



# MICROBES IN HUMAN WELFARE

## CHAPTER SNAPSHOT

- 9.1 Microbes in household products
- 9.2 Microbes in industrial products
- 9.3 Microbes in sewage treatment and energy generation
- 9.4 Microbes in the production of biogas
- 9.5 Microbes as bio-control agents and bio-fertilisers
- 9.6 Bioremediation

## Evaluation

- Which of the following microorganism is used for production of citric acid in industries?  
(a) *Lactobacillus bulgaris*  
(b) *Penicillium citrinum*  
(c) *Aspergillus niger*  
(d) *Rhizopus nigricans*  
[Ans. (c) *Aspergillus niger*]
- Which of the following pair is correctly matched for the product produced by them?  
(a) *Acetobacter aceti* - Antibiotics  
(b) *Methanobacterium* - Lactic acid  
(c) *Penicillium notatum* - Acetic acid  
(d) *Saccharomyces cerevisiae* - Ethanol  
[Ans. (d) *Saccharomyces cerevisiae* - Ethanol]
- The most common substrate used in distilleries for the production of ethanol is \_\_\_\_\_  
(a) Soyameal (b) Groundgram  
(c) Molasses (d) Corn meal  
[Ans. (c) Molasses]
- Cry toxins obtained from *Bacillus thuringiensis* are effective against for \_\_\_\_\_  
(a) Mosquitoes (b) Flies  
(c) Nematodes (d) Bollworms  
[Ans. (d) Bollworms]
- Cyclosporin - A is an immunosuppressive drug produced from \_\_\_\_\_  
(a) *Aspergillus niger*  
(b) *Monascus purpureus*  
(c) *Penicillium notatum*  
(d) *Trichoderma polysporum*  
[Ans. (d) *Trichoderma polysporum*]
- Which of the following bacteria is used extensively as a bio-pesticide?  
(a) *Bacillus thuringiensis*  
(b) *Bacillus subtilis*  
(c) *Lactobacillus acidophilus*  
(d) *Streptococcus lactis*  
[Ans. (a) *Bacillus thuringiensis*]
- Which of the following is not involved in nitrogen fixation?  
(a) *Pseudomonas* (b) *Azotobacter*  
(c) *Anabaena* (d) *Nostoc*  
[Ans. (d) *Pseudomonas*]
- $\text{CO}_2$  is not released during  
(a) Alcoholic fermentation  
(b) Lactate fermentation  
(c) Aerobic respiration in animals  
(d) Aerobic respiration in plants  
[Ans. (b) Lactate fermentation]
- The purpose of biological treatment of waste water is to \_\_\_\_\_.  
(a) Reduce BOD  
(b) Increase BOD  
(c) Reduce sedimentation  
(d) Increase sedimentation  
[Ans. (a) Reduce BOD]
- The gases produced in anaerobic sludge digesters are  
(a) Methane, oxygen and hydrogen sulphide  
(b) Hydrogen sulphide, methane and sulphur dioxide  
(c) Hydrogen sulphide, nitrogen and methane  
(d) Methane, hydrogen sulphide and  $\text{CO}_2$   
[Ans. (d) Methane, hydrogen sulphide and  $\text{CO}_2$ ]
- How is milk converted into curd? Explain the process of curd formation.  
Ans. The LAB bacteria grows in milk and convert it into curd, thereby digesting the milk protein casein. A small amount of curd added to fresh milk as a starter or inoculum contains millions of *Lactobacilli*, which under suitable temperature ( $\leq 40^\circ\text{C}$ ) multiply and convert milk into curd. Curd is more nutritious than milk as it contains a number of organic acids and vitamins.
- Give any two bioactive molecules produced by microbes and state their uses.  
Ans. Antibiotics are chemical substances produced by microorganisms which can kill or retard the growth of other disease causing microbes even in low concentration. Examples of antibiotics are:  
(i) **Penicillin:** Penicillin is an antibiotic produced by the fungus *Penicillium notatum*.  
**Action:** It is bactericidal in action and inhibits the synthesis of the bacterial cell wall.



