Waste Water Treatment

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Introduction

Sewage treatment or **domestic wastewater treatment**, is the process of removing contaminants from wastewater, both runoff and domestic. It includes physical, chemical and biological processes to remove physical, chemical and biological contaminants. Its objective is to produce a waste stream (or treated effluent) and a solid waste or sludge also suitable for discharge or reuse back into the environment. This material is often inadvertently contaminated with toxic organic and inorganic compounds.

Lay out of Waste Water Treatment Plant

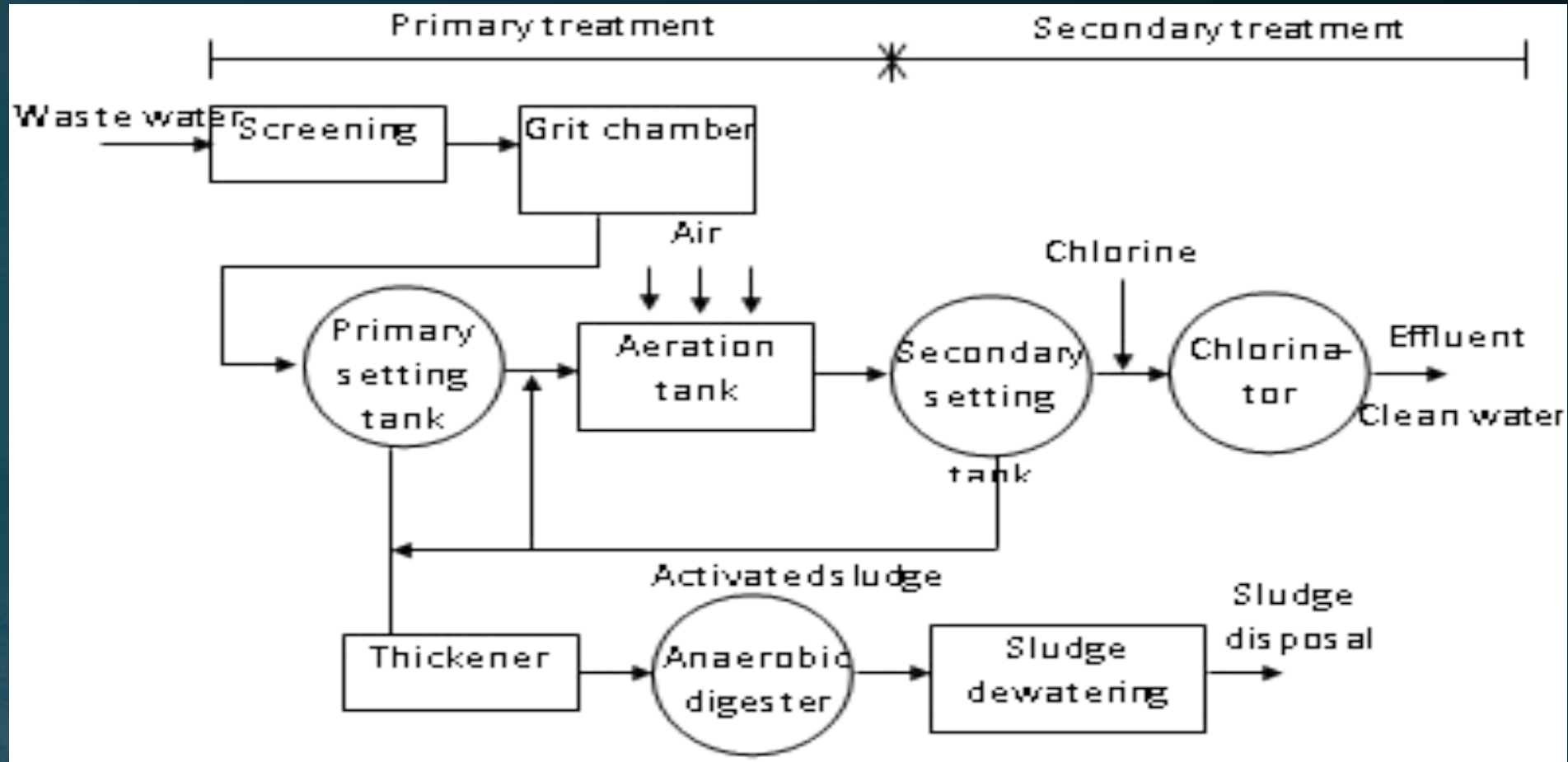

Chart: 4.9 Wastewater treatment plant-providing primary and secondary treatment facility using activated sludge process.

