CHAPTER

10

Microbes in Human Welfare

Microbes

Microbes are integral components of Earth's biological systems. These tiny, single-celled creatures are microscopic and can only be seen under a microscope. They come in diverse forms including protozoans, viruses, bacteria, algae (small plant groups), and fungi, and are studied in the field of microbiology. While some microbes are the causal agents of infectious diseases, humans have also harnessed their benefits for various purposes.

Microbes in household Products

Microbes play a significant role in our daily lives, including their use in household products. For example, ***Lactobacillus***, commonly known as **Lactic Acid Bacteria (LAB)**, is used to make curd from milk. By growing in milk, LAB converts it into curd. Similarly, the dough used for making popular food items such as dosa, idle, cakes, and bread are fermented by bacteria or yeast such as ***Saccharomyces cerevisiae***.

Another example of microbial use in household products is cheese-making. Different varieties of cheese are made by partial digestion of milk using various microbes. For instance, ***Propionibacterium shermanii*** is used in Swiss cheese, while **Penicillium roquefortii** is used in Roquefort cheese. These microbes contribute to the texture, flavors, and taste of each type of cheese.

Toddy, a traditional drink from Southern India, is another household product that utilizes microbes. It is made by fermenting sap from palm trees, coconuts, and other sources. In curd-making, the amount of curd added as raw material to convert milk into curd is known as inoculum.

Overall, microbes play a crucial role in the production of household products, making them an essential part of our daily lives.

Microbes in Industrial Products

Microbes are essential in the industrial production of various products valuable to human beings, including beverages, antibiotics, chemicals, enzymes, and other bioactive molecules. Here are some points that elaborate on the role of microbes in industrial products:

Fermented Beverages:

Saccharomyces cerevisiae, commonly known as brewer's yeast, is used to produce fermented beverages like beer, wine, and spirits.

The microbe is also used in the production of bakery products like bread, where it helps to leaven the dough.

Antibiotics Production:

Microorganisms are crucial in the production of antibiotics, which suppress the growth of disease-causing microbes.

The first discovered antibiotic, penicillin, was obtained from a mould called **Penicillium notatum** by Alexander Fleming.

Other antibiotics like ***streptomycin, terramycin, and fumagillin*** have also been purified from various microbial sources.

It's Important to use antibiotics judiciously to ensure maximum therapeutic efficiency and to prevent the emergence of resistant microorganisms.

Chemicals, Enzymes, and Other Bioactive Molecules:

Microbes are used for the commercial and industrial production of certain chemicals, enzymes, and bioactive molecules.

Organic acids like ***citric acid, acetic acid, butyric acid, and lactic acid***, are produced by microbes like **Aspergillus niger, Acetobacter aceti, Clostridium butylicum**, and **Lactobacillus**, respectively.

Ethanol, a bioactive molecule, is produced by ***Saccharomyces cerevisiae***.

Industrial Production:

Microbes are grown in large vessels called **fermenters** or **bioreactors** for industrial production purposes.

Fermenters or ***bioreactors*** provide a controlled environment for the growth of microbes, which is essential to maintain their productivity.

Microbes are also genetically modified to improve their efficiency and the quality of the products they produce.

In conclusion, microbes play a crucial role in the production of various industrial products, and their use has revolutionized the way we produce food, medicines, chemicals, and other essential products

Enzymes and their functions

Lipase serves as an ingredient in laundry detergents.

Pectinase and **protease** are utilized in the production of clarified bottled juices.

Streptokinase, derived from the **Streptococcus bacterium**, acts as a clot buster to dissolve blood clots in patients who have experienced myocardial infarction.

Bioactive molecules have numerous uses in the medical field. For instance, **Cyclosporin-A,** derived from ***Trichoderma polyparium*** fungi, acts as an immunosuppressive agent for patients who have undergone organ transplant surgeries. Meanwhile, **Statins**, which are sourced from ***Monascus purpureus*** yeast, are effective in lowering blood cholesterol levels.

Microbes in Sewage Treatment

Microbes play a crucial role in sewage treatment, where heterotrophic microorganisms like bacteria, fungi, and protozoa, naturally present in sewage, are utilized. **Sewage treatment plants (STPs)** are responsible for treating wastewater that contains a variety of discarded materials, including domestic and agricultural wastes, as well as human excreta.

