Course: B.Sc. Microbiology

Semester: IV

Paper Code: MBIOCC409

Unit IV

Paper Name: Environmental Microbiology

Topic: **Waste Water Treatment**

Faculty Name: Dr. Niti Yashvardhini

Department : Microbiology

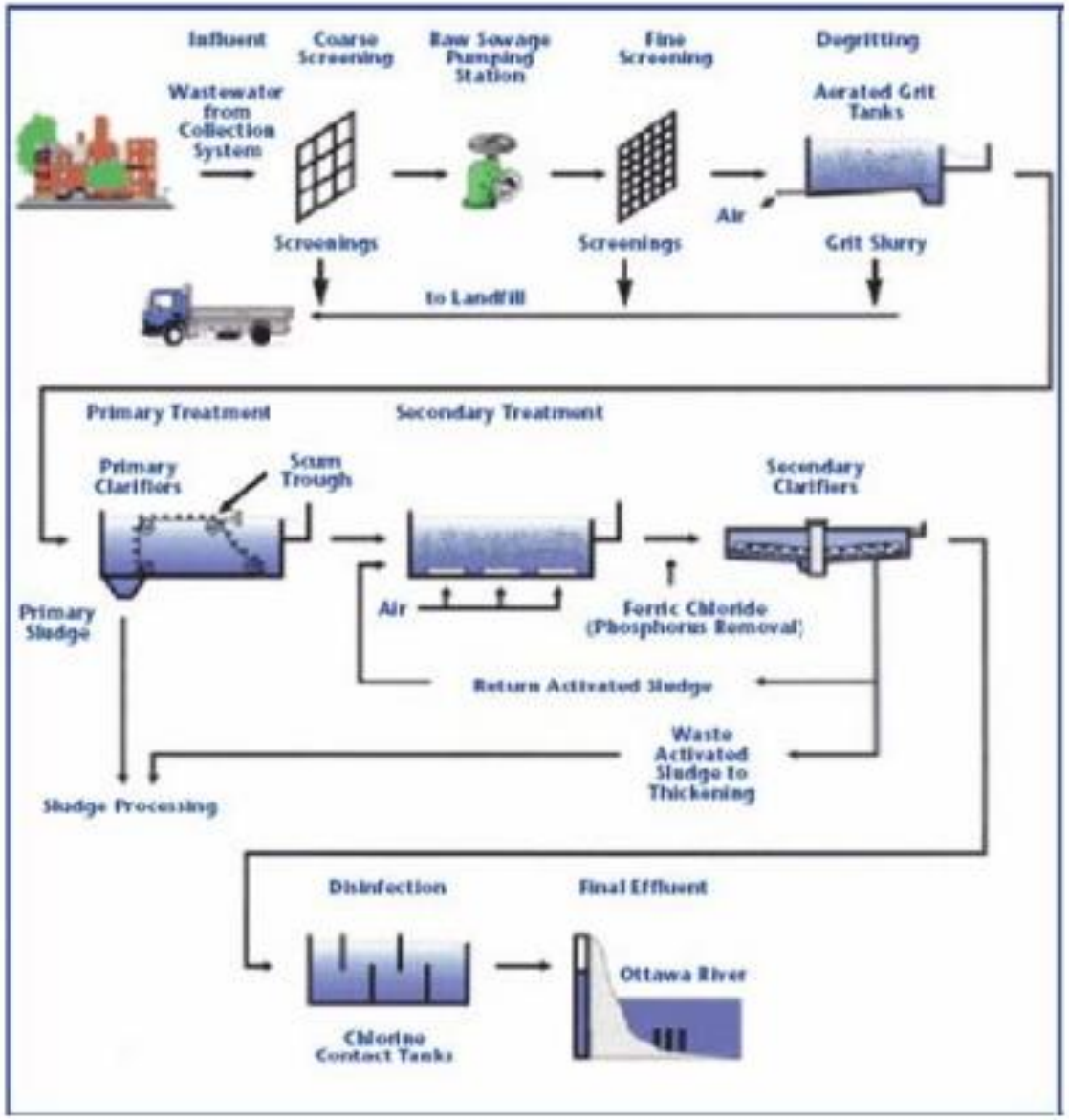
Email Id: nitiyashvardhini@gmail.com

Introduction

- Wastewater comes from a variety of sources.
- The principal objective of wastewater treatment is generally to allow human and industrial effluents to be disposed of without danger to human health or unacceptable damage to the natural environment.
- Irrigation with wastewater is both disposal and utilization and indeed is an effective form of wastewater disposal (as in slow-rate land treatment).
- However, some degree of treatment must normally be provided to raw municipal wastewater before it can be used for agricultural or landscape irrigation or for aquaculture.
- Sewage treatment generally involves three stages :

