

# SEWAGE

Facilitator:

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# Specific Learning Objectives

- At the end of session, the learner shall be able to know about:
  - Sewage and its importance.
  - Modern sewage treatment.
  - Oxidation pond.

# Introduction

- **Sewage** is a waste water from a community, containing solid and liquid excreta, derived from houses, streets, factories and industries.
- ‘Dry weather flow’ : average amount of sewage which flows through the sewerage system in 24 hours

# Health aspects

- Creation of nuisance, unsightliness and unpleasant odours.
- Breeding of flies.
- Pollution of soil and water.
- Contamination of food.
- Increase in the incidence of diseases especially enteric diseases.

# Composition of Sewage

- Sewage contains
  - 99.9 percent water and
  - 0.1 percent solids (partly organic and partly inorganic).
- The strength of the sewage may be expressed in terms of:
  - Biochemical oxygen demand,
  - Chemical oxygen demand and
  - Suspended solids.

# Biochemical Oxygen Demand (BOD)

- The amount of oxygen absorbed by a sample of sewage during a specified period (generally 5 days) at a specified temperature (usually 20°C) for aerobic digestion.
- The most important test carried out on sewage.
- Sewage with a BOD value of:
  - 300 mg/l (300 ppm) or above is termed as strong
  - 100 mg/l (100 ppm) or below is termed as weak.

# Chemical Oxygen Demand (COD)

- The amount of oxygen required to oxidize the organic matter by use of dichromate in an acid solution and to convert it to carbon dioxide and water.
- The value of COD is always higher than the BOD
  - many organic substances can be oxidized chemically but not biologically.
- COD is used to test the strength of wastewater that is either non biodegradable or contains compounds that inhibit activities of microorganisms.
  - Commonly, BOD is used to test the strength of untreated and treated municipal and biodegradable industrial waste waters.

# Suspended solids

- If the suspended solids are 500 mg/l or more, it is termed strong.
- If the suspended solids are 100 mg/l or less, it is termed weak.



# Sewage Purification

- The aim of sewage treatment is:
  - to convert an offensive and potentially dangerous mixture into an inoffensive effluent and sludge
  - which can be disposed off safely and without causing nuisance into river, sea or on land.
- The conversion of complex organic matter in the sewage to simpler substances takes place by two processes:
  - aerobic and
  - anaerobic.

- The **aerobic process**:

- requires a continuous supply of free dissolved oxygen for the aerobic microorganisms to break the organic matter into simpler substances such as carbon dioxide, ammonia, water, nitrite, nitrate, sulphate etc.

- The **anaerobic process**

- more effective where the sewage is highly concentrated and contains plenty of solids.
- Hence, this method is usually gainfully utilized for digestion of sludge in sewage works.
- The end products of anaerobic decomposition are methane, ammonia, carbon dioxide, hydrogen etc.