This treatment process takes place in two stages:

Primary Treatment: In this stage, physical removal of large and small particles from the sewage takes place via ***filtration*** and ***sedimentation***. Settling tanks are used to remove all grit and soil, and the solids that settle down at the bottom are known as **primary sludge**. It traps a considerable number of microbes and debris, while the supernatant forms the effluent that undergoes secondary treatment.

Secondary Treatment or **Biological Treatment**: In this stage, the primary effluent is passed into large aeration tanks that are mechanically agitated, promoting the growth of aerobic microbes that form flocs. These flocs, masses of bacteria associated with fungal filaments that form mesh-like structures, consume the major part of the organic matter present in the effluent, significantly reducing the **BOD (Biochemical Oxygen Demand)** of the effluent. As the BOD is reduced to 10-15% of raw sewage, the effluent is passed into a settling tank, and the sediment is called activated sludge, which is sent to anaerobic sludge digesters. In these digesters, anaerobic microbes like methanogens digest the organic mass and aerobic microbes, producing gases like methane (CH_4), hydrogen sulphide (H_2S), carbon dioxide (CO_2), etc. These gases form **biogas**, which is an additional benefit of the sewage treatment process.

Microbes in Biogas Production

Microbes play a crucial role in the production of biogas, which is a renewable energy source. The process involves the use of **methanogens** and **Methanobacterium**, which are microbes that produce methane.

Here are some important points to note:

- **Biogas** is composed mainly of **methane (50-70%) and carbon dioxide (30-40%)**, with small amounts of other gases such as hydrogen, nitrogen, ethylene, acetylene, ethane, propane, and hydrogen sulphide.
- **Cattle dung**, also known as "goober," is rich in methanogenic bacteria and is commonly used as a feedstock for biogas production.
- Biogas plants are designed to convert manure, waste, and other organic materials into energy and **bio-fertilizers**.
- This technology was developed in India by the **Khadi and Village Industries Commission (KVIC)** and the **Indian Agricultural Research Institute (IARI)**

Microbes as biocontrol agents

Microbes can be utilized as biological control agents to manage plant diseases and pests. Some examples of such agents include:

(i) **Bacillus thuringiensis**, a soil bacterium that produces a protein known as Bt toxin in its endospore form, which is toxic to insects such as cotton bollworm, termites, butterflies, ants, and others.

(ii) **Ladybirds** and **dragonflies** can be used to eliminate aphids and mosquitoes, respectively.

(iii) **Trichoderma**, a type of free-living fungi commonly found in root ecosystems, can act as biocontrol agents against plant pathogens.

(iv) **Baculoviruses** belonging to the genus Nucleopolyhedroviral are also effective biological control agents for insect pests.

Microbes as bio fertilizers

Microbes can increase the nutrient content of soil via their biological processes, making them **biofertilizers** that are responsible for increasing plant growth.

Different types of microbes such as bacteria, fungi, and cyanobacteria are known to enrich the nutrient quality of the soil.

The main sources of biofertilizers include:

i. **Symbiotic bacteria** such as **Rhizobium**, free-living bacteria in the soil like **Azotobacter and Az spirillum.**

ii. **Symbiotic fungi** like Mycorrhiza.

iii. **Symbiotic cyanobacteria** like Anabaena and Azolla, as well as free-living cyanobacteria such as Nostoc, Oscillatoria, and blue-green algae.

Microbes in Human Welfare

Microbes in Industrial Products

- Antibiotics: Penicillin is produced by *Penicillium notatum*
- Fermented beverages: Wine, Beer, brandy etc., is produced by *Saccharomyces cerevisiae*
- Organic acids:
  - *Aspergillus niger* (a fungus): Citric acid
  - *Acetobacter aceti* (a bacterium): Acetic acid
  - *Clostridium butylicum* (a bacterium): Butyric acid
  - *Lactobacillus* (a bacterium): Lactic acid
- Enzymes:
  - Lipases
  - Pectinases and Proteases (To clarify bottled juices)
  - Streptokinase (*Streptococcus*- used as clot buster)
- Bioactive molecules:
  - Statins- *Monascus purpureus*- used as blood-cholesterol lowering agents
  - Cyclosporin A- *Trichoderma polysporum*- used as an immunosuppressive drug.