(ii) **Streptomycin:** It is a broad spectrum antibiotic isolated from the *actinomycetes*, *streptomyces griseus*.

**Action:** It is bactericidal against both gram positive and gram negative bacteria especially against *Mycobacterium tuberculosis*.

### 13. What is biological oxygen demand?

**Ans.** BOD stands for Biological Oxygen Demand.

BOD refers to the amount of oxygen that would be consumed if all the organic matter in one litre of water were oxidized by bacteria. The greater the BOD of the waste water, the more is its polluting potential.

### 14. Explain the role of cry-genes in genetically modified crops.

**Ans. (i)** *Bacillus thuringiensis* is a soil dwelling bacterium which is commonly used as a biopesticide and contains a toxin called cry toxin. Scientists have introduced this toxin producing genes into plants and have raised genetically engineered insect resistant plants. **Eg.** *Bt-cotton*.

(ii) When the insects ingest the toxin crystals their alkaline digestive tract denatures the insoluble crystals making them soluble. The cry toxin then gets inserted into the gut cell membrane and paralyzes the digestive tract. The insect then stops eating and starves to death.

### 15. Write the key features of organic farming.

**Ans. (i)** Protecting soil quality using organic materials and encouraging biological activity.

(ii) Indirect provision of crop nutrients using soil microorganisms.

(iii) Nitrogen fixation in soils using legumes.

(iv) Weed and pest control based on methods like crop rotation, biological diversity, natural predators, organic manures and suitable chemical, thermal and biological interventions.

### 16. Justify the role of microbes as a bio-fertilizer.

**Ans. (i)** Bio-fertilisers are formulation of living microorganisms that enrich the nutrient quality of the soil. They increase physico – chemical properties of soils such as soil structure, texture, water holding capacity, cation exchange capacity and pH by providing several nutrients and sufficient organic matter.

(ii) The main sources of bio-fertilisers are bacteria, fungi and cyanobacteria. *Rhizobium* is a example for symbiotic nitrogen fixing bacteria. This bacterium infects the root nodules of leguminous plants and fixes atmospheric nitrogen into organic forms. *Azospirillum* and *Azotobacter* are free living bacteria that fix atmospheric nitrogen and enrich the nitrogen content of soil.

(iii) A symbiotic association between a fungus and the roots of the plants is called **mycorrhiza**. The fungal symbiont in these associations absorbs the phosphorus from soil and transfers to the plant. Plants having such association show other benefits such as resistance to root-borne pathogens, tolerance to salinity, drought, enhances plant growth and developments. For example, genus *Glomus* form mycorrhiza.

(iv) **Cyanobacteria** (or) blue green algae (BGA) are prokaryotic free-living organisms which can fix nitrogen. *Oscillatoria*, *Nostoc*, *Anabaena*, *Tolypothrix* are well known nitrogen fixing cyanobacteria. In water logged paddy fields **Cyanobacteria** multiply and fix molecular nitrogen. Cyanobacteria secrete growth promoting substances like indole-3-acetic acid, indole-3-butyric acid, naphthalene acetic acid, amino acids, proteins, vitamins which promotes plant growth and production.

(v) Biofertilisers are commonly used in organic farming methods.

(vi) This process involves the use of biological materials, avoiding synthetic substances to maintain soil fertility and ecological balance thereby minimizing pollution and wastage.



**17. Write short notes on the following.**

- a) **Brewer's yeast**    b) *Ideonella sakaiensis*  
 c) **Microbial fuel cells.**

**Ans. (a) Brewer's yeast:**

(i) *Saccharomyces cerevisiae* commonly called brewer's yeast is used for fermenting malted cereals and fruit juices to produce various alcoholic beverages. Wine and beer are produced without distillation, whereas whisky, brandy and rum are obtained by fermentation and distillation.