# Modern Sewage Treatment

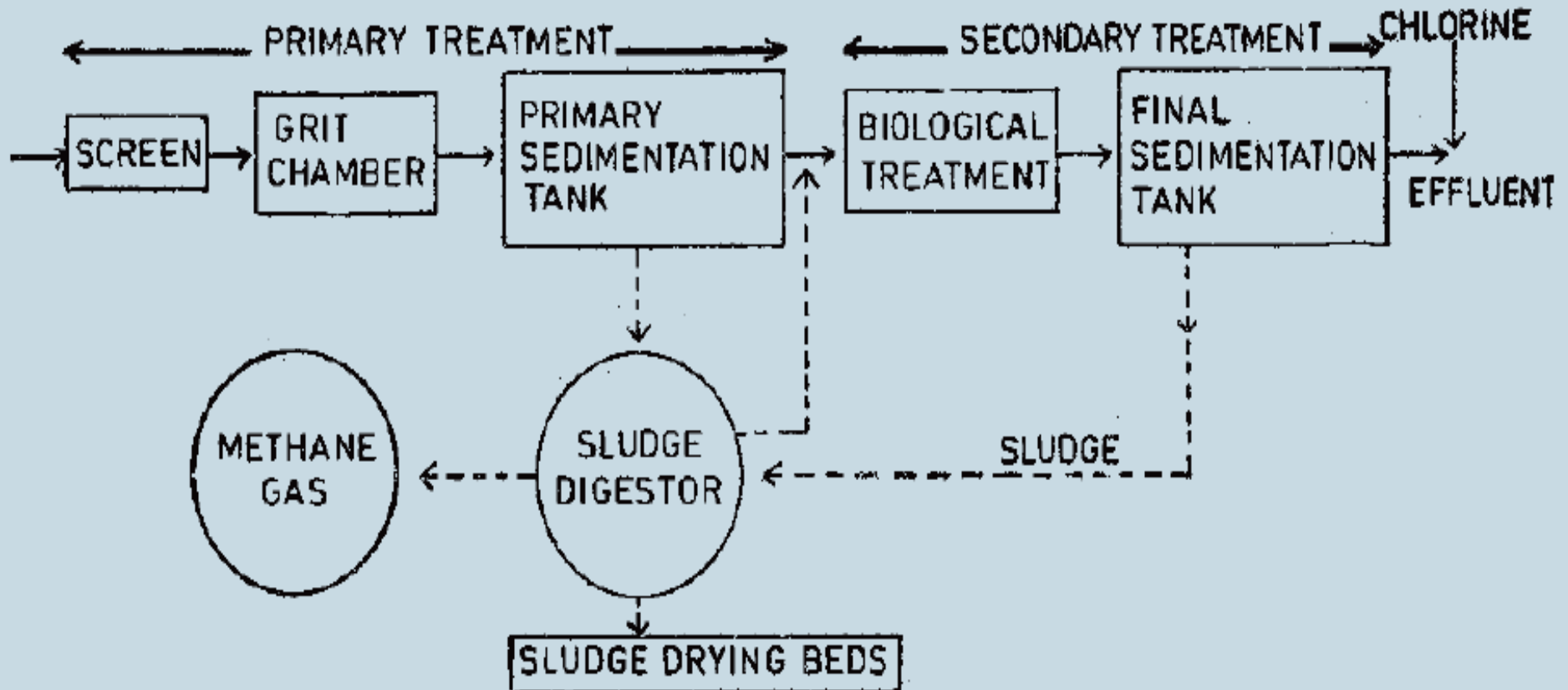
- The sewage treatment undergoes through many stages.
  - Primary, secondary and tertiary treatment stages.
- **Primary treatment :**
  - The first stage is the physical treatment to remove solids (from the liquid).
- **Secondary treatment :**
  - The primary treatment is followed by biological treatment brought about by aerobic and anaerobic bacteria.

- **Tertiary treatment :**

- Treatment rendered in addition to the conventional secondary treatment for improving further the quality of effluent is termed 'tertiary treatment' or advanced waste treatment process.

- Chemical treatment by the addition of coagulants may be used to assist sedimentation and sludge treatment.

# Flow diagram of a Modern Sewage Treatment Plant



# Primary Treatment

## **(a) Screening :**

- It is the first step in the sewage treatment for removing the larger solids.
- The raw sewage is passed through bar-screens with openings of 8 to 10 cm between the bars placed across the inflow channels.
- The screenings can be manually raked from the screens and buried.

## **(b) Grit Removal :**

- Combined sewerage systems carry grit from roads or other debris from general sullage and fine granular inorganic material.
- This material which otherwise causes heavy wear in pumps and tends to settle out and cause difficulty in later treatment processes must be removed in grit chambers and channels.
- The sewage is allowed to flow in a channel at a controlled velocity of about 30 cm/s, which is slow enough for the heavy non-organic solids to settle down but fast enough to carry the lighter organic solids forward.
- The grit is removed periodically, washed free of organic matter and dumped on waste land for reclamation or to fill excavations and quarries without causing nuisance.