Microbes as bio-fertilizers

- Bacteria:
  - *Rhizobium* (symbiotic bacteria)
  - *Azospirillum* and *Azotobacter* (free living bacteria).
- Fungi: Mycorrhiza- association of *Glomus* with plants
- Cyanobacteria:
  - Symbiosis: *Anabaena* in *Azolla*
  - Free living: *Nostoc, Oscillatoria* and blue green algae

Microbes in Sewage Treatment

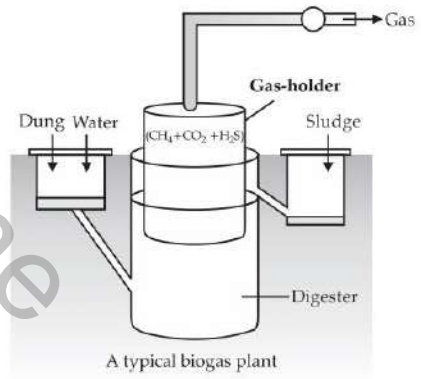
- Primary Sewage treatment: Involves removal of coarse solid materials
- Secondary Sewage treatment: Involves the action of microbes

Microbes in household

- Curd: *Lactobacillus* or LAB
- Bread: *Saccharomyces cerevisiae*
- Swiss Cheese: *Propionibacterium shermanii*

Microbes in Production of Biogas

- Bacteria involved is *Methanobacterium*



A typical biogas plant

Microbes as biocontrol agents

- *Bacillus thuringiensis:* Control butterfly caterpillars
- *Trichoderma sp.*
- Baculoviruses (esp. genus *Nucleopolyhedrovirus*): Controls insects and arthropods

Trace the Mind Map

First Level · Second Level · Third Level

Practice Questions

1.Which gas is produced during fermentation that causes dough to puff up in bread making?

(a) CO_2 (b) CO (c) O_2 (d) H_2

2.Which bacterium is responsible for the formation of Swiss cheese?

(a) Aspergillus niger (b) Lactobacillus

c) Propionibacterium shermanii (d) Penicillium roquefortine

3.What type of alcoholic beverages are produced by distilling fermented broth?

(a) wine and beer (b) wine, whisky, and brandy

c) whisky, brandy, and rum (d) whisky, beer, and brandy

4.Which organism is commonly used in the production of wine, beer, whisky, brandy, and rum?

(a) Clostridium butylicum (b) Aspergillus niger

(c) Saccharomyces cerevisiae (d) Penicillium notatum

5.Which antibiotic was extensively used to treat American soldiers wounded in World War II?

(a) Streptokinase (b) Penicillin (c) Statins (d) Neomycin

6.Which diseases are treated with antibiotics?

(a) diphtheria, whooping cough (b) plague (c) leprosy (d) All of the above

7.Which microbe is used commercially to produce butyric acid?

(a) Clostridium butylicum (b) Streptococcus butylicum

(c) Trichoderma polysporum (d) Saccharomyces cerevisiae

8.Which of the following pairs is incorrect?

(a) Lipases – Used in detergents for removing oil stains

(b) Pectinases and proteases – Used in clarifying bottled juices

c) Statins – Competitively inhibit the enzyme responsible for cholesterol synthesis

(d) None of the above

9.Which substance is used as a "clot buster" to remove clots from blood vessels in patients who have had a heart attack?

(a) Ethanol (b) Statins (c) Cyclosporin-A (d) Streptokinase

10.What do the letters A and B refer to in sewage?

(a) A – inorganic matter, B – bacteria

(b) A – organic matter, B – pathogenic microbes

(c) A – organic matter, B – virus

(d) A – inorganic matter, B – pathogenic microbes

11.What does a higher BOD value indicate in water samples?

(a) High pollution level (b) Low pollution level

(c) Moderate pollution level (d) Pollution level cannot be determined

12.Which plan was launched by the Ministry of Environment and Forests to protect rivers from water pollution?