Different stages of Waste Water Treatment

Typically, sewage treatment involves three stages

- *Primary treatment (Physical Treatment)*
- *Secondary treatment (Biological Treatment)*
- *Tertiary treatment (Chemical Treatment)*

Primary Treatment of Waste Water

- The primary treatment of waste water begins with **simple screening**. Screening removes large floating objects such as sticks, old shoes and whatever else that might otherwise damage the other units of treatment plants.
- After screening, the waste water passes into a grit chamber, where it is held for a few minutes. Here sand, grit and other heavy materials are settled down.
- From the grit chamber, the waste water passes to a primary sedimentation tank or settling tank. Here flow of waste water reduces sufficiently to allow most of the suspended solids to settle out by gravity. The solids that settle, called **primary sludge** or **raw sludge**. This sludge can be removed from the bottom of the tank and then disposed for the further treatment (**sludge digestion**).
- Primary treatment of waste water reduces 50% to 60% of the suspended solids and 25% – 30% of the BOD of the waste water. Reduction of suspended solids and BOD by primary treatment reduces the load of secondary treatment of waste water.

Secondary Treatment of Waste Water

- The main purpose of secondary treatment of waste water is to remove more BOD and suspended solids from water. Usually microorganisms are used to remove that BOD and so this is called biological treatment also.
- There are different types biological treatment –
  - 1) Trickling filter
  - 2) Rotating disc Biological Contactor
  - 3) Activated Sludge Process
  - 4) Oxidation Pond.

Trickling Filters

- Trickling filters are used for the biological treatment of domestic sewage and industrial wastes. In the waste water treatment plant, trickling filter is always preceded by primary sedimentation tank so that the settleable solids in the waste water may not clog the filter. Similarly, a final sedimentation tank or secondary sedimentation tank to remove the settleable organic solids, which are produced in the filtration process, always follows trickling filter.

- The trickling filter consists of a tank which is circular or rectangular in shape. The tank is filled up by the crushed rocks, large gravels, broken bricks, ceramics etc. These are called **filtering media**. The under-drainage system is provided in the tricking filter to collect the effluent. The individual rocks of the filtering media are covered by a layer of **biological slime** consisting of **aerobic bacteria**. The waste water can be sprayed on the surface of the trickling filter from a **fixed or moving sprayer**.

- When the waste water is sprayed over the filtering media which is covered by the biological slime, the organic material present in the waste water is absorbed and accumulated by microorganism (mainly aerobic bacteria). These microorganisms partly degrade these organic wastes. **As a result, maximum amount of BOD value is reduced here**. During the process of degradation, the weight and thickness of slime increases and ultimately **slides off** the filtering media and is collected at the bottom of the filter along with the treated water. This sliding process is called **sloughing**. The collected slough from the bottom of the tank is allowed to pass to the next unit i.e. **secondary sedimentation tank**. On the basis of hydraulic and organic loading there are two types of trickling filter, (a) Low rate trickling filter, (b) High rate trickling filter.