### **(c) Primary Sedimentation :**

- It is the third step to remove as much of the organic solids as possible from the liquid sewage in sedimentation tanks.
- The sewage is retained in sedimentation tanks for 4 to 12 hours.
- Slow moving paddles to encourage flocculation of solids and increased settling velocities may be incorporated.
- The process removes 50-60 percent of the suspended solids and about 40 percent of the BOD of the sewage.
- The settled sludge is removed by mechanical either continuously or at frequent intervals to prevent it from becoming septic.
- The sewage is then treated biologically.



# Secondary Treatment

- The secondary or biological treatment of sewage essentially involves the oxidation of suspended and dissolved organic matter by aerobic bacteria.
  - Carbonaceous matter is converted to carbon dioxide and water.
  - Nitrogenous material is converted to ammonia, nitrites, and nitrates.
- Fungi, algae, ciliate protozoa, insects and worms supplement the bacterial digestion.
- The main processes employed for biological treatment are as under:

## **(a) Percolating or Trickling Filters :**

- The effluent from the primary sedimentation tanks is brought into the percolating filter through a central pipe.
- The effluent is sprinkled uniformly on the surface of the bed by a revolving device.
- The rotating pipes sprinkle a thin layer of effluent on the surface of the filter.
- This effluent then trickles down the filter.
- The percolating filter consists of beds 1.5 to 2 m in depth, made of stone, cinders, slag, brick pieces or other impervious material generally from 3 to 8 cm in size.
- A slimy 'zooglear' film of aerobic bacteria and other organisms develops on the surface of the stones.

- In trickling downward through the bed, the sewage donates its organic content to the vital zoogeleal film for its nutrition and in return receives soluble organic salts produced by oxidation.
- Access of air through the filter is essential for the zoogeleal fauna to oxidize the organic matter.
- A competent percolating filter plant reduces the BOD of the raw sewage by 85 to 95 percent.
- Percolation is followed by final settling into secondary sedimentation or humus tanks to remove the particles of the zoogeleal matter and innocuous debris