(a) Ganga action plan (b) Yamuna action plan

(c) Both Ganga and Yamuna action plans (d) None of the above

13.Which gaseous component of biogas is the most flammable?

(a) Methane, CO_2, H_2, and HS_2 (b) Methane

(c) CO_2, H_2, and HS_2 (d) CO, methane, and N_2

14.Which bacteria is present in the rumen of cattle?

(a) Rhizobium (b) Azotobacter (c) Methanobacterium (d) Clostridium

15.Who collaborated to develop the gobar gas generation technology in India?

(a) A – Rural Bank of India, B – Khadi and Village Industries Commission

(b) A – Indian Agricultural Research Institute, B – Khadi and Village Industries Commission

c) A – National Bank for Agriculture and Development, B – Indian Agricultural Research Institute

(d) A – National Bank for Agriculture and Development, B – Khadi and Village Industries Commission

16.What is Bacillus thuringiensis used for?

(a) Biofungicide (b) Biopesticide (c) Biocontrol agent (d) Bioweapon

17.What does the prefix "Bt" mean in Bt cotton?

(a) "Barium-treated" cotton seeds

(b) "Bigger thread" variety of cotton with better tensile strength

(c) Produced by "biotechnology" using restriction enzymes and ligases

(d) Carrying an endotoxin gene from Bacillus thuringiensis

18.What are Trichoderma species potentially useful for in root ecosystems?

(a) Biopesticides (b) Biofertilisers (c) Methanogens

(d) Vectors for genetic engineering

19.Which of the following is not a characteristic of Baculoviruses (Nucleopolyhedrovirus)?

(a) Host specificity (b) Narrow spectrum applications

(c) Effects on non-target insects (d) Utility in IPM programme

20.What should a biocontrol agent possess to be a part of an integrated pest management?

(a) Species-specific and symbiotic

(b) Free-living and broad spectrum

(c) Narrow spectrum and symbiotic

(d) Species-specific and inactive on non-target organisms

21.Who established the function of penicillin as an antibiotic?

a) Alexander Flemming b) Ernst Chain c) Howard Florey d) Both (b) and (c)

22.How are big holes in Swiss cheese made?

a) By a machine

b) By a bacterium producing a large amount of carbon dioxide

c) By a bacterium that produces carbon monoxide gas

d) By a fungus that produces a lot of gases during its metabolic activities

23.Which of the following refers to a methane-rich fuel gas produced by the breakdown of organic matter with the help of certain bacteria?

A) A-Gobar gas, B-aerobic, C-fermentative b) A-Biogas, B-anaerobic, C-methanogenic

c) A-water gas, B-aerobic, C-Methanogenic d) A-Biogas, B-anaerobic, C-fermentative

24.Which of the following plants is considered medicinal?

a) Cinchona b) Opium c) Rauwolfia d) All of these

25.Which of the following are the main benefits of LAB (lactic acid bacteria)?

a) Only I – increase vitamin-amount, thus increasing nutrient quality of milk

b) Only II – checks disease-causing microbes in the stomach

c) I and II

d) None of these

26.What is produced during the anaerobic fermentation of agricultural wastes?

a) Methane b) Ethanol c) Carbon monoxide d) Biogas

27.Which of the following serves as a biofertilizer in paddy fields?

a) Anabaena b) Azospirillum c) Nostoc d) Both (a) and (c)

28.Which microbe is used in the commercial production of butyric acid?

a) Clostridium butylicum b) Streptococcus butylicum

c) Trichoderma polysporum d) Saccharomyces cerevisiae

29.What is primary treatment?

a) Physical removal of large and small particles from sewage

b) Biological removal of large and small particles from sewage

c) Both (a) and (b)

d) Chemical removal of large and small particles from sewage

30.What are the benefits of mycorrhizae?

a) I and II – resistance to root-borne pathogen and tolerance to salinity and pathogen

b) I and III – resistance to root-borne pathogen and overall increase in plant growth and development

c) II and III – tolerance to salinity and pathogen and overall increase in plant growth and development

d) I, II, and III – resistance to root-borne pathogen, tolerance to salinity and pathogen, and overall increase in plant growth and development

