MANIDHANAEYAM FREE IAS ACADEMY – TNPSC GROUP II & IIA

UNIT – I-BIOLOGY

Animals, plants and human life

1. Uses of Microorganisms

Medicine

1. Antibiotics

The word 'anti' means 'against'. Antibiotic is a substance produced by living organisms which is toxic for other organisms. Sir Alexander Fleming was the first person to discover the antibiotic penicillin in the year 1928. The antibiotic penicillin was obtained from the fungi Penicillium chrysogenum. It is used to treat diseases such as tetanus and diphtheria. The antibiotic, streptomycin is obtained from Streptomyces bacteria to cure various bacterial infections. Eg. Plague.

2. Vaccines

Vaccines are prepared from dead or weakened microbes. Edward Jenner was the first person to discover small pox vaccine. He coined the term vaccination. When the vaccine is injected to the body of a patient, the body produces antibodies to fight against the germs. These antibodies remain inside the body and protect from future invasion of the germs. Therefore, vaccination is otherwise called as immunization. Eg: MMR vaccine is given for preventing Measles, Mumps and Rubella. BCG (Bacille Calmette Guerin) vaccine is given for preventing Tuberculosis.

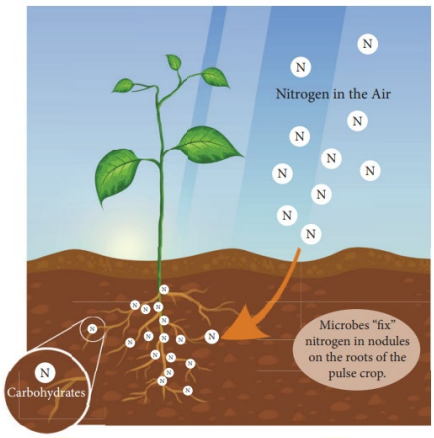
Agriculture

1. Natural fertilizer

Microorganisms are called as decomposers because they act upon degradable wastes. During the process, nitrates and other inorganic nutrients are released into the soil, making the soil fertile. This compost is called as natural fertilizer.

2. Nitrogen fixation

Rhizobium bacteria living in the root nodules of leguminous plants enrich the soil by fixing the atmospheric nitrogen as nitrates which are essential for the growth of plants. Some free living bacteria in soil, like Cyanobacteria Nostoc can also fix nitrogen biologically.



3. Bio-control agents

Microbes are used to protect the crops from pests. Some of them are given below.

- Bacillus thuringiensis (Bt cotton) helps to control insects.
- Trichoderma (Fungi) helps to protect roots and controls plant pathogens.
- Baculoviruses (Virus) attack insects and other arthropods.

Industry

1. Sewage treatment

Aerobic microbes are allowed to grow in the primary effluent during the secondary stage of waste water treatment. These microbes consume the major part of the organic matter in the effluent. Eg. Nitrobacter sps. In the anaerobic treatment of sewage Methanobacterium is used.

2. Production of biogas

Human and animal faecal matter and plant wastes are broken down by anaerobic bacteria to produce methane (biogas) along with carbon dioxide and hydrogen. These bacteria are called as methanogens.

3. Production of alcohol and wine

Alcoholic drinks are prepared by fermentation process using yeast. Sugars present in grapes are fermented by using yeast. Beer is produced by the fermentation of sugars in rice and barley.

4. Microbes in retting and tanning

Flax plants are tied in bundles and kept in water. Bacteria loosen the supporting fibres of the stem by acting on the stem tissues. This process is known as retting. Linen thread is made from these fibres. Eg. Pseudomonas aeruginosa.

In tanning industry bacteria act upon the skin of animals and makes it soft and therefore it becomes pliable.

In daily life

1. Making bread

Yeast is used in bakeries to make bread and cakes. They are added to the dough to produce carbon dioxide which makes the dough rise. Bread and cakes are soft due to carbon dioxide gas. Chlorella (green algae) which is rich in proteins and vitamins is added to the dough to enrich the bread with nutrients.

2. Preparation of curd and cottage cheese

Lactose in the milk gets turned into Lactic acid by the action of Lactobacillus (bacteria). Therefore, milk becomes thick (curd). It gives the sour taste. When curd is processed cottage cheese (panneer) is obtained.

