Microbes act as biocontrol agents in three ways, either they cause diseases in the pests or compete with them or kill them.
Biotechnology has extended widely and has developed many biocontrol agents. For example, Bacillus thuringiensis which is often referred to as Bt is a microbial biocontrol agent. Spraying the solution of Bt made of spores on plants will kill the butterfly caterpillars. The spores that are ingested release toxins in the guts of the larvae and kill them.

Biotechnology has developed disease-resistant and pest-resistant plants by injecting the toxic genes of B. thuringiensis into plants. For e.g. Bt cotton. Fungus-like Trichoderma and baculoviruses of genus Nucleopolyhedrovirus are some other microbial biocontrol agents. These agents are specific in nature; this along with the cost limits their use.

Biofertilizers

"Biofertilizers are substances that contain microorganisms, which when added to the soil increase its fertility and promotes plant growth."

What is Biofertilizer?

Biofertilizers are the substance that contains microbes, which helps in promoting the growth of plants and trees by increasing the supply of essential nutrients to the plants. It comprises living organisms which include mycorrhizal fungi, blue-green algae, and bacteria. Mycorrhizal fungi preferentially withdraw minerals from organic matter for the plant whereas cyanobacteria are characterized by the property of nitrogen fixation. Nitrogen fixation is defined as a process of converting the di-nitrogen molecules into nitrogen compounds. For instance, some bacteria convert insoluble forms of soil phosphorus into soluble forms. As a result, phosphorus will be available for plants.

Types of Biofertilizers

Following are the important types of biofertilizers:

Symbiotic Nitrogen-Fixing Bacteria

Rhizobium is one of the vital symbiotic nitrogen-fixing bacteria. Here bacteria seek shelter and obtain food from plants. In return, they help by providing fixed nitrogen to the plants.

Loose Association of Nitrogen-Fixing Bacteria

Azospirillum is a nitrogen-fixing bacteria that live around the roots of higher plants but do not develop an intimate relationship with plants. It is often termed as rhizosphere association as this bacteria collect plant exudate and the same is used as a food by them. This process is termed as associative mutualism.

Symbiotic Nitrogen-Fixing Cyanobacteria

Blue-Green algae or Cyanobacteria from the symbiotic association with several plants. Liverworts, cycad roots, fern, and lichens are some of the Nitrogen-fixing cyanobacteria. Anabaena is found at the leaf cavities of the fern. It is responsible for nitrogen fixation. The fern plants decay and release the same for utilization of the rice plants. Azolla pinnate is a fern that resides in rice fields but they do not regulate the growth of the plant.

Free-Living Nitrogen-Fixing Bacteria

They are free-living soil bacteria which perform nitrogen fixation. They are saprotrophic anaerobes such as Clostridium beijerinckii, Azotobacter, etc. Among all the types of biofertilizers, Rhizobium and Azospirillum are most widely used.

Components of Biofertilizers

The components of biofertilizers include:

Bio Compost

It is one of the eco-friendly product composed of waste material released from sugar industries which are decomposed. It is magnified with human-friendly bacteria, fungi, and various plants.

Tricho-Card

It is an eco-friendly and nonpathogenic product used in a variety of crops as well as in horticultural and ornamental plants, such as paddy apple, sugar cane, brinjal, corn, cotton, vegetables, citrus, etc. It acts as a productive destroyer and antagonistic hyper parasitic against eggs of several bores, shoot, fruit, leaves, flower eaters and other pathogens in the field.

Azotobacter

It protects the roots from pathogens present in the soil and plays a crucial role in fixing the atmospheric nitrogen. Nitrogen is a very important nutrient for the plant and about 78% of the total atmosphere comprises of nitrogen.

Phosphorus

Phosphorus is one of the essential nutrients for plants growth and development. Phosphate solubilizing microorganisms, hydrolyze insoluble phosphorus compounds to the soluble form for uptake by plants. Many fungi and bacteria are used for the purpose such as Penicillium, Aspergillus, Bacillus, Pseudomonas, etc.

Vermicompost

It is an Eco-friendly organic fertilizer comprises of vitamins, hormones, organic carbon, sulfur, antibiotics that help to increase the quantity and quality of yield. Vermicompost is one of the quick fixes to improve the fertility of the soil.

Importance of Biofertilizers

Biofertilizers are important for the following reasons:

- Biofertilizers improve soil texture and yield of plants.
- They do not allow pathogens to flourish.
- They are eco-friendly and cost-effective.
- Biofertilizers protect the environment from pollutants since they are natural fertilizers.
- They destroy many harmful substances present in the soil that can cause plant diseases.
- Biofertilizers are proved to be effective even under semi-arid conditions.

Applications of Biofertilizers

Following are the important applications of biofertilizers:

Seedling root dip

This method is applicable to rice crops. The seedlings are planted in the bed of water for 8-10 hours.

Seed Treatment

The seeds are dipped in the mixture of nitrogen and phosphorus fertilizers. These seeds are then dried and sown as soon as possible.

Soil Treatment

The biofertilizers along with the compost fertilizers are mixed and kept for one night. This mixture is then spread on the soil where the seeds have to be sown.