31.What gases are present in biogas, a mixture of inflammable gases?

a) Methane, CO_2, and O_2 b) Methane, CO_2, and nitrogen

c) Methane and CO_2 d) CO, methane, and hydrogen sulfide

32.What is the process for biogas production from waste biomass with the help of methanogenic bacteria?

a) Multi-step process
b) One-step process
c) Two-step process
d) Three-step process

33.What are organisms called that are used to enrich the nutrient quality of soil?

a) Bacteria
b) Cyanobacteria
c) Fungi
d) All of these

34.Which of the following serves as a biofertilizer in paddy fields?

a) Anabaena
b) Azospirillum
c) Nostoc
d) Both (a) and (c)

35.Which microbe is used in the commercial production of butyric acid?

a) Clostridium butylicum
b) Streptococcus butylicum
c) Trichoderma polysporum
d) Saccharomyces cerevisiae

36.What is primary treatment?

a) Physical removal of large and small particles from sewage

b) Biological removal of large and small particles from sewage

c) Both (a) and (b)

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d) I, II, and III – resistance to root-borne pathogen, tolerance to salinity and pathogen, and overall increase in plant growth and development

38.What gases are present in biogas, a mixture of inflammable gases?

a) Methane, CO_2, and O_2

b) Methane, CO_2, and nitrogen

c) Methane and CO_2

d) CO, methane, and hydrogen sulfide

39. Where microorganisms or microbes are found?

(a) Soil, air, water and inside the bodies of living Organisms

(b) Thermal vents deep in soil

(c) under snow and in highly acidic environments

(d) of the above

40.What is the process for biogas production from waste biomass with the help of methanogenic bacteria?

a) Multi-step process

b) One-step process

c) Two-step process

d) Three-step process

41.What are organisms called that are used to enrich the nutrient quality of soil?

a) Bacteria b) Cyanobacteria c) Fungi d) All of these

42.What do nitrifying bacteria do?

a) Convert free nitrogen to nitrogen compounds

b) Convert proteins into ammonia

c) Reduce nitrates to free nitrogen

d) Oxidize ammonia to nitrates

43.Which of the following statements are true?

I. Ladybirds and dragonflies are used to get rid of aphids and mosquitoes

II. Bacteria are used to control butterflies

III. Trichoderma sp., free-living fungi, are present in root ecosystems where they act against several plant pathogens

IV. Rhizobium is a symbiotic bacterium that lives in the stem of legumes

a) I, II, and III b) I, III, and IV c) II, III, and IV d) II and IV

44.What does the prefix in the context of cotton cultivation mean?

a) 'Barium-treated' cotton seeds

b) 'Bigger thread' variety of cotton with better tensile strength

c) Produced by 'biotechnology' using restriction enzymes and ligases

d) Carrying an endotoxin gene from Bacillus thuringiensis

45.Which of the following cyanobacteria can fix atmospheric nitrogen?

I. Anabaena II. Nostoc II. Spirulina IV. Oscillatoria

a) I, II and III b) I, II and IV c) II, III and IV d) III and IV

46.What is the method for estimating the BOD of wastewater?

a) Measuring total organic matter b) Measuring biodegradable organic matter

c) Measuring oxygen evolution d) Measuring oxygen consumption

47.What is the primary process used in secondary sewage treatment?

a) Chemical process b) Physical process c) Mechanical process d) Biological process

48.How does producer gas differ from biogas?

a) Contains methane b) Contains carbon monoxide

c) Contains carbon dioxide d) Produced by fermentation

49.What is Bacillus thuringiensis used for?

a) Biofungicide b) Biopesticide c) Biocontroller d) Bioweapon

50.Why do farmers need to purchase fresh hybrid seed every year for high-yielding hybrid crop varieties?

a) Hybrid vigor is not long-lasting due to inbreeding depression

b) They are not allowed to grow their own seed

c) Increased heterozygosity is always associated with hybrid vigor

d) The government has accepted Dunkel's proposals

Answers

1.(a) CO_2

Fermentation is the process by which microorganisms, such as yeast or bacteria, break down sugars to produce energy in the absence of oxygen. During fermentation, yeast produces carbon dioxide (CO2) gas as a byproduct, which causes dough to rise and puff up in bread making.