3. In Human Intestine

• Lactobacillus acidophilus that lives in the human intestine helps in digestion of food and fights against harmful disease causing organisms.

• E.coli bacteria living in human intestine help in synthesizing vitamin K and vitamin B complex.

Microbes in Food Process

Microorganisms commonly used for food processing are yeast, bacteria, and moulds. Fermentation process which is carried out by microorganisms results in the production of organic acids, alcohol and esters. They help to preserve food and generate distinctive new food products.

1. Food preservation

i. Traditional techniques

Fermentation

Fermentation is the microbial conversion of starch and sugars into alcohol. It makes foods more nutritious and palatable.

Pickling

Pickling is a method of preserving food in an edible antimicrobial liquid. It is of two types: chemical pickling and fermentation pickling.

In chemical pickling, food is placed in an edible liquid that kills bacteria and other microorganisms. Eg. Vinegar, alcohol, vegetable oil (pickling agents). In fermentation pickling, bacteria in the liquid produce organic acid as preservation agent that produces lactic acid due to the presence of Lactobacillus.

Boiling

Boiling liquid food items kill all the microbes. Eg. Milk and Water.

Sugaring

Sugar is used to preserve fruits in an antimicrobial syrup with fruits such as apples, pears, peaches, plums or in a crystallized form, so that the product is stored in dry condition.

ii. Modern techniques

Pasteurization

It is a process for preservation of liquid food. This method was invented by Louis Pasteur in 1862. Milk is preserved by this method. It is heated up to 70 ^{o}C to kill the bacteria and it is cooled to 10 ^{o}C to prevent the growth of remaining bacteria. Then milk is stored in sterilized bottles in cold places.

2. Food production

Probiotics are live food supplements used in yoghurt and other fermented milk products. Eg. Lactobacillus acidophilus and Bifidobacterium bifidum. These bacteria improve the microbial spectrum in the gut and thus contribute to the following effects.

- Decrease the risk of colon cancer
- Decrease cholesterol absorption
- Prevent diarrheal diseases by increasing immunity.

2. Bio-indicators

A bio-indicator or biological indicator is any species or group of species whose function or status reveals the qualitative status of the environment. Biological indicators are used to document and understand changes in earth's living systems especially changes caused by the activities of an expanding human population.Bio-indicators of soil health give us information about soil structure, development, nutrient storage and biological activities.

Biological indicator characterises the state of an ecosystem and brings its modifications. Lichen is a natural bio-indicator of climate change and air pollution effect. It is a combination of an alga and a fungus which live together in symbiotic association. Lichen is a sensitive environmental parameter like temperature, humidity, wind and air pollutants. It gives information about changes in climate, air quality and biological process.

3. Bio-control Methods

Bio-control or biological control is a method of controlling pests such as insects, mites, weed and plant diseases using other organisms. Bio-predators, bio-pesticides, bio-repellents' and bio-fertilizers are used for controlling microorganisms which cause damage to the crops, pests and insects.

1. Bio-predators

These are naturally occurring insects that use pests for feeding or multiplication. These are called bio-predators. By introducing large numbers of predators in a greenhouse we can destroy the pest. Predators like Chrysopa spp. and Menochilus spp. are highly useful in controlling pests like aphids, white flies, cotton bollworms, leaf insects etc.

2. Bio-pesticide

Bio-pesticides are living organism or their derived parts which are used as bio-control agents to protect crops against insect pests. Bio-pesticides are of different types based on their origin.

i. Fungal bio-pesticides

Trichodermaviride is a fungus used as a biological pesticide. It is useful to control various disease caused by fungi such as wilt, rusting of leaves and root disease.

ii. Bacterial bio-pesticide

A culture of bacillus thuringiensis bacteria is effectively used to control the pest Lepidoptera that attack cotton and maize plants. Panchagavya and leaves decoction of some plants are also used as bio- pesticides.

3. Bio-repellant

Compound Azadiractin obtained from seeds of neem serves as a good insect-repellant. One of the earliest pesticides used by man was margosa leaves. The dried leaves repel the pests from stored grains.