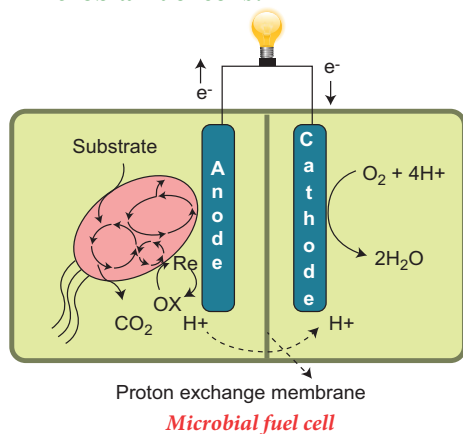
(ii) **Oenology** is the science and study of wine and wine making. Wine is made from the fermentation of grape juice. Grape juice is fermented by various strains of *Saccharomyces cerevisiae* into alcohol.

(iii) **Beer** is produced from germinated barley malt grain by *Saccharomyces cerevisiae*. Rum is made from fermented sugarcane or molasses or directly from sugarcane juice by *Saccharomyces cerevisiae*. **Whisky** is made from fermented grain mash by *Saccharomyces cerevisiae*.

(iv) *Saccharomyces cerevisiae* is the major producer of ethanol ( $C_2H_5OH$ ). It is used for industrial, laboratory and fuel purposes.

**(b) *Ideonella sakaiensis*:**

(i) *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. This is an example of Microorganisms playing a role in Bioremediation.

**(c) Microbial fuel cells:**

(i) A microbial fuel cell is a bio-electrochemical system that drives an electric current by using bacteria and mimicking bacterial interaction found in nature.

(ii) Microbial fuel cells work by allowing bacteria to oxidize and reduce organic molecules.

(iii) Bacterial respiration is basically one big redox reaction in which electrons are being moved around.

(iv) 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.

**18. List the advantages of biogas plants in rural areas.**

**Ans. (i)** Biogas can be produced from raw materials such as agricultural wastes, manures, municipal waste, plant material, sewage, food waste etc., available naturally in rural areas.

(ii) The biogas plants convert the organic materials into gas and organic fertilizer by anaerobic decomposition, by microbes.

(iii) The biogas is devoid of smell and burns with a blue flame without smoke.

(iv) Biogas is used for cooking and lighting

(v) The slurry drained out of the biogas plant serves as a organic fertilizer which is free, ecofriendly and thus no waste is generated from the process.

(vi) The cattle dung is a primary raw material for Gobar gas production which is easily available in rural areas.

(vii) Biogas plant technology is supported by Government agencies. Further the set up does not require a lot of space. There are no side effects and the whole process is eco friendly and easily manageable in rural areas.

**19. When does antibiotic resistance develop?**

**Ans. (i)** Antibiotic resistance occurs when bacteria develop the ability to defeat the drug designed to kill or inhibit their growth.



- (ii) Antibiotic resistance is accelerated by the misuse and over use of antibiotics, as well as poor infection prevention control.
- (iii) Antibiotics should be used only when prescribed by a certified health professional.
- (iv) When the bacteria become resistant, antibiotics cannot fight against them and the bacteria multiply. Narrow spectrum antibiotics are preferred over broad spectrum antibiotics. They effectively and accurately target specific pathogenic organisms and are less likely to cause resistance. "**Superbug**" is a term used to describe strains of bacteria that are resistant to the majority of antibiotics commonly used today.

20. What is the key difference between primary and secondary sewage treatment?

Ans.

S. No.	Primary Treatment	Secondary Treatment
i.	It involves the physical removal of solid, and particulate organic and inorganic materials from the sewage through filtration and sedimentation. The supernatant is the effluent which is taken for secondary treatment.	The process takes place in large aeration tanks with vigorous growth of microbes. These organisms break down the organic matter and reduces the Biological oxygen demand. It is further passed into a setting tank where are bacterial 'flocs' sediment to form the activated sludge. A small part of the sludge serves as inoculum for aeration tank and is pumped back. The remaining part of the sludge is pumped into large tanks called anaerobic sludge digesters where the anaerobic bacteria digest the sludge. Biogas is produced which is used as a source of energy and organic waste has been completely digested.
ii.	It is a total physical process.	It is a biological process.
iii.	The solid waste is mainly removed.	The dissolved organic waste is removed by this process by aerobic and anaerobic means.
iv.	It is a simpler process	It is more time consuming and a major part of sewage treatment.
v.	No by products are produced	Biogas production occurs.