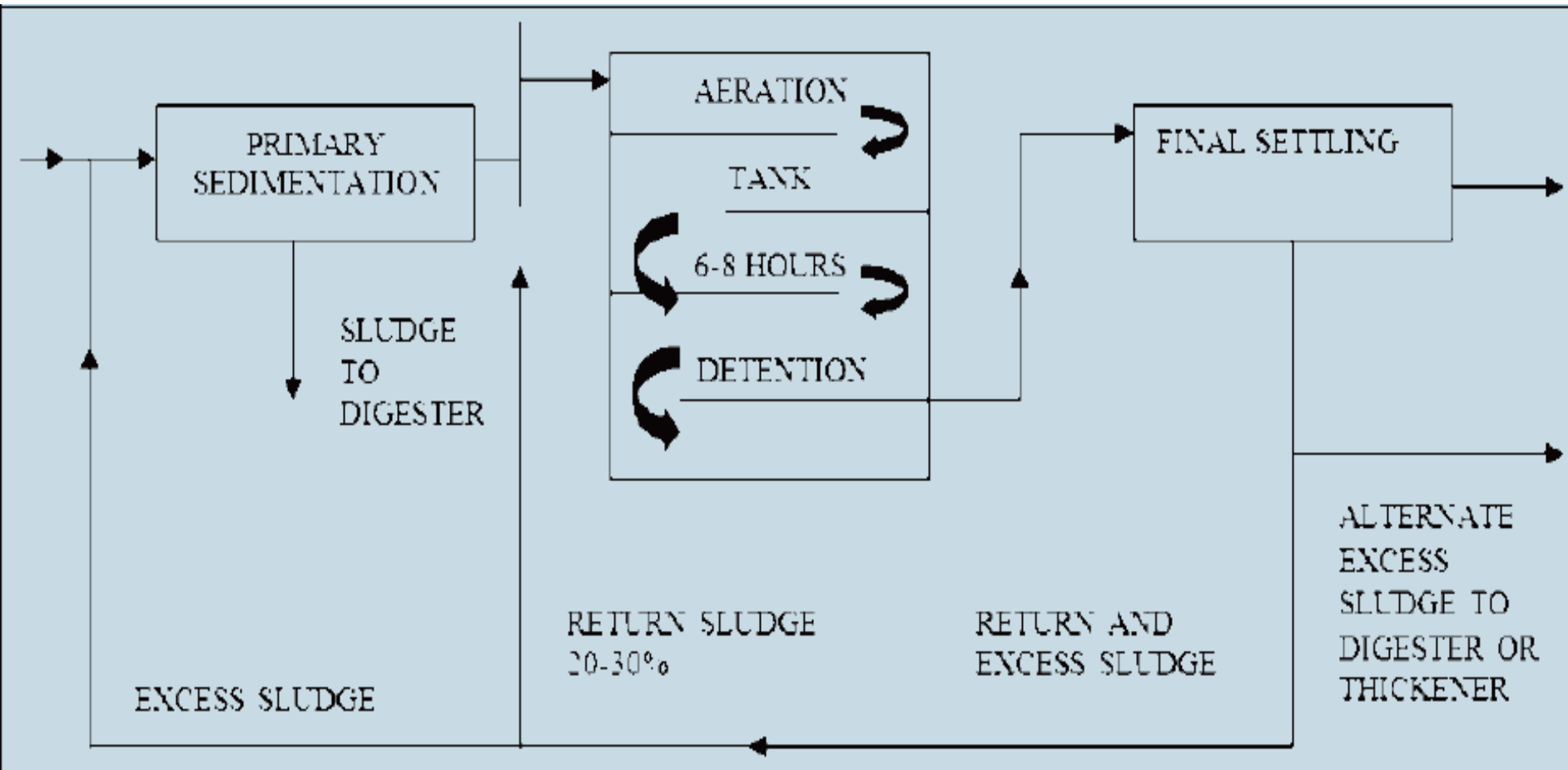
## **b) Activated Sludge Process :**

- Activated sludge process is an alternative to the percolating or trickling filter method.
- **Principle :**
- The principle is to add sufficient quantity of sludge obtained from the final settlement tank (called 'activated sludge' or return sludge) to sewage that is to be treated (the effluent from the primary sedimentation tank).
- Activated sludge contains active aerobic bacteria vital for decomposition of sewage.
- This mixture (called the 'mixed liquor') is mechanically aerated in an aeration tank to facilitate bacterial decomposition.
- In the presence of ample oxygen the aerobic bacteria utilize the raw sewage and convert it into stabilized, odourless compounds.

- **Process :**
- The process requires air supply and thorough mixing which brings about an intimate contact of the organic solids with oxygen and aerobic bacteria.
- First the effluent from the primary sedimentation tank is mixed for an hour or two with the activated sludge returned from the final sedimentation tank to form the 'mixed liquor'.
- Oxygenation of this mixed liquor is carried out for 4 to 6 hours by one or more of these methods:
  - (i) Diffused Air System : Compressed air is blown through porous plates, domes or pipes fixed at the bottom of aeration channels.
  - (ii) Simplex Surface Aeration : Motor driven propellers are used to mix and break up the sewage into fine spray, bring it in contact with air and induce circulation in hopper bottomed chambers.

- **The plant :**
- The plant consists of a long channel or a series of chambers through which the sewage passes while aeration process proceeds.
- The aeration is followed by settling in tanks.
- The sludge is removed and the clear purified final effluent flows out for safe discharge.
- Most of this activated sludge is returned to be mixed with the sewage from the primary settling tanks.
- Thus there is a continuous circulation of activated sludge within the system.

# Activated Sludge Process



- The activated sludge method is a more efficient than trickling filter method.
- Activated sludge plant occupies one tenth of the space occupied by a trickling filter and is also faster.
- This however is costlier to install and run.
- It is best suited for large towns.



- Following secondary treatment, there are two types of substances that are left, viz., the semisolid sludge and the watery effluent.
- These two products are dealt in the following ways :

# Sludge Treatment

- The sludge from primary or final sedimentation tanks contains 90 to 95 percent water.
- This high water content needs to be reduced for converting the sludge to a solid condition in which it may be used or disposed off harmlessly.
- Anaerobic digestion is the most preferred sludge treatment method.