4. Bio-fertilizer

Bio-fertilizers are organisms which can bring about soil nutrient enrichment. Nitrogen fixing microorganisms have the capability of converting free nitrogen into nitrogenous compounds and make the soil fertile. The main source of bio-fertilizers is cyano bacteria and certain fungi. Free living cyano bacterium involves in nitrogen fixation along with photosynthesis. Eg. Anabeana, Nostoc. Symbiotic bacteria also fix atmospheric nitrogen. E.g. Rhizobium. Although the chemical fertilizers increase food production, they degrade the natural habitat.

4. Biofertilizers

Biofertilizers are substances that contain living microorganisms which, when applied to seeds, plant surfaces, or soil, colonize the rhizosphere or the

interior of the plant and promote growth by increasing the supply or availability of primary nutrients to the host plant.

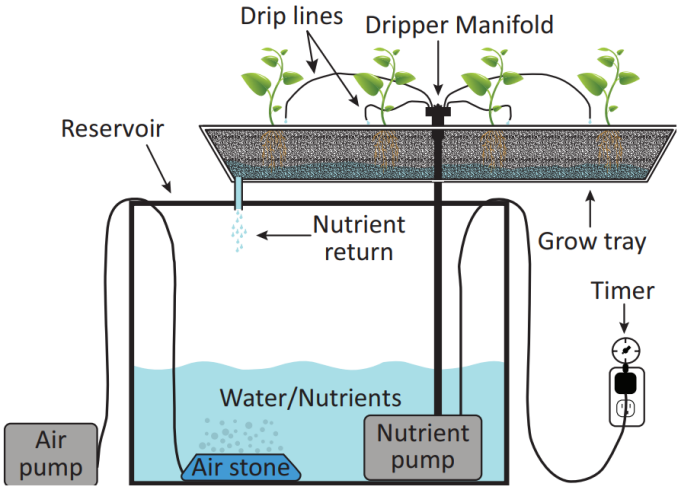
Types of Biofertilizers

1. **Rhizobium:** Rhizobium is a soil bacterium that colonize the roots of leguminous plants to form root nodules. The bacteria fix atmospheric nitrogen and convert them to ammonia.
2. **Azospirillum:** Azospirillum bacteria has the ability to use atmospheric nitrogen and transport this nutrient to the crop plants. It is inoculated on maize, barley, oats and sorghum crops. It increases productivity of cereals by 5 - 20%, of millets by 30% and fodder by over 50%.
3. **Azotobacter:** Application of Azotobacter bacteria has been found to increase yield of wheat, rice, maize and sorghum. Apart from nitrogen fixation, these organisms are capable of producing antifungal and antibacterial compounds.
4. **Mycorrhizae:** These fungi have symbiotic association with the roots of vascular plants. They increase the uptake of phosphorus. e.g. Citrus, Papaya.
5. **Azolla:** Azolla is a free floating, aquatic fern found on water surfaces having a cyanobacterial symbiotic association with Anabaena. It is a live floating nitrogen factory using energy from photosynthesis to fix atmospheric nitrogen.

5. Hydroponics, Aeroponics and Aquaponics

Hydroponics

Hydroponics is the method of growing plants without soil, using mineral nutrient solutions in water. The containers are made of glass, metal or plastic. They range in size from small pots for individual plants to huge tank for large scale growing. It was demonstrated by a German Botanist Julius Von Sachs in 1980. Hydroponics is successfully employed for the commercial production of seedless cucumber and tomato. Plants are suspended with their roots submerged in water that contain plant nutrients. The roots absorb water and nutrients, but do not perform the anchoring function. Therefore, the plants must be mechanically supported from above.

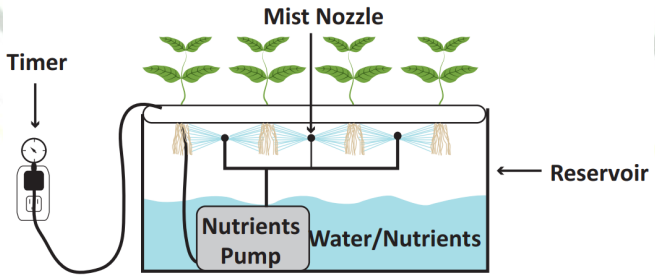


Importance of hydroponics

1. Conservation of water and nutrients.
2. Controlled plant growth.
3. In deserts and Arctic regions hydroponics can be an effective alternative method.