## Additional Questions

CHOOSE THE CORRECT ANSWER || 1 Mark ||

### I. CHOOSE THE CORRECT OPTIONS FOR THE BELOW QUESTIONS

1. The enzyme \_\_\_\_\_ is got from *Aspergillus*.  
 (a) Rennet (b) Zymase  
 (c) Amylase (d) Lipase  
**[Ans. (c) Amylase]**
2. World Biofuel day is observed on \_\_\_\_\_.  
 (a) 10<sup>th</sup> September (b) 22<sup>nd</sup> April  
 (c) 10<sup>th</sup> August (d) 17<sup>th</sup> October  
**[Ans. (c) 10th August]**

3. *Lactobacillus* helps to produce \_\_\_\_\_.  
 (a) Citric acid (b) Milk  
 (c) Acetic acid (d) Butyric acid  
**[Ans. (a) Citric acid]**
4. *Aspergillus niger* helps to produce \_\_\_\_\_.  
 (a) Citric acid (b) Acetic acid  
 (c) Turmeric acid (d) Lactic acid  
**[Ans. (d) Lactic acid]**
5. Genetically engineered \_\_\_\_\_ are used as clot buster in cardiac related issues.  
 (a) Staphylococcus (b) Yeast  
 (c) Penicillium (d) Streptococci  
**[Ans. (d) Streptococci]**



3. Enzyme needed for cheese production \_\_\_\_\_  
[Ans. Rennet]
4. Substance which gives flavour to yoghurt \_\_\_\_\_ Acetaldehyde. [Ans. Acetaldehyde]
5. Process involved in milk getting converted to curd \_\_\_\_\_  
[Ans. coagulation of milk protein]
6. Dough for idli and dosa is fermented by this organism \_\_\_\_\_  
[Ans. *Leuconostoc mesenteroides*]
7. Organism involved in bread making \_\_\_\_\_  
[Ans. *Saccharomyces cerevisiae*]
8. Example of single cell protein \_\_\_\_\_  
[Ans. spirulina]
9. Meaning of the word antibiotic \_\_\_\_\_  
[Ans. against life]
10. Who used the term antibiotic for the first time?  
[Ans. Selman Waksman]
11. Name the antibiotic discovered by Waksman \_\_\_\_\_.  
[Ans. Streptomycin]
12. Who discovered penicillin \_\_\_\_\_  
[Ans. Alexander Flemming]
13. Queen of drugs \_\_\_\_\_ [Ans. penicillin]
14. Antibiotic used for Tuberculosis treatment \_\_\_\_\_  
[Ans. streptomycin]
15. The name used for strains of bacteria with resistance to majority of antibiotics \_\_\_\_\_  
[Ans. superbugs]
16. Science dealing with process as applicable to fermentation \_\_\_\_\_.  
[Ans. zymology]
17. Scientific name of brewer's yeast \_\_\_\_\_  
[Ans. *Saccharomyces cerevisiae*]
18. Name given to inhibiting effect of oxygen on fermentation process \_\_\_\_\_  
[Ans. Pasteur effect]
19. Raw material needed for beer production \_\_\_\_\_ germinated barley.  
[Ans. germinated barley]
20. The other name of industrial \_\_\_\_\_ alcohol  
[Ans. ethanol]
21. Commonly used biofuels \_\_\_\_\_  
[Ans. ethanol and biodiesel]
22. Most suitable oilseed identified for biodiesel production \_\_\_\_\_.  
[Ans. *Jatropha curcas*]
23. A bio-electrochemical system \_\_\_\_\_  
[Ans. microbial fuel cell]
24. Major component of bio gas \_\_\_\_\_  
[Ans. methane]
25. A bacterium used as biopesticide \_\_\_\_\_  
[Ans. *Bacillus thuringiensis*]
26. Toxin coded by cry genes \_\_\_\_\_  
[Ans. Delta endotoxin]
27. Fungus which produces bioherbicide \_\_\_\_\_  
[Ans. *Phytophthora palmivora*]
28. Viruses used as Biocontrol agents \_\_\_\_\_  
[Ans. Buculoviruses]
29. Free living bacteria used as biofertilizer \_\_\_\_\_  
[Ans. *Azospirillum/ Azotobacter*]
30. Symbiotic bacterium used as bio fertilizer \_\_\_\_\_  
[Ans. *Rhizobium*]
31. Cyanobacteria /Blue green algae used as bio fertilizer \_\_\_\_\_.  
[Ans. *Nostoc / Anabaena*]
32. Process of using microbes to reduce or degrade pollutants \_\_\_\_\_  
[Ans. Bioremediation]
33. Genetically engineered bacterium which can digest hydrocarbons in oil spills \_\_\_\_\_  
Pseudomonas putida  
[Ans. *Pseudomonas putida*]
34. An anaerobic fungus used in bioremediation \_\_\_\_\_  
[Ans. *phanerochaete chrysosporium*]
35. An endophytic fungus which can break down polyurethane \_\_\_\_\_  
[Ans. *pestalotiopsis microspora*]

