

# Civil Engineering

## Environmental Engg : Vol-II

(Sewage Disposal & Air Pollution Engineering)

Comprehensive Theory

*with* Solved Examples and Practice Questions



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### **Environmental Engineering : Vol-II (Sewage Disposal & Air Pollution Engineering)**

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# Treatment of Sewage

## INTRODUCTION

Waste water can be defined as any water or liquid that contains impurities or pollutants in the form of solids, liquid or gases or their combinations in such a concentration that is harmful if disposed of into the environment. Sewage, before being disposed of either in river streams or on land, has generally to be treated, so as to make it safe. The degree of treatment required, however, depends upon the characteristics of the source of disposal.

### 5.1 Treatment Methods

Generally, physical, chemical or biological means are applied to waste water to carry out specific function on the principles of either one or a combination of the means employed. Based on the means used, treatment methods have been broadly classified as unit operations and unit processes.

#### 5.1.1 Unit Operations

It involves contaminant removal by physical forces. The major treatment methods falling under this category are screening, mixing, sedimentation, grit chamber etc.

#### 5.1.2 Unit Process

It involves biological and/or chemical reactions type of treatment in which the removal of contaminants is brought about by the addition of chemicals or by the use of biological mass or microbial activities. Based on the type of agent used biological unit process are

##### (a) Suspended Growth Process

**Example :** Activated Sludge Process, Aerated Lagoon, Oxidation Pond, Aerobic and Anaerobic Sludge Disaster etc.

##### (b) Attached Growth Process

**Example:** Trickling filter, Rotating Biological Contractors, Bio-towers etc.

- Although unit operations and processes are natural phenomena, may be initiated, enhanced or otherwise controlled by altering the environment in the reactor. Reactor refers to the vessel, or containment structure, along with all of its appurtenances, in which the unit operation or unit process takes place.

- A wastewater treatment system is composed of a combination of unit operations and unit processes designed to reduce certain constituents of wastewater to an acceptable level. Unit operations and processes commonly used in wastewater treatment are listed in the table below:

**Table: 5.1** Unit Operations, Unit Processes and Systems for Waste Water Treatment

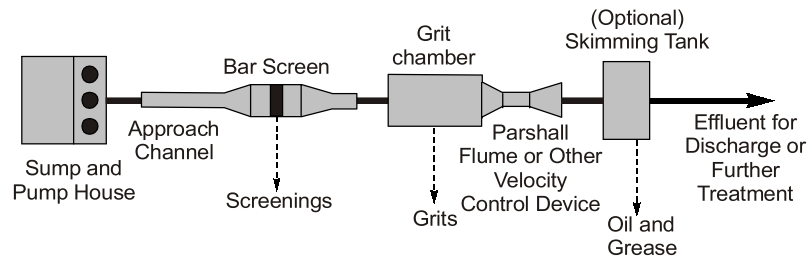
Contaminant	Unit operation, unit process or treatment system
Suspended solids	Sedimentation Screening and comminution Filtration variations Flotation Chemical-polymer addition Coagulation/ sedimentation Land treatment systems
Biodegradable organics	Activated-sludge variations Fixed-film: trickling filters Fixed-film: rotating biological contactors Lagoon and oxidation pond variations Intermittent sand filtration Land treatment systems Physical-chemical systems
Pathogens	Chlorination Hypochlorination Ozonation Land treatment systems
Nutrients: Nitrogen	Suspended-growth nitrification and denitrification variations Fixed-film nitrification and denitrification variations Ammonia stripping Ion exchange Breakpoint chlorination Land treatment systems
Phosphorus	Metal-salt addition Lime coagulation/sedimentation Biological-chemical phosphorus removal Land treatment systems
Refractory organics	Carbon adsorption Tertiary ozonation Land treatment systems
Heavy metals	Chemical precipitation Ion exchange Land treatment systems
Dissolved inorganic solids	Ion exchange Reverse osmosis Electrodialysis