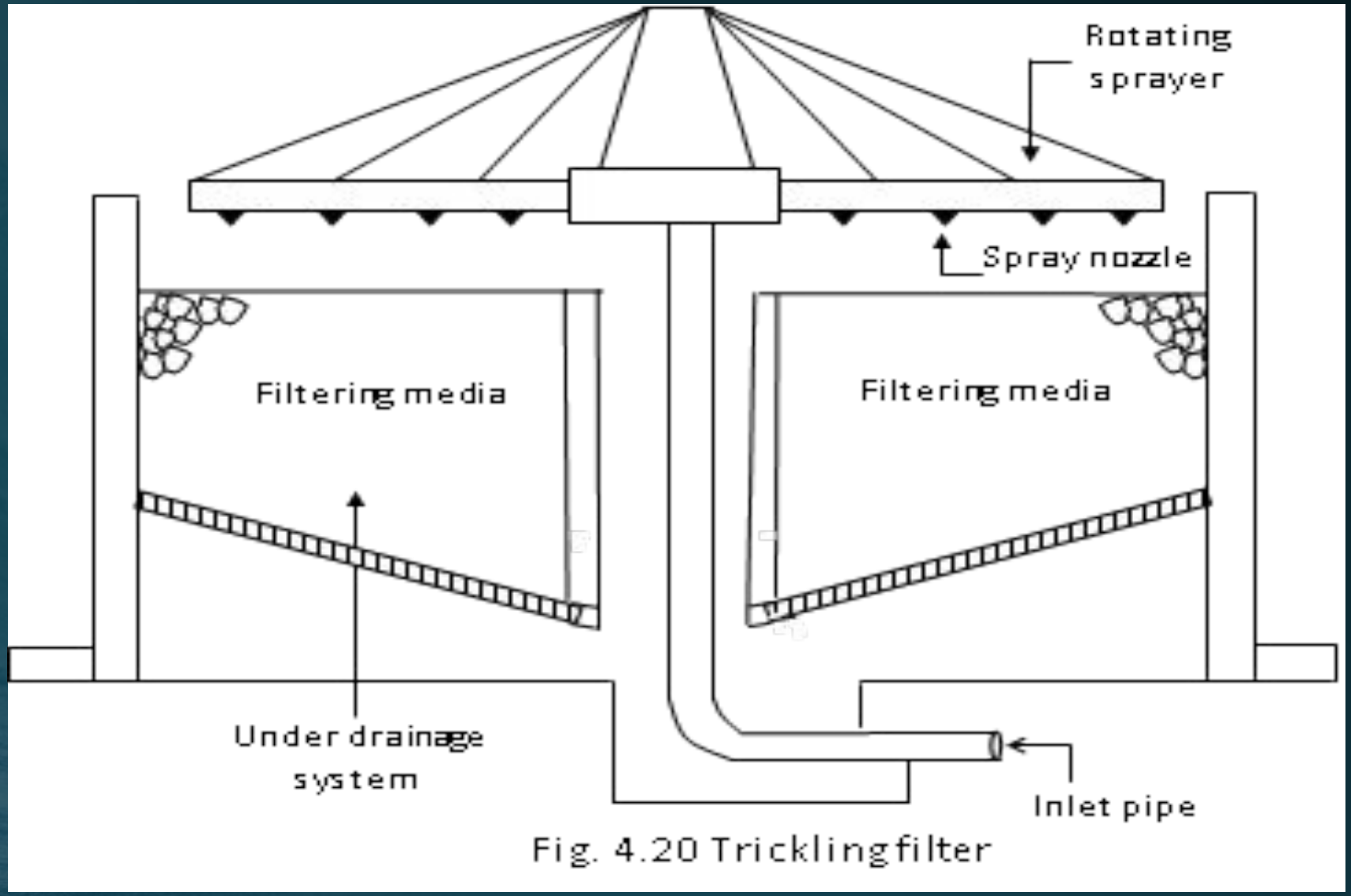

Fig. 4.20 Tricklingfilter

Rotating disc Biological Contactor (RBC)

- Rotating disc Biological Contactor (RBC) is one of the newest methods of biological treatment of wastes. The treatment unit consists of a **cylindrical bottomed horizontal flow tank** on which a partially submerged light weight rotating unit is placed, along the direction of flow. The rotating unit consists of a series of closely spaced biologically inactive discs mounted on the rotating rod or shaft. The microbial film grows and covers the entire available surface of the discs.