## VERY SHORT ANSWERS

2 Marks

1. What are probiotics? Give examples

**Ans.** Probiotics are live microorganisms intended to provide health benefits when consumed, generally by improving or restoring the gut flora. **Eg.** Lactic acid bacteria in milk.





### 19. What is "clot buster"?

**Ans.** Streptokinase produced by the bacterium *Streptococcus* and genetically engineered *Streptococci* are used as "clot buster" for removing clots from the blood vessels of patients who have undergone myocardial infarction.

### 20. What is rennet?

**Ans.** It is an enzyme and can be used to separate milk into solid curds for cheese making.

### 21. What are the aims of National River conservation plan (NRCP)?

**Ans.** The aims of NRCP are:

- (i) To capture the raw sewage flowing into the river through open drains and divert them for treatment.
- (ii) Setting up sewage treatment plants for treating the diverted sewage.
- (iii) Construction of low cost sanitation toilets to prevent open defecation on river banks.

### 22. What are methanogens?

**Ans.** Methane producing bacteria are called methanogens **Eg.** *Methanobacterium*. It is present in anaerobic sludge and rumen of cattle. It plays a role in Gobar gas production.

### 23. Name the stages of anaerobic digestion in a Biogas plant.

**Ans.** (i) solubilisation, (ii) acidogenesis and (iii) methanogenesis.

### 24. What is biocontrol?

**Ans.** Biocontrol is a method of controlling pest by use of microbes such as fungi, bacteria, viruses or by naturally occurring substances derived from plants and animals. **Eg.** Lady bird beetle is used to control aphids.

### 25. What are biopesticides?

**Ans.** The use of a microbes or other biological agents to control a specific pest is called a biopesticide. Biopesticides are used to control insect pests. The lady bird beetle and dragonflies are useful to control aphids and mosquito larvae respectively.

### 26. What are cryogenes?

**Ans.** They are genes present in the bacterium *Bacillus thuringiensis* and code for crystal proteins called

Delta-endotoxin which are toxic to certain Insect pests. The Bacteria is used to produce genetically engineered insect resistant plants.

### 27. Give example of a mycoherbicide.

**Ans.** The first bioherbicide developed in 1981 was a **Mycoherbicide** derived from the fungus *Phytophthora palmivora*. It controls the growth of strangler vine in citrus crops.

### 28. What are mycorrhiza?

**Ans.** A symbiotic association between a fungus and the roots of the plants is called mycorrhiza. The fungal symbiont in these associations absorbs the phosphorus from soil and transfers to the plant. Plants having such association show other benefits such as resistance to root-borne pathogens, tolerance to salinity, drought, enhances plant growth and developments. For example, many members of the genus *Glomus* form mycorrhiza.