1. Primary Treatment or Mechanical Treatment
2. Secondary Treatment or Biological Treatment
3. Tertiary Treatment or Advance Biological or Chemical Treatment

Sewage Waste Management



Water Quality Measures

Temperature

Turbidity

Bacteria (Fecal Coliform, *E. coli*, and Enterococci)

Dissolved Oxygen

pH

Nutrients

Sediment

Toxic Substances

Ammonia

Metals

Mercury

Organics

PRIMARY TREATMENT

- In primary treatment suspended solid and floating material is removed.
- The primary level of treatment uses screens and settling tanks to remove the majority of solids.
- Effluent is passes through a screen which is used to remove certain material like wood pieces, plastic , paper, floating debris.
- Then effluent is passed through chamber which is known as grit chamber.
- This step is extremely important, because solids make up approximately 35 percent of the pollutants that must be removed.

PRIMARY TREATMENT (Contd.....)

- The water is then put into settling tanks (or clarifiers), where it sits for several hours, allowing the sludge to settle and a scum to form on the top.
- The scum is then skimmed off the top
- The primary treatment generally removes up to 50 percent of the BOD
- While primary treatment removes a significant amount of harmful substances from wastewater, it is not enough to ensure that all harmful pollutants have been removed.

PRIMARY TREATMENT

Primary treatment is of two types:-

1. Physical Treatment
2. Chemical Treatment

PHYSICAL TREATMENT

Following methods can be used:-

a) Screening

Screen chamber remove dead animals, branches of tree, logs of wood, rags and other coarse floating material.

The effluent is passed through the bar screens for rag removal.

b) Grit Chamber

Grit include sand, ash, egg shell etc . of diameter less then 0.2 mm.

The effluent moves to the grit tanks.

These tanks reduce the velocity of the effluent so that heavy particles may fall to the bottom.

c) Floatation or skimming tank

Fats, waxes, fatty acid, soap, minerals and vegetable oil present in waste water are removed

oil and grease are lighter than water they are normally separated by natural flotation .

Bubbling on the bottom of the tank is done to ensure floating matter rises and remain on the surface of waste water to be separated out easily.

CHEMICAL TREATMENT

It is done by following methods:

(i) Sedimentation

- Settling down of suspended particles at the bottom of water is called Sedimentation.
- This process is also known as clarification.
- In this process water is collected into big pond , slowly- slowly impurities are settled down by gravitation.
- The process of sedimentation can be accelerated by adding Alum

(ii) Coagulation

- In plain sedimentation, the heavier particles settle down.
- Fine particles take many hours or sometimes days to settle down.
- Colloidal particles which are fine particles of size finer than 0.0001 mm carry electric charges on them.
- The water possesses colour which is mainly due to colloidal matter and dissolve organic matter in water.
- The turbidity in water is mainly due to the presence of very fine particles of clay, silt and organic matter.

(iii) Flocculation

•Flocculation is the agglomeration of destabilized particles into microfloc and after into bulky floccules which can be settled called floc.
•The addition of another reagent called flocculants or a flocculants aid may promote the formation of the floc.
•Flocculators or polyelectrolytes are organic high molecular weight compound comprising many inorganic group.
•These group groups undergo ionisation when dissolve in water.
•Two important flocculators are polyacryalamide and BA-2 flocculator (cation exchange type).

(iv) Filteration

•To remove colloidal and suspended matter remaining after sedimentation and to remove bacterial load, filtration is done
•The process of filtration usually consist of allowing the water pass through thick layer of sand or porous material which retain coarse impurities on its surface and in pores.
•The apparatus used for filtration process is called a filter.

SECONDARY TREATMENT

- It is the process in which microorganism play a very important role for the treatment of effluent.
- Microorganism like bacteria, fungi decompose the organic waste and convert into simpler form.
- The main function of secondary treatment is to convert the reaming organic matter of sewage into stable form by oxidation and nitrification.
- The objective of secondary treatment is the further treatment of the effluent from primary treatment to remove the residual organics and suspended solids.
- In most cases, secondary treatment follows primary treatment and involves the removal of biodegradable dissolved and colloidal organic matter using aerobic biological treatment processes.
- Secondary treatment of wastewater uses bacteria to digest the remaining pollutants.

