3.7 Wastewater Pollution and Some Control Processes of Wastewater

Wastewater can be defined as any water or liquid that contains impurities or pollutants.

- **Origin of Wastewater**

Wastewater can be classified by their origin as: domestic wastewater and industrial wastewater.

1. Domestic wastewater: that is collected and discharged from residential and commercial established.
2. Industrial wastewater: is formed at industrial plants where water is used for various processes and washing rinsing of equipment.

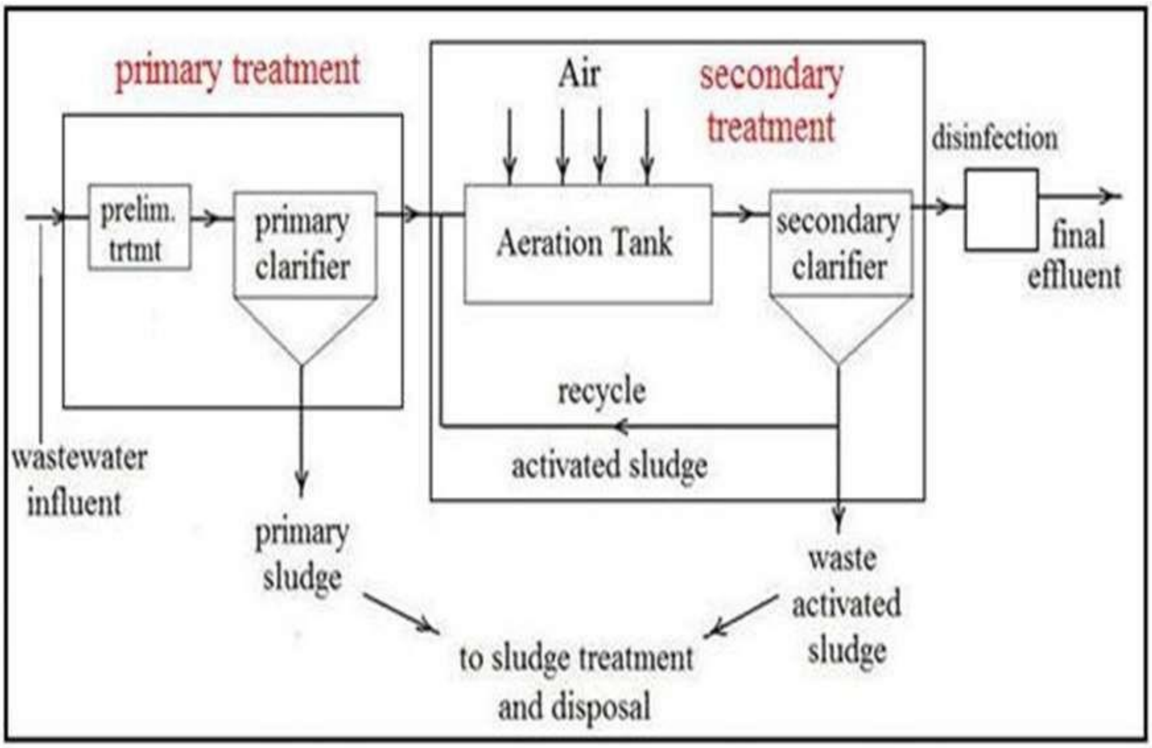
Waste water generated by household activity, industries or garbage landfills is called sewage which is classified as the municipal water pollution. Sewage contains solid matters in the form of suspended colloidal and dissolved organic matter, detergent, mineral matter, nutrients and gases. Sewage is one of the major causes of water borne diseases and therefore the treatment of sewage is one of the important tasks. For a long time, treatment of municipal waste in the form of sewage involved mainly of the removal of suspended solids, oxygen demanding materials and harmful bacteria. Now the disposal of the solid residue from sewage has been improved by applying municipal treatment processes.

3.7.1 The objectives of wastewater treatment:

The objective of wastewater treatment is to reduce the concentration of specific pollutants in water to the level where the treated water will meet the acceptable quality standards and will not adversely affect the environment. The specific processes needed for wastewater treatment vary according to both how the water was used and where the wastewater will be discharged.

3.7.2 Overview of Waste Water Treatment

The treatment of waste water is carried out in the following four stages: 1. Preliminary Treatment 2. Primary treatment 3. Secondary treatment, and 4. Tertiary treatment. The diagram below shows the wastewater treatment processes.



Primary and Secondary Wastewater Treatment

3.7.3 Wastewater Treatment Processes

1. **Preliminary Treatment:**
As wastewater enters a treatment facility, it typically flows through a step called preliminary treatment. A screen removes large floating objects, such as rags, cans, bottles and sticks that may clog pumps, small pipes, and down stream processes. The screens vary from coarse to fine and are constructed with parallel steel or iron bars, while others may be made from mesh screens with much smaller openings.

2. **Primary Treatment:**
When the waste water is to be dumped off into a river or flowing steam, the treatment is carried out by sedimentation, coagulation and filtration. This is known as primary treatment. If the water is required for drinking purposes, it has to undergo further treatment called secondary and tertiary treatments.