### 29. What is the significance of cyanobacteria as a biofertilizer?

**Ans.** **Cyanobacteria** (or) blue green algae (BGA) are prokaryotic free-living organisms which can fix nitrogen. **Eg.** *Oscillatoria*, *Nostoc*. In water logged paddy fields **Cyanobacteria** multiply and fix molecular nitrogen. Cyanobacteria secrete growth promoting substances like indole-3-acetic acid, indole-3-butyric acid, naphthalene acetic acid, amino acids, proteins, vitamins which promotes plant growth and production.

### 30. Define bioremediation.

**Ans.** 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.

### 31. Why is curd more nutritious than milk?

**Ans.** Curd is more nutritious than milk Since it contains a number of organic acids and vitamins.

## SHORT ANSWERS

3 Marks

### 1. Mention a therapeutic use of Yeast.

**Ans.** Recombinant human insulin has been produced using yeast (*Saccharomyces cerevisiae*) which is used in diabetes treatment.

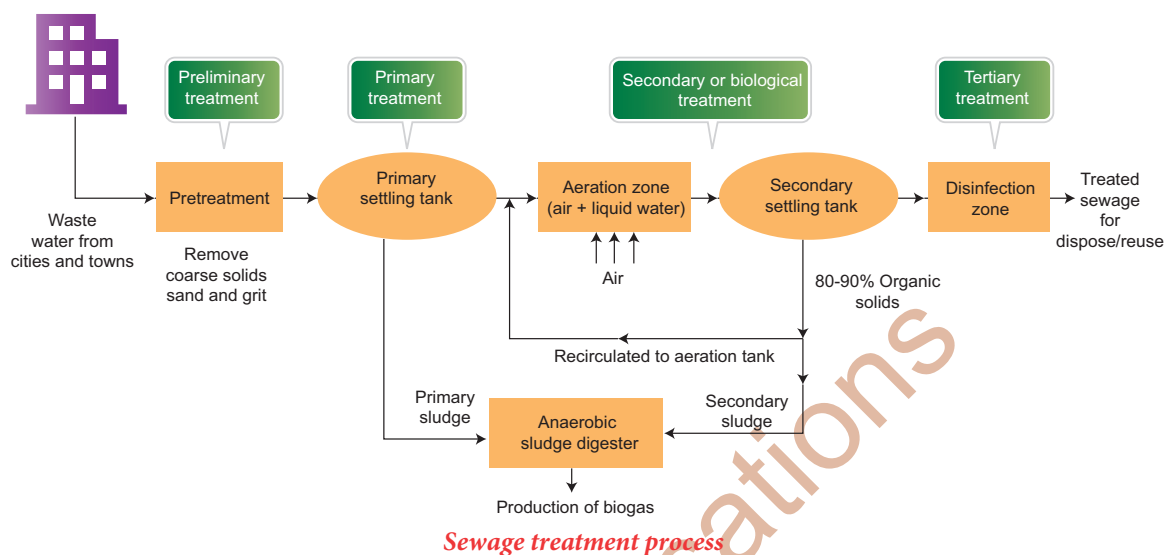


## LONG ANSWERS

5 Marks

## 1. Explain the process of sewage treatment.

**Ans.** Sewage treatment is usually performed in the following three stages:

(i) **Primary treatment:**

- (a) Primary treatment involves the physical removal of solid and particulate organic and inorganic materials from the sewage through filtration and sedimentation.
- (b) Floating debris is removed by sequential filtration. Then the grit (soil and small pebbles) are removed by sedimentation.
- (c) All solids that settle form the primary sludge and the supernatant forms the effluent, and is taken for secondary treatment.