- The sludge is pumped daily into enclosed digestion tanks.
- With anaerobic fermentation a gas comprising of about 70 percent methane and 30 percent carbon dioxide is produced.
- This sludge gas is a valuable fuel.
  - It can be used to generate the entire power needed for running the activated sludge plant.
  - Power is used for pumping, air compression, electricity generation, and heating on the plant.
  - The surplus gas may be compressed and used as vehicle fuel or cooking.

- Sewage sludge contains useful nitrogen and phosphorus, and although rather deficient in potassium, it forms a moderately good fertilizer.
- Undigested primary sludge and undigested activated sludge are easier to apply to land, and their humus content improves the soil.
- In suitable circumstances sewage sludge may be composted with municipal refuse.
  - Where sludge cannot be used either as a fertilizer or for composting, or, in a few cases, for recovery of by-products, it is usually tipped for land reclamation, dumped at sea, or incinerated.

# Disposal of Effluent

## a) Disposal on Land :

- If suitable land is available the effluent can be used gainfully for irrigation purposes.
  - Over the past few decades, there has been a considerable revival of interest in the use of wastewater for crop irrigation in arid and semiarid regions owing to the scarcity of alternative water supply and the need to increase food production.
- Reuse of treated effluent for the irrigation of crops and urban 'green spaces' (such as parks and golf courses) has expanded significantly in many countries.

- **Risks in sewage farming :**
- Enteric viruses appear to be particularly persistent in sewage, under natural conditions.
- Sewage farming or spread of treated effluent on farms is still used in many countries, particularly those having low rainfall and high temperatures.
- Enteric viruses have been found in raw sewage in concentrations of 1-10 per ml in various countries.
- Thus the risk of transmission of infections through sewage farming remains alive.
- The risk increases if the sewage had not been treated adequately, prior to its discharge for sewage farming.