- Sewage can be treated in different ways. Treatment processes are often classified as:
  - (i) Preliminary treatment
  - (ii) Primary treatment
  - (iii) Secondary (or Biological) treatment
  - (iv) Complete final treatment



**(i) Preliminary Treatment**

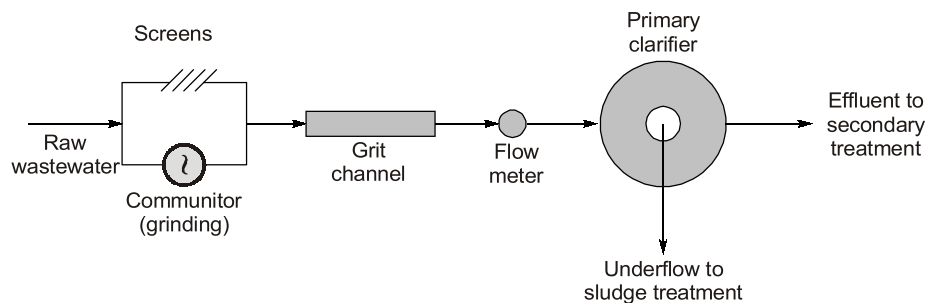
- Preliminary treatment consists solely in separating the floating materials (like dead animals, tree branches, papers, pieces of rags, wood, etc.), and also the heavy settleable inorganic solids.
- It also helps in removing the oils and greases, etc. from the sewage. This treatment reduces the BOD of the wastewater, by about 15 to 30%.
- The processes used are : Screening for removing floating papers, rags, clothes, etc., Grit chambers or Detritus tanks for removing grit and sand, and Skimming tanks for removing oils and greases.



**Fig. 5.1** Flow diagram of a typical preliminary treatment system

**(ii) Primary Treatment System**

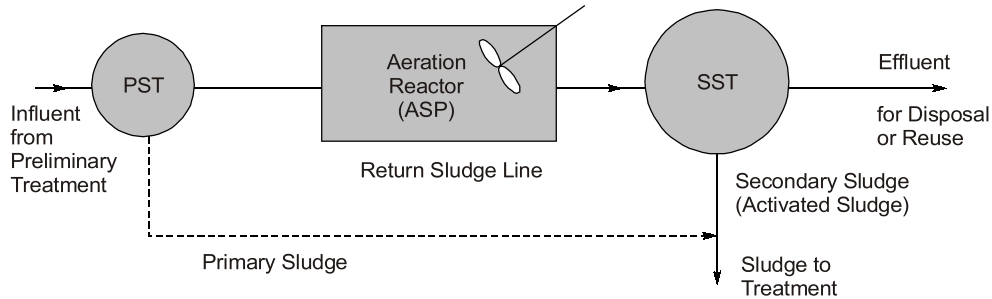
- Primary treatment consists in removing large suspended organic solids. This is usually accomplished by sedimentation in Settling basins.
- The liquid effluent from preliminary treatment, often contains a large amount of suspended organic material and has a high BOD (about 60% of original).
- Sometimes, the preliminary as well as primary treatments are classified together, under primary treatment.
- The organic solids, which are separated out in the sedimentation tanks (in primary treatment), are often stabilised by anaerobic decomposition in a digestion tank or are incinerated. The residue is used for land fills or soil conditioners.
- It will not remove the colloidal and soluble (dissolved) organic content of waste water.
- Large debris are removed by screen or may be reduced in size by grinding devices.
- Disposal of inorganic matter is convenient because it does not decompose. But, disposal of organic matter is difficult because if it is disposed untreated, it will create nuisance. Hence it is desired that inorganic and organic matters are removed in two different units.
- Primary treatment removes approx 60 - 70% of suspended solid.