- There are two halves of the rotations of the discs. During the first half, the disc should be partially merged inside the waste water of the tank; the remaining part should be in air. The microbial film of the submerged part of the disc is getting food i.e. organic wastes from the waste water during this period. As a result, the concentration of organic wastes reduces which leads to reduction of BOD of the waste water too. During the next half, the portion which was inside the waste water rotates and exposed to the air while the remaining portion which was in air initially now dipped into the waste water. The portion which is now in air, the microbial films of it are getting oxygen from the atmosphere and maintain their aerobic growth. During this rotational process, the thickness of the microbial film increases and ultimately **slide off** the disc and collected at the bottom of the tank. This is called **sloughing** and as it is a continuous process, a constant thickness of microbial film on the disc is maintained.

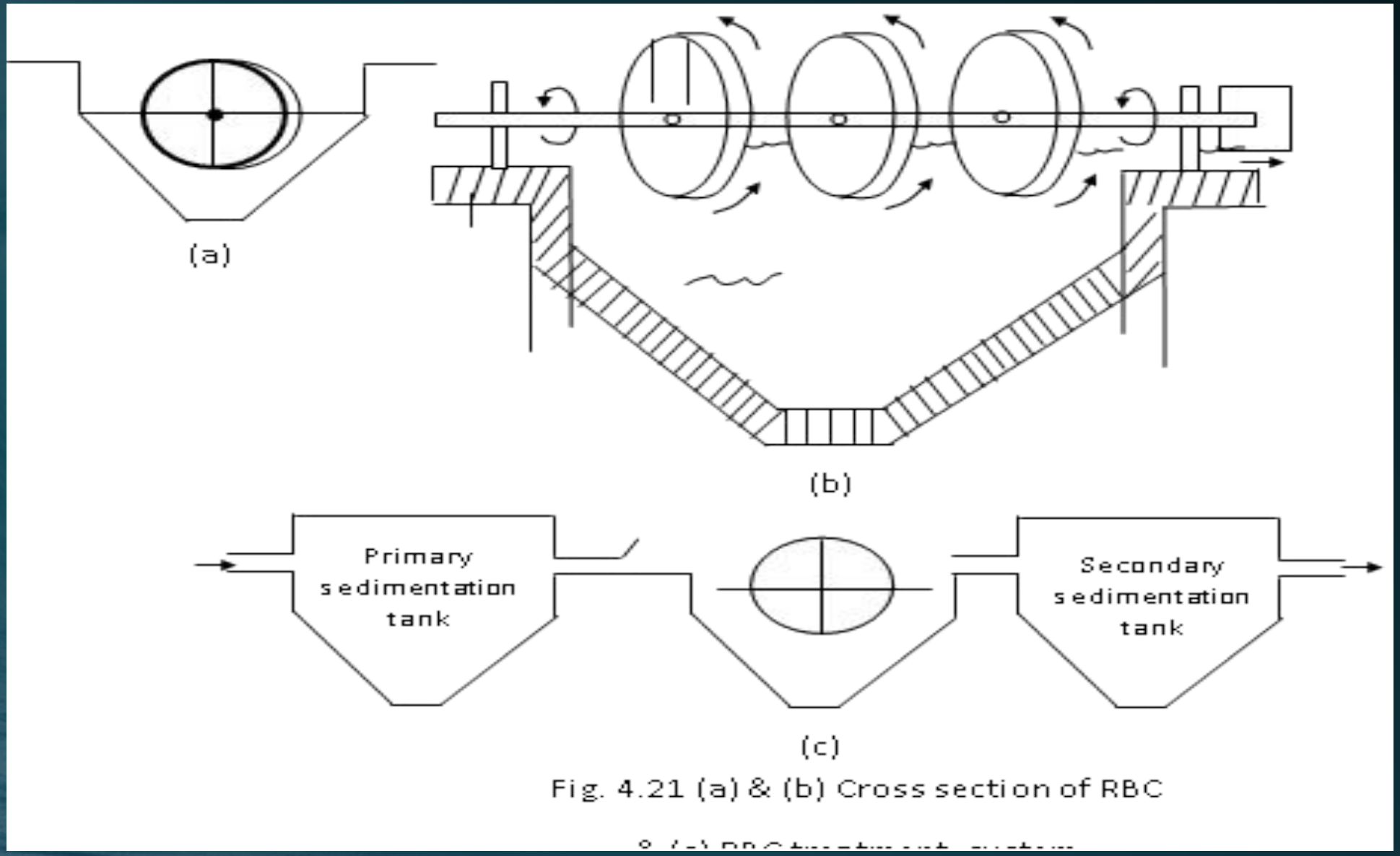

Fig. 4.21 (a) & (b) Cross section of RBC

Activated Sludge Process

- Activated sludge process is the most modern method of secondary waste water treatment. The sludge produce in this method, contains living micro-organism in it and so it is called **activated sludge**. This activated sludge is recycled for the further treatment of the waste water.
- The objective of activated sludge process treatment is to remove the organic waste i.e., BOD from the waste water.
- There are four different types of activated sludge process –

(a) Conventional process

(b) Contact process

(c) Step aeration

(d) Complete mixed process.

The steps are involved in the activated sludge process:

(i) A rectangular tank is usually used into which waste water is allowed to stay here for a certain period. Number of aerator should be placed in this tank for the supply of oxygen. This tank is called as **aeration tank**. The activity micro-organisms which are used here to treat the waste water, is dependent on the supply of oxygen.

(ii) The aeration tank always be preceded by a primary sedimentation tank and followed by a secondary sedimentation tank. The suspended solid present in the waste water should be removed by primary sedimentation tank before entering in the aeration tank and the sludge produced during the activated sludge process should be settled in the secondary sedimentation tank.