## **(b) Disposal by Dilution :**

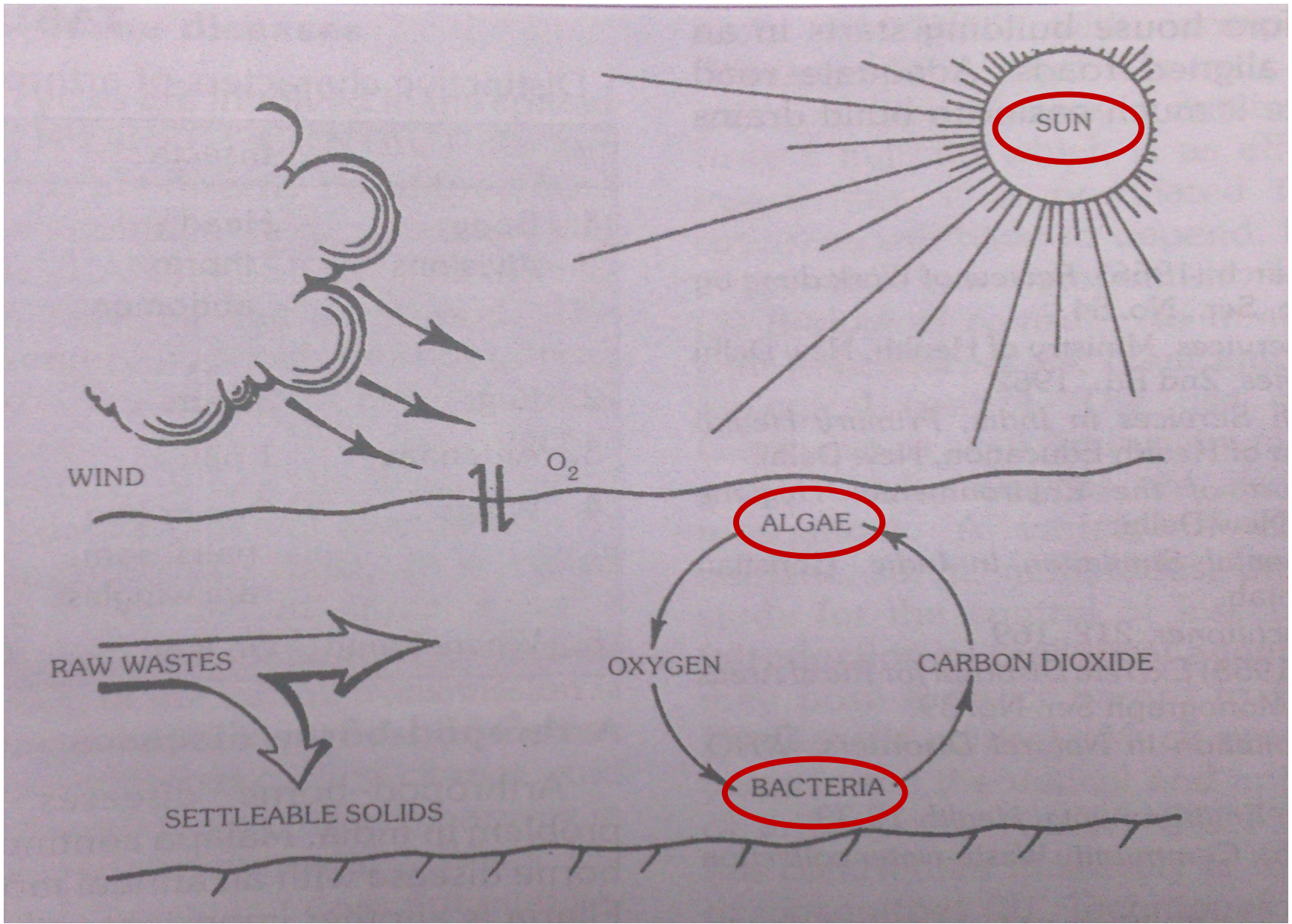
- Discharging the effluent into bodies of water such as rivers, streams, lakes and sea for the purpose of dilution and oxidation of the impurities by the dissolved oxygen in water is termed as “disposal by dilution”.
- The BOD content of the effluent and diluting capacity of the bodies of water are the important considerations before discharging effluent into the water body.
- Since river water is used for drinking, effluent must be adequately treated before discharging.
- Lately industrial waste and chemicals are being dumped into the sewage, which poses a threat to people's health, when the effluent is eventually discharged into rivers.
- The aquatic flora and fauna is also adversely affected.

# Oxidation pond

- “Redox Pond, Sewage Lagoon and Waste Stabilization Pond”.
- Probably the cheapest method of satisfactory sewage disposal.
- It is an open shallow pool up to 5 feet deep with an inlet and outlet.
- The presence of **algae**, **bacteria** decomposing organic matter and **sunlight** are mandatory for the functioning of oxidation pond.



# Oxidation pond



- Bacteria oxidize sewage to carbon dioxide, ammonia and water.
- The algae, with the help of sunlight utilize carbon dioxide, water and other organic substances for its growth.
- Algae releases oxygen during photosynthesis, which is used by bacteria.
- So the pond works as an aerobic system during the sunlight hours, and anaerobically during the dark (night) hours, especially in the lower layers.
- The effluent can be used for farming or can be discharged into rivers after suitable treatment.

- If the pond runs well, it is an accepted method for sewage disposal in small communities.
- Ponds have the advantage of providing a fairly high degree of treatment at relatively low cost, with minimal requirement of equipment or skilled operators.

# Oxidation Ditch/Aerated Lagoon

- The process used in oxidation ditch or aerated lagoon utilizes mechanical rotors for extended aeration and thus minimizes the requirement of land area.
- The land requirement in this method is barely one tenth of oxidation pond.
- During primary sedimentation itself, a reduction of 30-40% in the number of coliforms is obtained (as against 90% and 95% in other biological treatment processes).
- On stabilization with a 30-day retention, coliforms reduce to 99 - 99.9%.

# Take Home Message

- Effective and hygienic disposal of sewage is a social need as well as health need.
- Modern sewage treatment plant is effective way of sewage disposal.
- Oxidation pond is a method of sewage treatment with various advantages (fairly high degree of treatment at relatively low cost, with minimal requirement of equipment or skilled operators.)