2.(c) Propionibacterium shermanii

Swiss cheese is a type of cheese made by introducing the bacterium Propionibacterium shermanii during the cheese-making process. This bacterium produces carbon dioxide gas, which causes the characteristic holes or "eyes" in Swiss cheese.

3.(b) wine, whisky, and brandy

Distillation is the process of separating and concentrating the alcohol content of fermented broth by heating and cooling it. This process is used to produce higher alcohol content beverages, such as whisky, brandy, and rum, from fermented grains or fruits. Wine, which is made from fermented grapes, can also be distilled to produce brandy.

4.(c) Saccharomyces cerevisiae

Saccharomyces cerevisiae, also known as brewer's yeast or baker's yeast, is a type of yeast commonly used in the production of alcoholic beverages, such as wine, beer, whisky, brandy, and rum. This yeast consumes sugars in the fermented broth and produces alcohol and carbon dioxide gas as byproducts.

5.(b) Penicillin

Penicillin, a group of antibiotics derived from the fungus Penicillium, was extensively used to treat bacterial infections during World War II, including infections in American soldiers wounded in combat.

6.(d) All of the above

Antibiotics are drugs used to treat bacterial infections, and they can be used to treat a wide range of bacterial diseases, including diphtheria, whooping cough, plague, leprosy, and many others.

7.(a) Clostridium butylicum

Clostridium butylicum is a bacterium used commercially to produce butyric acid, a carboxylic acid with a wide range of industrial applications, such as in the production of plastics, textiles, and food additives.

8.(d) None of the above

All of the pairs listed in this question are correct. Lipases are enzymes used in detergents to remove oil stains, pectinases and proteases are enzymes used in the clarification of bottled juices, and statins are drugs that competitively inhibit the enzyme responsible for cholesterol synthesis.

9.(d) Streptokinase

Streptokinase is a protein produced by the bacterium Streptococcus that is used as a "clot buster" to break down blood clots in patients who have had a heart attack or other serious blood clotting disorder.

10.(d) A – inorganic matter, B – pathogenic microbes

The letters A and B are used to categorize different types of sewage solids. "" solids refer to inorganic matter, such as sand and gravel, while "

11.(a) High pollution level. BOD (Biochemical Oxygen Demand) is a measure of the amount of dissolved oxygen required by microorganisms to break down the organic matter in water. A high BOD value indicates that there is a high level of organic matter present in the water sample, which can be caused by pollutants such as sewage, agricultural runoff, or industrial discharges.

12.(c) Both Ganga and Yamuna action plans. The Ministry of Environment and Forests launched the Ganga Action Plan in 1985 to reduce pollution in the Ganga River, and later the Yamuna Action Plan in 1993 to address pollution in the Yamuna River.

13.(b) Methane. Methane is the primary component of biogas, which is produced through the anaerobic digestion of organic matter. It is highly flammable and is used as a fuel for heating and electricity generation.

14.(c) Methanobacterium. Methanobacterium is a type of bacteria that is present in the rumen of cattle and is responsible for producing methane as a byproduct of the digestion of cellulose.

15.(d) A – National Bank for Agriculture and Development, B – Khadi and Village Industries Commission. The technology for goober gas generation in India was developed by the National Bank for Agriculture and Development and the Khadi and Village Industries Commission in the 1970s.

16.(b) Biopesticide. Bacillus thuringiensis (Bt) is a type of bacteria that produces a protein toxin that is toxic to certain insect pests. It is used as a biopesticide to control pests in agriculture and forestry.

17.(d) Carrying an endotoxin gene from Bacillus thuringiensis. Bt cotton is a genetically modified variety of cotton that carries a gene for a protein toxin produced by Bacillus thuringiensis. This toxin is toxic to certain insect pests and provides protection to the cotton plant.

18.(a) Biopesticides. Trichoderma species are commonly used as biopesticides to control plant pathogens and diseases. They also have the potential to promote plant growth and improve soil health.