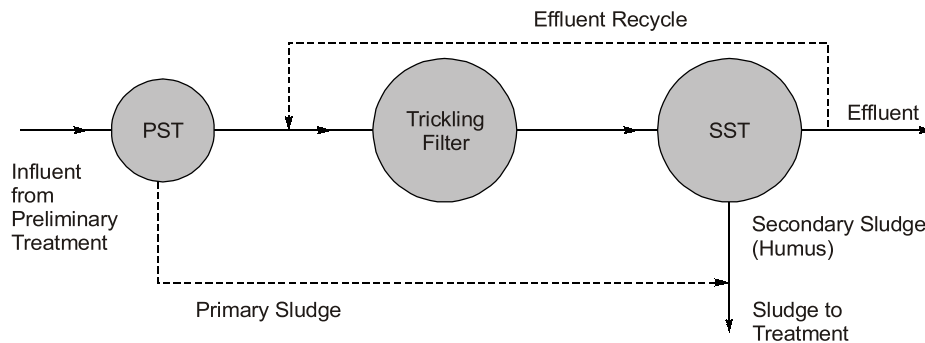
**Fig. 5.2** Typical primary treatment system

**(iii) Secondary Treatment System**

- Secondary treatment involves further treatment of the effluent, coming from the primary sedimentation tank.
- Secondary treatment usually consists of biological conversion of dissolved and colloidal organics into biomass that can subsequently be removed by sedimentation.

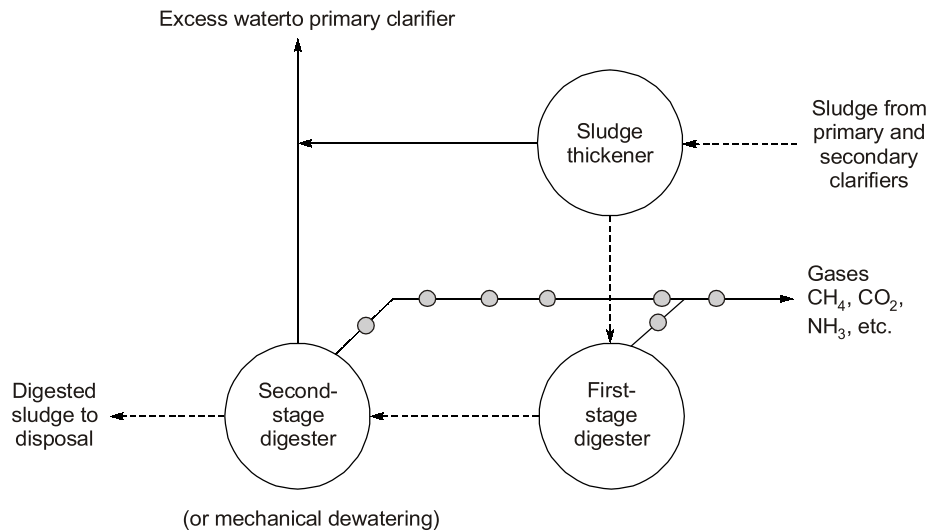


**Fig. 5.3** Secondary treatment system with activated sludge process



**Fig. 5.4** Secondary treatment system with trickling filter

- Contact between microorganisms and the organics is optimized by suspending the biomass in the wastewater or by passing the wastewater over a film of biomass attached to solid surfaces. The most common suspended biomass system is the activated sludge process as shown in figure 5.3.
- Recirculating a portion of the biomass maintains a large number of organisms in contact with the wastewater and speeds up the conversion process. The classical attached biomass system is the trickling filter as shown in figure 5.4.
- Stones or other solid media are used to increase the surface area of biofilm, growth mature biofilms peel off the surface and are washed out to the settling basin with the liquid underflow. Part of the liquid effluent may be recycled through the system for additional treatment and to maintain optimal hydraulic flow rates.
- Secondary systems produce excess biomass that is biodegradable through endogenous catabolism and by other microorganisms.
- Secondary sludges are usually combined with primary sludge for further treatment by anaerobic biological process as shown in figure 5.5.