(iii) The efficiency of the activated sludge process depends on the ratio of organic waste present in the waste water to the micro-organism added to it. As the organic waste is the food of the micro-organism, this ratio is called ratio of food to micro-organism. (F/M).

iv. When micro-organism is added to the waste water, the combination of both is called the ‘mixed liquor’ (ML). The mixed liquor (ML) is then, allowed to pass to the next unit i.e., secondary sedimentation tank.

v) In the secondary sedimentation tank, the mixed liquor is allowed to stay there for a certain time. This time is called as ‘mean cell resistance time’ (MCRT).

vi) During this period, the micro-organisms which are present in the waste water become active after getting oxygen from the aeration tank, start to decompose the organic wastes. As the concentration of organic waste reduces, the demand of oxygen i.e., BOD also reduces.

vii) After the decomposition of the organic waste, some simple solid substances are produced. The combination of mixed liquor (ML) and these suspended solid substances, togetherly called ‘mixed liquor suspended solid’ (MLSS).

viii. The mixed liquor suspended solids (MLSS) is then separated i.e., solid liquid separation take place. The liquid which is free from any organic waste, is allowed to pass to the next unit for the further treatment (if any) and solids are gradually settle down at the bottom of the tank from where it is collected as sludge.

ix. The sludge collected from the bottom of the secondary sedimentation tank, contains active micro-organism in it and so this type of sludge is called activated sludge.

x. Maximum portion of this sludge is disposed off for the sludge digestion and remaining portion is recycled to aeration tank for the further decomposition of organic waste. As the activated sludge contain active micro-organism and so there is no need to introduce any micro-organism from the outside. The micro-organism may increase in their number after getting sufficient oxygen from the aeration tank. This micro-organism again decomposes the organic waste and hence reduce the BOD of waste water.