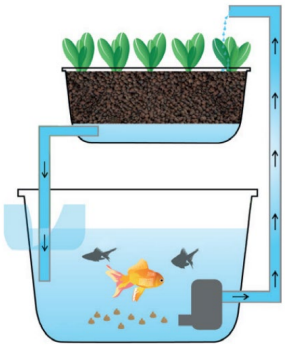
Aeroponics

The aeroponic system is the high-tech type of hydroponic gardening. The growth medium in this type is primarily air. The roots hang in the air and are misted with nutrient solution. The misting is usually done for every few minutes, as roots will dry out rapidly if the misting cycles are interrupted. A timer controls the nutrient pump much like other types of hydroponic systems, except that the aeroponic system needs a short cycle timer that runs the pump for a few seconds every couple of minutes.



Aquaponics

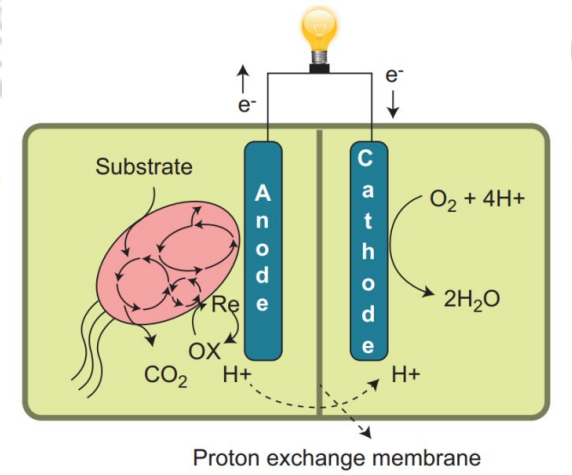
Aquaponics is a system of a combination of conventional aquaculture with hydroponics in a symbiotic environment, in which plants are fed with the aquatic animals' excreta or wastes. These wastes are broken down by nitrifying bacteria initially into nitrites and later into nitrates that are utilized by the plants as their nutrients. Thus, the wastes are utilized and water is recirculated back to the aquaculture system.



Aquaponics consists of two main parts, aquaculture- for raising aquatic animals like fish and hydroponics-for raising plants. Green leafy vegetables like chinese cabbage, lettuce, basil, coriander, parsley, spinach and vegetables like tomatoes, capsicum, chillies, bell peppers, sweet potato, cauliflower, broccoli and egg plant can be grown in aquaponics.

6. 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. 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.



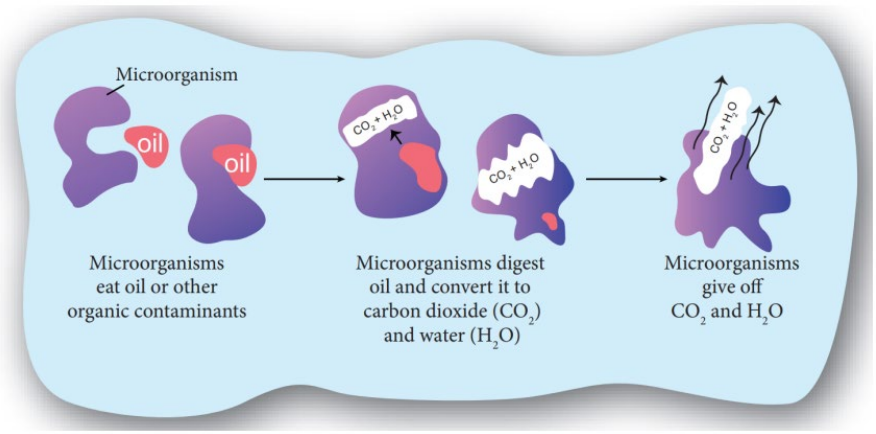
7. Bioremediation

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 (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).

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.



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.

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.