SECONDARY TREATMENT (Contd....)

- This is accomplished by forcefully mixing the wastewater with bacteria and oxygen.
- The oxygen helps the bacteria to digest the pollutants faster. The water is then taken to settling tanks where the sludge again settles, leaving the water 90 to 95 percent free of pollutants.
- Secondary treatment removes about 85 to 90 percent of BOD and suspended solid, and about 90 to 99 percent of coliform bacteria.

- Biological Treatment Can be classified into:

1. Aerobic treatment
2. Anaerobic treatment

1. Aerobic Treatment

The treatment which is carried out by microorganism in the presence of oxygen.

In this, the biological treatment is performed in the presence of oxygen by aerobic microorganisms (principally bacteria) that metabolize the organic matter in the wastewater, thereby producing more microorganisms and inorganic end-products (principally CO_2, NH_3, and H_2O).

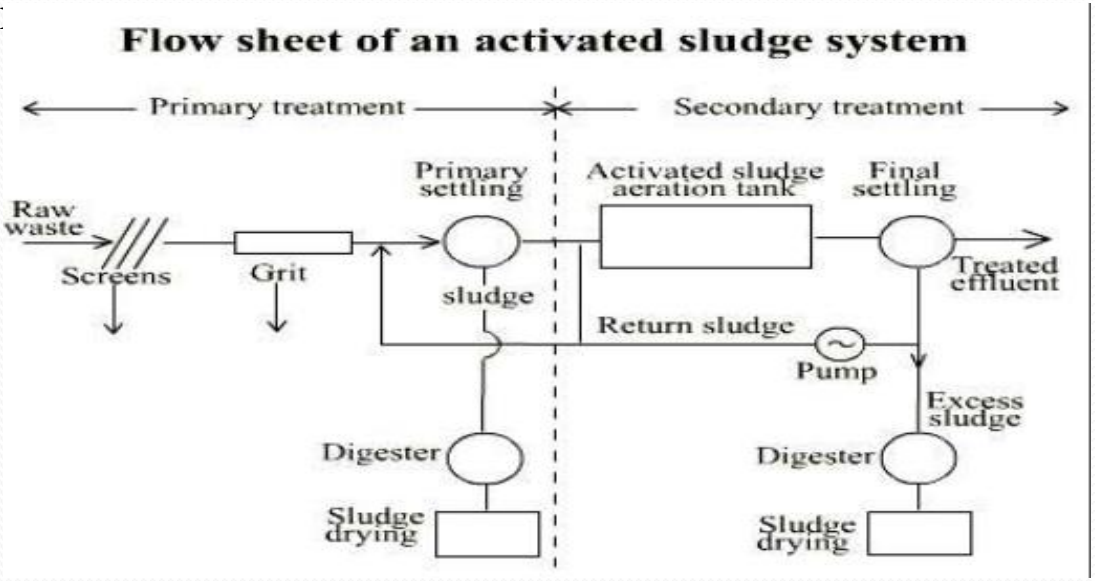
Several aerobic biological processes are used for secondary treatment differing primarily in the manner in which oxygen is supplied to the microorganisms and in the rate at which organisms metabolize the organic matter.

a) Activated Sludge Process

- The activated sludge treatment system consists of an aeration tank followed by a secondary clarifier.
- In the activated sludge process, the dispersed-growth reactor is an aeration tank or basin containing a suspension of the wastewater and microorganisms, the mixed liquor.
- The contents of the aeration tank are mixed vigorously by aeration devices which also supply oxygen to the biological suspension .
- Settled sewage, mixed with fresh sludge that is recirculated from the secondary clarifier, is introduced into the aeration tank.
- Compressed air is then injected into the mixture through porous diffusers located at the bottom of the tank.
- As it bubbles to the surface, the diffused air provides oxygen and a rapid mixing action.
- Air can also be added by the churning action of mechanical propeller-like mixers located at the tank surface.
- Aeration devices commonly used include submerged diffusers that release compressed air and mechanical surface aerators that introduce air by agitating the liquid surface.

a) Activated Sludge Process (Contd...)