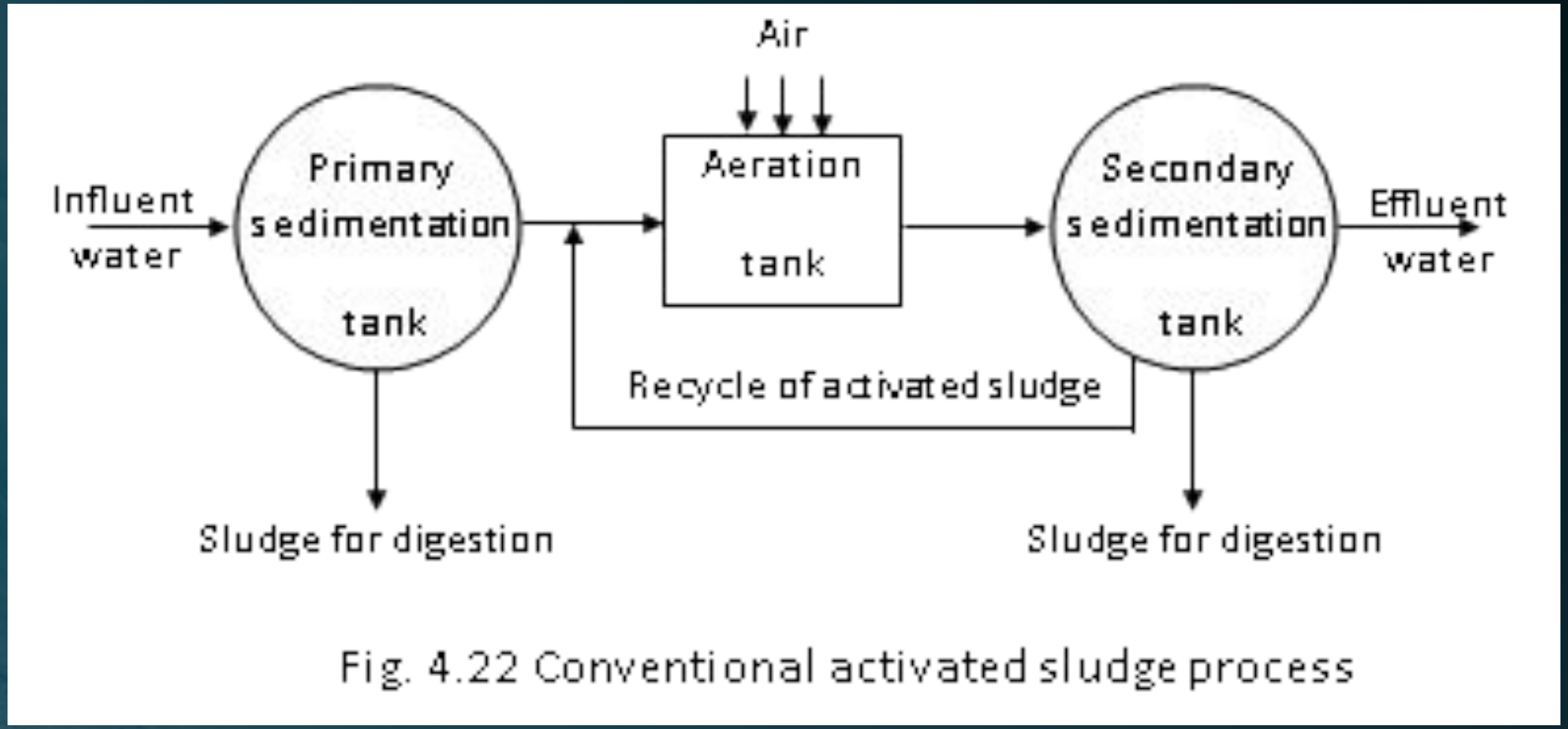

Fig. 4.22 Conventional activated sludge process

Advantages of activated sludge process:

i) Activated sludge process reduces maximum amount of BOD from the waste water.
ii) Pathogens are reduced by this method.
iii) Little space is required.

Disadvantages of activated sludge process:

i) The efficiency of the process depends on separation of solids from liquid.
ii) It is difficult to operate and skilled man power is required.

Differences between trickling filter and activated sludge process

Trickling filter	Activated Sludge Process
i) Bacterial growth is fixed on the filtering bed.	i) Bacterial growth is suspended along with sludge i.e., activated sludge.
ii) There is no need to recycle the sludge	ii) Recycle of sludge is very important.
iii) Produce insets & foul smell during the operation	iii) Pathogens are destroyed and no smell is produced.
iv) Low operating cost.	iv) High operating cost.
v) Less efficiency to remove BOD.	v) High efficiency to remove the BOD.