The following steps are performed to do primary treatment of water:

a. **Sedimentation:** This step is carried out in large tanks specially built for this purpose in sewage treatment plant. The polluted water is allowed to settle so that silt, clay and other matter settle to be bottom and water is slowly allowed to move out. Fine particles do not settle and are thus required to be removed in the next step.

b. **Coagulation:** Fine particles and colloidal suspension are combined into large particles by a process called coagulation. This step is carried out by the addition of special chemicals called coagulants (flocculants) such as potash alum. The large particles either settle to the bottom or are moved in the next step.

c. **Filtration:** Suspended particles, flocculants, bacteria and other organisms are filtered by passing the water through a bed of sand or finely divided coal or through some fibrous materials. The total impurities collected in these steps are called sludge. It is used as a valuable fertilizer. On composting (i.e. the action of anaerobic bacteria), it releases sludge gas. It consists mainly of methane gas which is used for cooking purposes.

3. **Secondary or Biological Treatment:**

The water after primary treatment is not fit for drinking purposes and has to undergo further treatment. This is done through secondary or biological treatment. A commonly used method is to allow polluted water to spread over a large bed of stones and gravel so that the growth of different microorganisms needing nutrients and oxygen is encouraged. Over a period of time a fast-moving food chain is set up. For example, bacteria consume organic matter from the polluted water; protozoa live on bacteria. This process involves the following steps:

a. **Softening:** By this treatment undesirable cations of calcium and magnesium are removed from hard waters. Either water is treated with lime and soda ash to precipitate Ca^{2+} ions as carbonates or it is passed through cation exchangers. This makes water soft.

b. **Aeration:** In this process, soft water is exposed to air by forcing air through it to add oxygen to water. This encourages bacterial decomposition of organic matter into harmless products such as carbon dioxide and water. The addition of oxygen reduces carbon dioxide and sulphide. The water is as yet not fit for drinking purposes. The pathogenic and other microorganisms need to be killed. This is done in the next treatment.

4. **Tertiary Treatment:**

The tertiary treatment is actually disinfecting water. Disinfection is carried out to kill harmful microorganisms that may be present in the water supply and to prevent microorganisms regrowing in the distribution systems. Good public health owes a lot to the disinfection of water supplies. Without disinfection, waterborne disease becomes a problem, causing high infant mortality rates and low life expectancy. These are some advantages of the disinfection process:

- Effectiveness in killing a range of microorganisms.
- Potential to form possibly harmful disinfection byproducts.
- Ability of the disinfecting agent to remain effective in the water throughout the distribution system.
- Safety and ease of handling chemicals and equipment.
- Cost effectiveness.

For example, of disinfectants (Chlorine) is the most commonly used disinfectant used for killing bacteria. Other methods of disinfection such as ultraviolet radiation and ozone gas treatment. A summary of each of the main disinfection processes is given below:

a. Chlorination:

Chlorination is the most widely used disinfectant for drinking water. It is cheap, easy to use, effective at low dose levels against a wide range of infectious microorganisms, and has a long history of safe use around the world. Chlorine gas and water react to form HOCl and hydrochloric acid (HCl). In turn, the HOCl dissociates into the hypochlorite ion (OCl–) and the hydrogen ion (H+), according to the
following reactions:

1- $Cl_2 + H_2O \Leftrightarrow HOCl + HCl$

2- $HOCl \Leftrightarrow H^+ + OCl^-$

b. Chloramination:

Chloramines are produced when ammonia and chlorine are added to water together. They are less effective than chlorine in killing microorganisms because they are not as chemically active. However, chloramines maintain their disinfecting capability longer than chlorine and are ideal for very long distribution systems or for water supplies with long holding times in service reservoirs.

c. Ozone:

Ozone (O3) is the most powerful disinfectant used in water treatment. It is even effective against the difficult to treat protozoan parasites, Cryptosporidium and Giardia. Ozone, which only recently began to be used, destroys soluble contaminants such as algal toxins, taste and odour compounds and trace levels of insecticides.

d. Ultraviolet irradiation:

Ultraviolet radiation (UV) is a component of sunlight. Sunlight achieves disinfection by ultraviolet irradiation naturally. In water treatment, an appropriate level of UV irradiation, produced by mercury lamps, can kill bacteria and viruses. However, there is some uncertainty surrounding the effectiveness of UV irradiation against Cryptosporidium and Giardia. UV irradiation adds no chemicals to water and uses equipment that is relatively simple to operate and maintain.

3.7.4 Examples about the daily flow rate, Lime mass, and the detention time.

EXAMPLE 1

A channel 2 m wide has a water flowing to a depth of 0.5 m. What is the **daily flow** in the channel if the velocity of the water is 0.75 m/s?

Solution:

RATE OF FLOW = WIDTH x DEPTH x VELOCITY

= (2 m) (0.5 m) (0.75 m/s)

= 0.75 m^3/s

However, we are asked to find the daily flow. Daily Flow = rate of flow x 60 s/min x 1440 min/d

= (0.75 m^3/s) (60 s/min) (1440 min/d)

= 64800 m^3/d

EXAMPLE 2

A lime solution having a mass of 80 kg contains 85% water and the remainder is lime. What is the mass of the lime?

Solution :

The total mass of the solution is 80 kg which represents 100%. If the water represents 85%, then the lime represents:

(Total Mass) - (Mass of Water) = (Mass of Lime)

100% - 85% = 15%

Mass of lime = 15% x 80 kg

= 0.15 x 80 kg

= 12 kg

EXAMPLE 3

A sedimentation tank has a capacity of 132 m^3. If the hourly flow to the clarifier is 47 m^3/h, what is the detention time?

Solution:

Since the flow rate is expressed in hours, the detention time calculated is also in hours:

Detention time = Volume of tank / Flow rate

$$= 132 \text{ m}^3 / 47 \text{ m}^3/\text{h}$$

Detention time = 2.8 h