- Following the aeration step, the microorganisms are separated from the liquid by sedimentation and the clarified liquid is secondary effluent.
- Under such oxygenated conditions, microorganisms thrive, forming an active, healthy suspension of biological solids—mostly bacteria—called activated sludge.
- About six hours of detention is provided in the aeration tank. This gives the microbes enough time to absorb dissolved organics from the sewage, reducing the BOD.
- About 30 percent of the sludge is recirculated back into the aeration tank, where it is mixed with the primary effluent.
- This recirculation is a key feature of the activated sludge process.
- The recycled microbes are well acclimated to the sewage environment and readily metabolize the organic materials in the primary effluent.
- The remaining 70 percent of the secondary sludge must be treated and disposed of in an acceptable manne



b) Trickling Filter

- A trickling filter or biofilter consists of a basin or tower filled with support media such as stones, plastic shapes, or wooden slats.
- Wastewater is applied intermittently, or sometimes continuously, over the media.
- Microorganisms become attached to the media and form a biological layer or fixed film.
- Organic matter in the wastewater diffuses into the film, where it is metabolized.
- Oxygen is normally supplied to the film by the natural flow of air either up or down through the media, depending on the relative temperatures of the wastewater and ambient air.
- Forced air can also be supplied by blowers but this is rarely necessary.
- The thickness of the biofilm increases as new organisms grow.
- The sloughed material is separated from the liquid in a secondary clarifier and discharged to sludge processing.
- Clarified liquid from the secondary clarifier is the secondary effluent and a portion is often recycled to the biofilter to improve hydraulic distribution of the wastewater over the filter.

c) Rotating Biological Contactors

- Rotating biological contactors (RBCs) are fixed-film reactors similar to biofilters in that organisms are attached to support media.
- In the case of the RBC, the support media are slowly rotating discs that are partially submerged in flowing wastewater in the reactor.
- Oxygen is supplied to the attached biofilm from the air when the film is out of the water and from the liquid when submerged, since oxygen is transferred to the wastewater by surface turbulence created by the discs' rotation.
- Sloughed pieces of biofilm are removed in the same manner described for biofilters.

d) Oxidation ponds

- Oxidation ponds, also called lagoons or stabilization ponds, are large, shallow ponds designed to treat wastewater through the interaction of sunlight, bacteria, and algae.
- Algae grow using energy from the sun and carbon dioxide and inorganic compounds released by bacteria in water.
- During the process of photosynthesis, the algae release oxygen needed by aerobic bacteria.
- Mechanical aerators are sometimes installed to supply yet more oxygen, thereby reducing the required size of the pond.
- Sludge deposits in the pond must eventually be removed by dredging. Algae remaining in the pond effluent can be removed by filtration or by a combination of chemical treatment and settling.

Other methods

Constructed wetland

- A constructed wetland is an artificial wetland created as a new or restored habitat for native and migratory wildlife, for anthropogenic discharge.
- Natural wetlands act as a bio filter, removing sediments and pollutants such as heavy metals from the water.
- Constructed wetlands can be designed to emulate these features.

Membrane bioreactor (MBR)

- Membrane bioreactor (MBR) is the combination of a membrane process like microfiltration or ultrafiltration with a suspended growth bioreactor.
- It is widely used for municipal and industrial wastewater treatment with plant sizes up to 80,000 population equivalent (i.e. 48 million litres per day).

Aerated lagoon or aerated basin

- It is a holding and/or treatment pond provided with artificial aeration to promote the biological oxidation of waste waters.
- It uses oxygen (or air) and microbial action to biotreat the pollutants in wastewaters.

2. Anaerobic Treatment

The treatment which is carried out by aerobes in the absence of oxygen.

The need of oxygen is supplied by oxidation of oxygenated compound for e.g SO_2.

Anaerobic digestion may be defined as being the biological oxidation of degradable organic sludge by microbes under anaerobic conditions.

This process is employed for the treatment of organic sludges and concentrated organic industrial wastes.

Most microbes used in this process are facultative anaerobes.

Fundamentals of Anaerobic Digestion

- Anaerobic digestion occurs in an environment with no molecular oxygen and substantial organic matter.
- The organic material is a food source for the microbes.
- The microbes convert the food into oxidized materials, new cells, energy, and some gaseous end products (such as CH_4 and CO_2).

- *Generalized Equation*
- Organic matter + combined O_2 $\xrightarrow{\text{anaerobic microbes}}$ new cells + energy + CH_4 + CO_2 + end products

- Sources of combined O_2: CO_3^{2-}, SO_4^{2-}, NO_3^-, PO_4^{3-}
- Some of the end products: H_2S, H_2, N_2

•Most of the bacteria forming these organic acids are facultative anaerobes and are found in soil.