Oxidation Pond

Oxidation Ponds

Oxidation ponds are large, shallow ponds, typically 1 to 2 m deep, where raw waste water is decomposed by the micro-organisms. Oxidation ponds can be designed to maintain aerobic condition throughout, but more often the decomposition taking place near the surface is **aerobic**, while that near the bottom is **anaerobic**. Such ponds, having a mix of aerobic and anaerobic conditions are called **facultative ponds**. In ponds, the oxygen required for the aerobic decomposition is derived from the surface aeration and algal photosynthesis.

In aerobic zone of the facultative ponds, the organic wastes are decomposed by the aerobic bacteria and produce CO_2.

$$\text{Organic waste} + O_2 + \text{aerobic bacteria} \rightarrow CO_2 + H_2O \qquad \ldots (1)$$

In the anaerobic zone of the facultative ponds, the organic wastes are decomposed by anaerobic bacteria –

$$\text{Organic waste} + \text{aerobic bacteria} \longrightarrow Co2 + NH3 + H2s + CH4 \qquad \ldots (2)$$

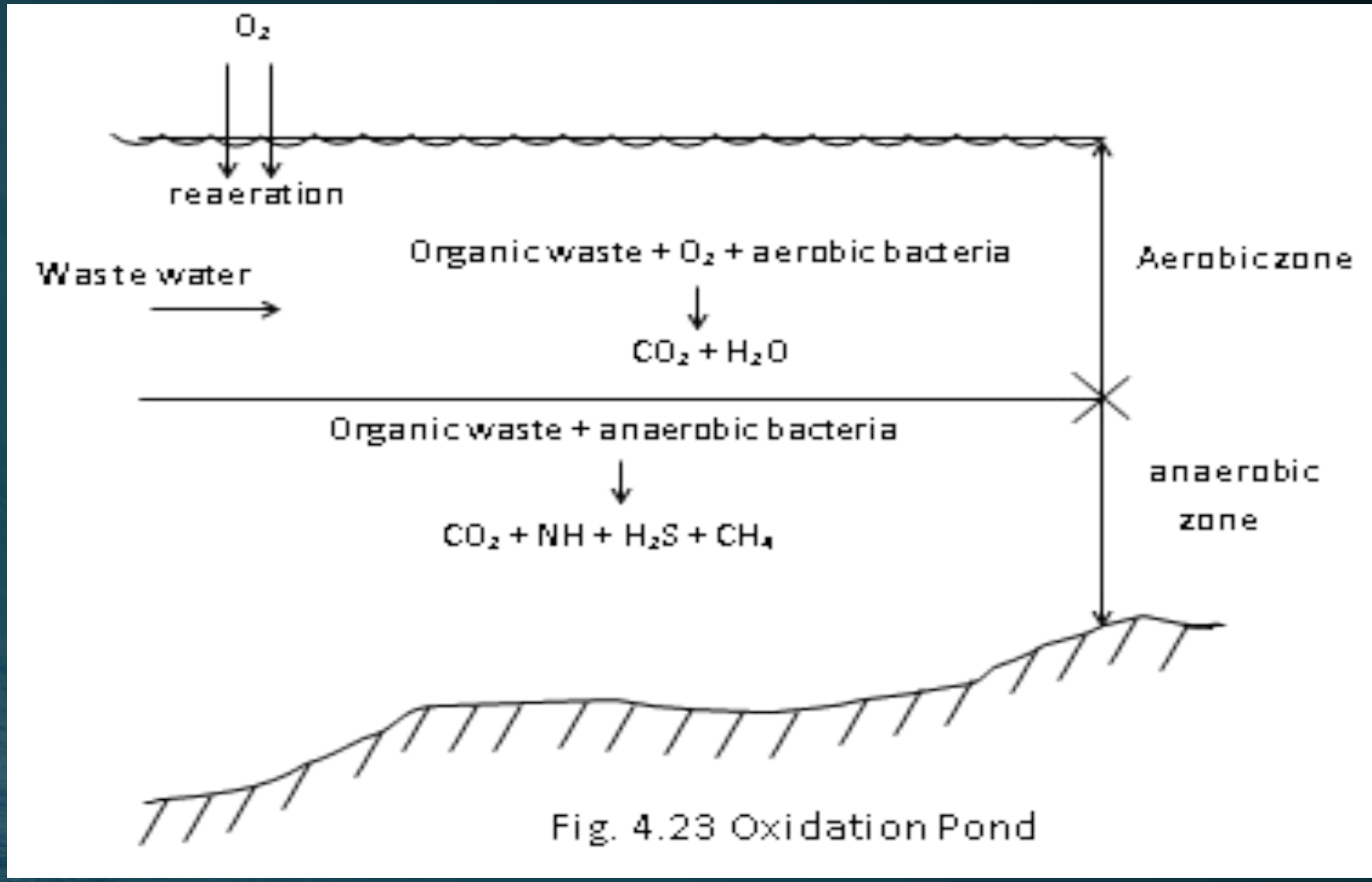

Fig. 4.23 Oxidation Pond

Sludge Digestion