**Fig. 5.5** Sludge treatment system

- The results are gaseous end products, principally methane (CH<sub>4</sub>) and carbon dioxide (CO<sub>2</sub>) and liquids and inert solids. The methane has significant heating value and may be used to meet part of the power requirements of the treatment plant.
- The liquids contain large concentration of organic compounds and are recycled through the treatment plant.
- The solid residue has a high mineral content and may be used as a soil conditioner and fertilizer on agriculture lands. Other means of solids disposal may be by incineration or by land filling.
- Sometimes primary and secondary treatment can be accomplished together as shown in figure. The oxidation pond mostly approximates natural systems with oxygen being supplied by algal photosynthesis and surface reaeration. This oxygen seldom penetrates to the bottom of the pond and the solids that settle are decomposed anaerobically.
- In the aerated lagoon system, oxygen is supplied by mechanical aeration and the entire depth of the pond is aerobic.
- Decomposition of the biomass occurs by aerobic endogenous catabolism.
- The small quantity of excess sludge that is produced is retained in the bottom sediments.
- The effluent from the secondary biological treatment will usually contain a little BOD (5 to 10% of the original), and may even contain several milligrams per litre of DO.
- The treatment reactor in which the organic matter is decomposed (oxidised) by aerobic bacteria are known as aerobic biological units, as may consist of
  - (i) Filter (intermittent sand filters as well as trickling filters)
  - (ii) Aeration tanks with the feed of recycled activated sludge (i.e. the sludge, which is settled in secondary sedimentation tank receiving sludge from the secondary sedimentation tank).
  - (iii) Oxidation ponds and Aerated lagoons

- Since all these aerobic units, generally make use of primary settled sewage, they are classified as secondary units.
- The treatment reactors in which the organic matter is destroyed and stabilized by anaerobic bacteria are known as anaerobic biological units and may consist of anaerobic lagoons, septic tanks, Imhoff tanks etc.
- Out of these units, only anaerobic lagoons, makes use of primary settled sewage and hence, only they can be classified under secondary biological units. Septic tanks and Imhoff tanks, using raw sewage, are, therefore, not classified as secondary units.
- The organic solids/sludge, separated out in the primary as well as in the secondary settling tanks, will be disposed of by stabilizing them under anaerobic process in a sludge digestion tank.

**(iv) The Final or Advanced Treatment**

- This treatment is sometimes called tertiary treatment. In most cases, secondary treatment of municipal wastewater is sufficient to meet effluent standards.
- In some instances, however additional treatment may be required. Tertiary treatment consists of removing the organic load left after the secondary treatment and particularly to kill the pathogenic bacteria.
- This treatment, which is normally carried out by chlorination, is generally not carried out for disposal of sewage in water, but is carried out, while using the river stream for collecting water for reuse or for water supplies.
- The sewage treatment is therefore, usually confined upto secondary treatment only. Well in fact various physical, chemical and biological processes are available for treatment, depending upon the particular requirement.
- The choice of the treatment methods depends on several factors, including the disposal facilities available.
- The individual operation of these units may be combined in different ways, depending upon the topography and other local needs, so as to create different types of treatment types.

**NOTE**



Actually, the distinction between primary, secondary and tertiary treatment is rather arbitrary, since many modern treatment method incorporate physical, chemical and biological processes in the same operation.

## 5.2 Primary Treatments

- Wastewater contains a wide variety of solids of various shapes, size and densities.
- Effective removal of these solids may require a combinations of unit operations such as screening, grinding and settling.
- Flow measurement devices are essential for the operation of waste water treatment plants and are generally included in the primary system.
- Operations to eliminate large objects and grit, along with flow measurements, often referred as preliminary treatment are an integral part of primary treatment.
- Operations common to primary system of waste water treatment plants are described below.