(ii) **Secondary treatment or biological treatment:**

- (a) The primary effluent is passed into large aeration tanks where it is constantly agitated mechanically and air is pumped into it.
- (b) This allows vigorous growth of useful aerobic microbes into floc (masses of bacteria associated with fungal filaments to form mesh like structures). Which consume the organic matter in the effluent.
- (c) This significantly reduces the BOD (Biochemical oxygen demand or Biological oxygen demand). BOD refers to the amount of the oxygen that would be consumed, if all the organic matter in one litre of water were oxidized by bacteria. The sewage water is treated till the BOD is reduced. The greater the BOD of the waste water more is its polluting potential.
- (d) Once the BOD of sewage water is reduced significantly, the effluent is then passed into a settling tank where the bacterial "flocs" are allowed to sediment. Which is called activated sludge. A small part of activated sludge is pumped back into the aeration tank to serve as the inoculum.
- (e) The remaining major part of the sludge is pumped into large tanks called anaerobic sludge digesters. Here, the bacteria which grow anaerobically, digest the bacteria and the fungi in the sludge. During digestion, bacteria produce a mixture of gases such as methane, hydrogen sulphide and  $\text{CO}_2$ . Which form biogas and can be used as a source of energy.



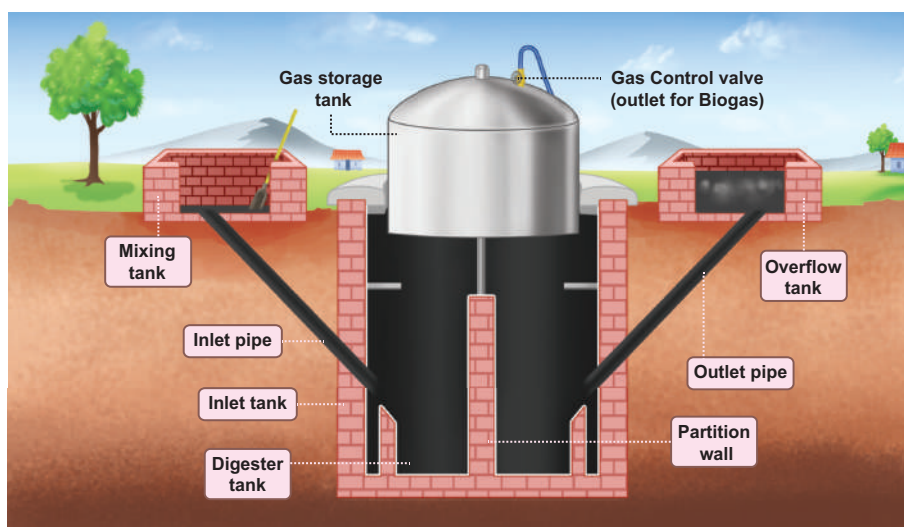


### (iii) Tertiary treatment

- (a) Tertiary treatment is the final process that improves the quality of the waste water before it is reused, recycled or released into natural water bodies.
- (b) This treatment removes the remaining inorganic compounds and substances, such as nitrogen and phosphorus.
- (c) UV is an ideal disinfectant for wastewater since it does not alter the water quality – except for inactivating microorganisms. UV is a chemical-free process that can completely replace the existing chlorination system and also inactivates chlorine-resistant microorganisms like *Cryptosporidium* and *Giardia*.

## 2. Explain the working of a biogas plant.

Ans.



**Biogas unit**

- (i) Biogas is a mixture of different gases produced by the breakdown of organic matter in the absence of oxygen. Biogas can be produced from raw materials such as agricultural wastes, manure, municipal wastes, plant material, sewage, food waste, etc.,
- (ii) The excreta of cattle called dung is commonly called “**Gobar**”. Gobar gas is generated by the anaerobic decomposition of cattle dung. It consists of methane,  $\text{CO}_2$  with some hydrogen, nitrogen and other gases in trace amounts.
- (iii) In a biogas plant, anaerobic digestion is carried out in an air tight cylindrical tank known as digester (Fig.). It is made up of concrete bricks and cement or steel. Bio-wastes are collected and slurry of dung is fed into this digester. It has a side opening into which organic materials for digestion are incorporated for microbial activity. Anaerobic digestion is accomplished in three stages: solubilisation, acidogenesis and methanogenesis. The outlet is connected to a pipe to supply biogas. The slurry is drained through another outlet and is used as fertilizer. Biogas is used for cooking and lighting.