APPLIED MICROBIOLOGY

Applied microbiology is the field of microbial science which deals with the scientific use of microbes or there their components for goods and services to humankind.

APPLIED ENVIRONMENTAL MICROBIOLOGY

Due to rapid industrialization & urbanization, issues such as waste management and pollution have become a real menace to human. If these problems were not addressed properly it will affect normal life and cause serious health hazards also. Microbes exist in all environmental conditions and they possess significant characteristics. Innovative experiments proved that judicious applications of microbes help to overcome waste management and pollution in eco-friendly manner. Following are some examples for this:

1. **Bioremediation**: It is the application of microbes to convert toxic pollutant to a non toxic or use full product. It helps to clean the environment and restore them to original state. It helps to degrade pollutants without producing any toxic by-product. By proper application of microbes in situ bioremediation is done at the contaminated site itself and ex situ bioremediation is done by transporting the waste to specific locations where proper condition is provided for the growth of the microbes. Eg: *Pseudomonas putida*, the first genetically modified organism to get patent developed by Anand Chakraborthy. It is called as "superbug" as this bacterium could utilize hydrocarbons in oil spill as a carbon source and thereby degrading the pollutants.
2. **Composting**: It is also a type of bioremediation in which the solid waste materials are degraded with naturally occurring microbes into harmless eco-friendly material. They are also done insitu or ex situ. This method is very cheap and economic as only least amount is needed for the infrastructure

3. **Biostimulation**: Addition of substance that encourage the growth of beneficial microbes in the environment to stimulate naturally occurring microbe which clean up a contaminant.
4. **Bioaugmentation**: Addition of special micro-organisms which satisfy the requirements for cleaning up the environment is called Bioaugmentation. Such microbes maybe from contaminated sites or from culture collection. Eg: Commercial preparations to improve degradation process in septic tank.
5. **Biofertilization**: Presence of nitrates and other nutrients is essential for healthy growth of the plants. Due to drastic use of chemical fertilizers the fertility of the soil is getting lost and the water resources are getting polluted. So, as an alternative, free living nitrogen fixing microbes can be sprayed in the fields. Eg: *Azotobacter, Anabaena azoolae*
6. **Sewage treatment**: In highly urbanized towns and cities sewage treatment is a major problem as huge amount of waste is generated. Microbes are scientifically used to to degrade or eliminate the organic matter and make the water usable for agricultural purpose. This practical solution is converted and large treatment plants are designed.

APPLIED AGRICULTURAL MICROBIOLOGY

Population is rising day by day and agricultural outcome is not sufficient to meet the increasing population. After Green Revolution, the agricultural outcome increased but due to extensive use of chemical pesticides and fertilizers caused serious environment pollution. Fertilizers and pesticides are essential part of agriculture which cannot be compromised. Through run-off water chemical pesticides and fertilizers reaches water bodies and cause eutrophication .Realizing the role of nitrogen fixing microbes and role of decomposers and chemotrophs in biogeochemical cycles, new technologies were formulated. It helps to reduce the cost of agricultural production and mitigate pollution. Even the dependence on fossil fuel for the production of nitrogenous fertilizers can also be reduced.

1. **Biofertilizers :** Nitrogenous fertilizers maybe free living type or or endosymbiotic type. Seeds for the planting may be coated with bacterial cultures so that the nitrates will be made available right from the beginning. Eg: *Rhizobium Azotobacter*. Phosphate solubilizing bacteria such as *Bacillus megatherium* are used as biofertilizers to increase the agricultural productivity. There are numerous beneficial microbes found in symbiotic association with the rhizosphere. It enhance the absorption of material by solubilizing complex substance into compounds that can be assimilated by the plants. Eg: *Agrobacterium, Pseudomonas*

2. **Biopesticide:** Pesticides have a vital role in eliminating the pest which are sure to attack the plants soon from the beginning of the agricultural practice. Chemical pesticides cause serious health hazards to human as well as other animals. As an alternative, microbes or their products are used to control harmful pest. Eg: *Bacillus thuringiensis* and its BT toxin. Spores of the bacteria are sprayed on the plants and when larvae of the insects feed on this, the bacteria reaches intestine and produce a toxic crystal which and damage the intestinal lining and kills the larvae. It is a novel strategy which is highly economic and less toxic

3. **Bioinoculation:** Suitable microbes are cultured and their spores are collected for feeding the soil. The culture containing viable cells which functions as the initiating population is applied to the soil is sprayed on the fields as a aqeous suspension. The farmers can reduce the dependency on chemical fertilizers and thereby reducing the cost of production .