•These are:

(i) Organic acid forming heterotrophs

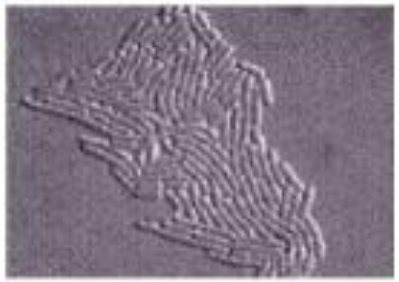
(ii) Methane producing heterotrophs.

- The genera of microbes responsible for anaerobic digestion are:

Pseudomonas
Flavobacterium
Alcaligenes
Escherichia
Aeroacter

- These microbes thrive in a wide pH range.

Pseudomonas


Escherichia

Advantages and Disadvantages of Anaerobic treatment

- Advantages of anaerobic digesters
  - Methane recovery by most of the microbial biomass produced in aerobic growth (biogas), can be used as alternate fuel source (green solution).
  - Reduces production of landfill gas, which when broken down aerobically releases methane into atmosphere (a powerful greenhouse gas).
  - Sludge occupies less volume, easier to dry.
  - Lower operating costs.
  - Odours/flies typically removed from system.

- Disadvantages of anaerobic digesters:
  - Accumulation of heavy metals and contaminants in sludge.
  - Narrow temperature control range.
  - Installing and managing an interrelated group of systems to safely handle heating of the tank, hydrogen sulphide reduction, methane transfer, heat production, electrical production, inter connection with the electrical grid and surplus heat management.

TERTIARY AND/OR ADVANCED TREATMENT

- Tertiary and/or advanced wastewater treatment is employed when specific wastewater constituents which cannot be removed by secondary treatment must be removed.

- Individual treatment processes are necessary to remove nitrogen, phosphorus, additional suspended solids, refractory organics, heavy metals and dissolved solids.

- The main function of tertiary treatment is to decrease the load of nitrogen and phosphorous compound present in the effluent by the following process.

- Effluent from primary clarifiers flows to the biological reactor, which is physically divided into five zones by baffles and weirs. In sequence these zones are:

(i) anaerobic fermentation zone (characterized by very low dissolved oxygen levels and the absence of nitrates);
(ii) anoxic zone (low dissolved oxygen levels but nitrates present);
(iii) aerobic zone (aerated);
(iv) secondary anoxic zone;
(v) Final aeration zone.

TERTIARY AND/OR ADVANCED TREATMENT (Contd...)

- The function of the first zone is to condition the group of bacteria responsible for phosphorus removal by stressing them under low oxidation-reduction conditions, which results in a release of phosphorus equilibrium in the cells of the bacteria.
- On subsequent exposure to an adequate supply of oxygen and phosphorus in the aerated zones, these cells rapidly accumulate phosphorus considerably in excess of their normal metabolic requirements.
- Tertiary (or advanced) treatment removes dissolved substances, such as colour, metals, organic chemicals and nutrients like phosphorus and nitrogen.
- There are a number of physical, chemical and biological treatment processes that are used for tertiary treatment.
- One of the biological treatment processes is called Biological Nutrient Removal (BNR).

Tertiary treatment can be done by:

a) Precipitation

- The effluent received after the secondary treatment is mixed with calcium oxide.

- The lime then react with phosphorous compound in waste to from insoluble calcium phosphate, which then settle down a the bottom of settling tank.

b) Nitrogen Stripping

- Nitrogen present in waste water is generally in the form of ammonia gas , nitrates and nitrites.

- Ammonia is highly undesirable in streams and lakes because it is extremely lethal to aquatic biota.

- Nitrogen eventually enhance Eutrophication, in order to remove nitrogen air is forced through the effluent which thereby result in the removal of ammonia gas.

c) Chlorination

- It is the process in which chlorine is used to kill micro-organism

- The main purpose of chlorination are to assist in the formation of floc in the process of coagulation together with other chemical, to prevent corrosion of sewers.

d) Ultraviolet Light

- The water is passed through banks of cylindrical, quartz-jacketed fluorescent bulbs.

- Ultraviolet disinfection is becoming more popular because of the increasing complications associated with the use of chlorine.

e) Ozone

- Ozone is too unstable to store, and has to be made as it is used.

- It is produced by passing an electrical discharge through air, which is then bubbled through the water.