- The sludge digestion breaks the organic part of the sludge into liquid and simple compounds which are stable, unfoul in nature. A portion of solids is converted into liquid and gases due to which volume of sledges reduced by 60% - 70%. The gases produced in this process can be used as fuel and the digested sludge has very good fertilizing value.

- Mostly sludge digestion takes place under anaerobic condition. Mainly two types of bacteria are responsible for this type of digestion. One group of bacteria attacks the organic substances such as fats, carbohydrate, protein etc. and converts them to organic acids and alcohols. This group of bacteria is known as **acid forming bacteria**. The second group of bacteria acts on the organic acid and produce methane and carbon dioxide. The group of bacteria is known as **methane forming bacteria or gas forming bacteria**.

- The first stage of sludge digestion process is known as **waste conversion**. This is also called as **acid forming stage**. The second stage is called as **waste stabilization**. This is also known as **acid regression.**

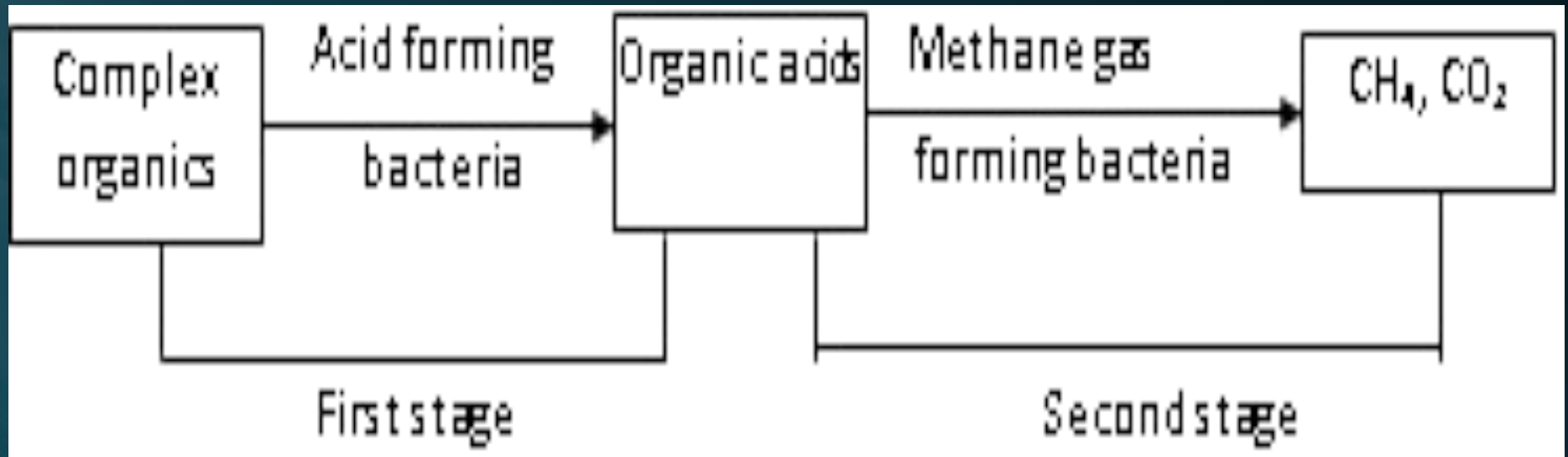

Fig. 4.24 Stages of sludge digestion