APPLIED INDUSTRIAL MICROBIOLOGY

Industrial microbiology is the part of microbiology dealing with the utilisation of microbes in industrial process. Here, the byproducts also may be of economic

importance. Microbial industrial process depends on biological and biochemical characteristics of organism which result in the transformation of materials into desirable products possibly of economic value. Metabolic activities of microbes and the metabolites are used in microbiology to produce goods that are beneficial to man.

1. **Microbial products:** Organic chemicals such as alcohol, lactic acid, citric acid, butanol, ethanol, vitamins, amino acids are are obtained from several microbes. Eg:

Microbe	Product
Lactobacillus	lactic acid
Acetobacter	citric acid
Clostridium	Acetone, butanol, ethanol
Yeast	Vitamins
E.coli	Aminoacids
Ralstonia	Recyclable plastics
Mucor miehei	Polyester
Rhodococcus	Acrylamide

2. **Single cell proteins**: Microbes themselves are nutritious food or supplements. So they are specifically cultured for maximum growth rate and by increasing biomass. They are harvested and when the biomass is highest, dried and packed for direct use as health products or food supplements. As the microbes are rich in protein, they are called Single cell proteins (SCP). Eg: *Spirulina maxima*

3. **Microbial enzymes :** Enzymes of microbes are produced at industrial levels to be used as detergents, clearing agents, textile sizing agents and agents for processing the food. They are eco-friendly and reduce the danger of eutrophication and concerned pollution.

4. **Mining with microbes**: Chemo lithotrophic and chemoautotrophic microbes are made use to extract ore from the mines. The characteristic feature of microbes is used for enrichment and recovery of desired metal through the process called bioleaching. It is the process in which microbes are used to dissolve elements and their compounds from more complex substance forming aqueous form which element is recovered. Ore of copper, gold, magnesium are being processed using microbes Eg: *Thiobacillus thioxidans*, *Pseuodomonas fluorescens.* Application of microbes reduce human resource management in this field. It also helps in reducing cost of processing and production of useful wastes such as sulfuric acid.

5. **Metabolic engineering**: it involves induction of inactive genes of microbes by manipulating the raw materials and other physicochemical factors which force the development of mutant that are more efficient in generating the desired substance. Almost all the industrial products manufactured using microbes are metabolites formed when the organism prefers fermentation pathway to generate energy

6. **Bioreactors:** Bioreactors are commercially used for the synthesis of desired products from microbes. Culture vessel in which huge quantities of medium can be maintained at proper environmental conditions and which facilitate the manufacture of required product is inevitable. Bioreactor is a system in which extensive large critical Biomass of organisms can be cultured in controlled condition. It can handle 500000 litres in a single vessel to manufacture a commercially important product.

APPLIED MEDICAL MICROBIOLOGY

Microbes have inevitable relationship with medical scenario.

1. **Microbes And Disease:** Any microbe that cause a disease is called a pathogen and this may be obligate or opportunistic. Applied medical microbiology emphasize in correlating the clinical symptoms and manifestation with specific pathogens and it is achieved through analysis of symptoms, preliminary diagnosis, testing of the suspected organism and specific culture techniques in a properly equipped laboratory. Applied medical microbiology depends of different type of media and culture techniques required for identification and characterization of a pathogen. Medical microbiology also emphasize in development of laboratory with high degree of sterility. Medical microbiology laboratory's are essential components of medical microbiology and disease management system.
2. **Microbes and antibiotics:** Antibiotics are substances derived from bacteria or any other microbe which is used to kill or retard the growth of other bacteria. They are metabolic products of microbes. Eg: *Streptomycin* from *Streptomyces* and its derivatives are most prevalent. Antibiotic peptides are heteropolymers of amino acids with almost 10 amino acids. Fungi are also source of antibiotics. Eg: *Pencillin notatum* is source of penicillin; the first antibiotic used in medicine. Several fungus sources of antibiotics and immunosuppression drug like cyclosporine which is produced as a secondary metabolite.
3. **Applied medical microbiology in prevention of epidemiological diseases**: Several contagious diseases affect mankind. Therefore, transmittable diseases are to be controlled at initial stages as they may spread to epidemic. If the causative agent is so virulent; it may become a pandemic. Applied medical microbiology interfere with the situation and make several procedures by which the disease can be contained Eg: For airborne disease, the source of infection and patients must be isolated and appropriate measures such as vaccine should be developed. In Vector Borne Disease, vectors are to be eliminated. Research and investigations in the field of applied medical

microbiology stress the importance of general cleanliness & hygienic conditions.