19.(c) Effects on non-target insects. Baculoviruses, including Nucleopolyhedrovirus (NPV), are highly specific to certain insect pests and have been used as biopesticides in integrated pest management programs. They have a narrow spectrum of activity and are not known to have significant effects on non-target insects.

20.(a) Species-specific and symbiotic. A biocontrol agent used in integrated pest management should be species-specific to the target pest and have a symbiotic relationship with the crop or its environment. This ensures that the agent is effective against the pest while minimizing harm to non-target organisms and the environment.

21.(d) Both (b) and (c). While Alexander Flemming discovered penicillin, it was Ernst Chain and Howard Florey who established its function as an antibiotic and developed methods for its mass production.

22.(b) By a bacterium producing a large amount of carbon dioxide. The bacterium Propionibacterium Fredericia is responsible for producing carbon dioxide gas during the production of Swiss cheese, which forms the characteristic holes in the cheese.

23.(b) A-Biogas, B-anaerobic, C-methanogenic. Biogas is a methane-rich fuel gas produced by the breakdown of organic matter in the absence of oxygen (anaerobic conditions) with the help of methanogenic bacteria.

24.(d) All of these. Cinchona, opium, and Rauwolffia are all medicinal plants with various uses in traditional medicine and modern pharmaceuticals.

25.(c) I and II. LAB (lactic acid bacteria) can increase the vitamin content of milk and also inhibit the growth of disease-causing bacteria in the gut, improving gut health.

26.(d) Biogas. Anaerobic fermentation of agricultural waste produces biogas, which is a mixture of methane and carbon dioxide that can be used as a fuel.

27.(b) Azospirillum. Azospirillum is a bacterium that can form a symbiotic relationship with plants, including rice, and serve as a biofertilizer, increasing nutrient uptake and plant growth.

28.(a) Clostridium butylicum. Clostridium butylicum is a bacterium that is used in the commercial production of butyric acid, which is used in the manufacture of various chemicals and food products.

29.(a) Physical removal of large and small particles from sewage. Primary treatment of sewage involves physical processes such as sedimentation and filtration to remove solid particles and organic matter from the wastewater.

30.(d) I, II, and III – resistance to root-borne pathogen, tolerance to salinity and pathogen, and overall increase in plant growth and development. Mycorrhizae are fungi that form a symbiotic relationship with plants, helping them to absorb nutrients from the soil and providing various benefits, including increased resistance to root-borne pathogens, tolerance to salinity and other stress factors, and overall improvement in plant growth and development.

31.Answer: c) Methane and CO_2

Explanation: Biogas is a mixture of gases, mainly composed of methane (50-75%) and carbon dioxide (25-50%), along with small amounts of other gases like hydrogen sulfide, nitrogen, and oxygen. Methane is the primary combustible gas and is responsible for the fuel value of biogas.

32.Answer: c) Two-step process

Explanation: Biogas production from waste biomass with the help of methanogenic bacteria is a two-step process: hydrolysis and acidogenesis, followed by methanogenesis. Hydrolysis breaks down the complex organic compounds into simpler compounds, while acidogenesis further degrades these compounds into organic acids. Methanogenesis is the final step where methane is produced by the methanogenic bacteria.

33.Answer: d) All of these

Explanation: Organisms like bacteria, cyanobacteria, and fungi are used to enrich the nutrient quality of soil. These microorganisms play a vital role in decomposing organic matter, fixing atmospheric nitrogen, and releasing nutrients that are available to plants. They also help in improving the soil structure and reducing soil erosion.

34.Answer: d) Both (a) and (c)

Explanation: Anabaena and Nostoc are nitrogen-fixing cyanobacteria that serve as biofertilizers in paddy fields. These cyanobacteria form symbiotic associations with the roots of rice plants and provide them with fixed nitrogen, thereby reducing the dependence on chemical fertilizers.

35.Answer: a) Clostridium butylicum

Explanation: Clostridium butylicum is a spore-forming bacterium that is used in the commercial production of butyric acid. Butyric acid is an important industrial chemical that is used in the manufacture of various products, including perfumes, flavorings, and plastics.