4. **Nosocomial disease** : Infections achieved from hospital when the patient is under treatment for another disease is called nosocomial disease. It can be prevented by cleanliness, stability of the hospital, especially the air conditioning ducts material, which encounters the patients, blood banks, surgical theatres, equipments and implants. Various microbiological sterilization and decontamination techniques should be applied to answer a pathogen free atmosphere in the hospital.
5. **Social and preventive medical microbiology**: Applied medical microbiology works in the field of social and preventive medicine by monitoring the environment and the community. Management of water and wastewater, proper maintenance of sewage system, disposal of the waste material, all these are part of applied medical microbiology. It also look to control the vector population which transmit pathogens. Also, this particular branch is to monitor the incidence of transmittable disease like Cholera, typhoid, malaria, hepatitis, plague which needs appropriate and immediate action. These are called reportable disease as any incident has to be reported immediately to government so that preventive measures can be taken.
6. **Vaccination:** Vaccination is a process of of preventing the transmittable diseases by injecting an individual with an antigen of a pathogen. It evokes strong immune response and prevents the proliferation of microbes Eg: BCG vaccine against tuberculosis
7. **Beneficial role of microbes in medical field**: Microbes play important role in providing beneficial material such as pharmaceuticals, food and food supplements like proteins and vitamins. Virus form one of the most efficient vectors for delivering genes and they are extensively used for or gene therapy treatment in humans. Use of bacteriophages as antibiotic agents are now intense and hot field of research. Several fungus which are pathogens are as

sources of food, medicine and industrial chemicals. There are also useful in producing antibiotics and immunosuppressant.

APPLICATION OF MICROBIOLOGY IN BIOTECHNOLOGY

Biotechnology is the application of scientific and engineering principles for the processing of materials through biological agents which is used for the goods and services for mankind. The technology of using microbes especially in the above said biotechnology applications is one of the innovative invention. Genetically engineered microbes function as biological factories for the manufacturing of essential materials which are useful for humankind.

1. **Cloning vectors:** Application of bacterial plasmids and bacteriophages as vector to deliver genes into cells while conducting gene cloning. Eg: Plasmids are isolated and cut using restriction nucleus and new genetic material is inserted. The modified vectors are reintroduced into competent cells for the desired application. Eg: *Agrobacterium* which infects plants and cause tumors. It contains plasmid called Ti plasmid which function as a vector to carry genes from prokaryote or eukaryote therefore it is called as a **shuttle vector.**
2. **Medically important proteins** Through genetic engineering and expression of various gene products, microbes are used to produce medical important proteins including insulin. Clotting factors for haemophilia patients, somatotropin for patients with growth problems, vaccination against HBV, antigens, peptide,s antibiotics are also synthesized.
3. **Taq polymerase** : From extremophile bacterium *Thermus aquaticus*, the taq DNA polymerase enzyme is isolated for PCR has revolutionized biotechnology and Molecular Biology.
4. **Restriction endonuclease:** It is an important enzyme which is used to cut the strands of DNA and called as molecular Scissors. This set of important enzymes given by microbiology to the field of biotechnology. DNA ligase is another set of

enzymes which are used to join two strands of DNA, is also contributed by microbes.

5. **Microbial biotechnology and Agriculture:** As agriculture is one of the most benefitted areas in utilizing the advances of microbial biotechnology. Developments in microbiology have been put to use in agriculture which result in increased yield and productivity Eg: Biofertilizers and Biopesticides
6. **Microbes in food technology:** Several microbes have important role in fermentation technology especially for the production of diary and bakery based products. They are involved in production of other food supplement such as vitamins, pickles, single cell protein, amino acids and flavours of natural foods. Probiotics which is other contribution of biotechnology has helped in enhanced immunity, control of diarrhoea and also they are used in poultry and cattle feeds.