36.Answer: a) Physical removal of large and small particles from sewage

Explanation: Primary treatment is the initial stage of sewage treatment, which involves the physical removal of large and small particles from the wastewater. During primary treatment, the wastewater is screened to remove large objects like rags, sticks, and plastics, and then passed through a sedimentation tank where suspended solids settle down to the bottom.

37.Answer: d) I, II, and III – resistance to root-borne pathogen, tolerance to salinity and pathogen, and overall increase in plant growth and development

Explanation: Mycorrhizae are symbiotic associations between fungi and the roots of plants. They help in increasing the nutrient uptake by the plants, particularly phosphorus, and also improve their resistance to root-borne pathogens and tolerance to salinity and drought. Mycorrhizae also help in improving the overall growth and development of plants.

38.Answer: c) Methane and CO_2

Explanation: Biogas is a mixture of gases, mainly composed of methane (50-75%) and carbon dioxide (25-50%), along with small amounts of other gases like hydrogen sulfide, nitrogen, and oxygen. Methane is the primary combustible gas and is responsible for the fuel value of biogas.

39.Microorganisms or microbes can be found in various environments, including soil, air, water, and inside the bodies of living organisms. Option (a) is the correct answer.

40.The process for biogas production from waste biomass with the help of methanogenic bacteria is a two-step process. First, hydrolysis and acidogenesis take place, which break down the complex organic molecules into simpler organic molecules such as amino acids, fatty acids, and sugars. Then, methanogenic bacteria convert these simpler organic molecules into biogas, which is composed primarily of methane and carbon dioxide. Option © is the correct answer.

41.Organisms that are used to enrich the nutrient quality of soil are called biofertilizers. Biofertilizers include bacteria, cyanobacteria, and fungi. Option (d) is the correct answer.

42.Nitrifying bacteria are a type of bacteria that oxidize ammonia to nitrates, which are then used by plants to build proteins and other essential molecules. Option (d) is the correct answer.

43.Ladybirds and dragonflies are used to get rid of aphids and mosquitoes (I) is true. Bacteria are used to control butterflies (II) is false. Trichoderma sp. Are present in root ecosystems where they act against several plant pathogens (III) is true. Rhizobium is a symbiotic bacterium that lives in the stem of legumes (IV) is false since it lives in the root nodules of legumes. Therefore, option (b) is the correct answer.

44.The prefix “Bt” in the context of cotton cultivation means that the cotton is carrying an endotoxin gene from Bacillus thuringiensis, which makes it resistant to certain insects. Option (d) is the correct answer.

45.Theanobacteria that can fix atmospheric nitrogen are Anabaena, Nostoc, and Oscillatoria. Spirulina is not able to fix atmospheric nitrogen. Therefore, the correct option is (b) I, II and IV.

46. BOD (Biochemical Oxygen Demand) is

A measure of the amount of dissolved oxygen needed by aerobic biological organisms to break down the organic matter in a sample of water. The method for estimating BOD of wastewater is to measure the oxygen consumption by microorganisms over a specified period. Therefore, the correct option is (d) Measuring oxygen consumption.

47.Secondaryreatment is a biological process that uses microorganisms to break down organic matter present in wastewater. The primary process used in secondary sewage treatment is a biological process. Therefore, the correct option is (d) Biological process.

48. Biogas and producer gas are both gases produced by the anaerobic digestion of organic matter. However, biogas contains a higher percentage of methane (50-70%) and lower carbon monoxide and carbon dioxide levels. In contrast, producer gas contains a lower percentage of methane (20-30%) and higher carbon monoxide and carbon dioxide levels. Therefore, the correct option is (b) Contains carbon monoxide.

49. Bacillus thuringiensis (Bt) is a soil-Dwelling bacterium that produces proteins toxic to certain insect pests. Bt is used as a biopesticide to control insect pests in agriculture and forestry. Therefore, the correct option is (b) Biopesticide.

50. Hybrid seeds are produced by crossing two genetically different parent plants. Hybrid plants tend to show increased heterozygosity, which can result in improved growth and yield. However, the hybrid vigor is not long-lasting due to inbreeding depression, which results in a decline in the quality of the seeds produced by the hybrid plants. Therefore, farmers need to purchase fresh hybrid seed every year for high- yielding hybrid crop varieties. Therefore, the correct option is (a)